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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.

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The Necessary Basic Knowledge and Abilities for Engineering Graduation

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

The reason, why we choose the title of this 7. Number of IDEAS was to share with our distinguished readers the thoughts of world-wide known excellent experts about these most important topics at the beginning of the new century.

The 5^{th} World Congress on Engineering Education and Training for the 21^{st} Century Requirements was organized successfully by the Polish Federation of Engineering Associations (NOT) in Warsaw on 12-14 September 2000 with about 150 participants from all over the world. More than 50 papers were presented. The President of FEANI, the Executive Director of WFEO and the President and Members of WFEO Committee on Education and Training were also present at the Congress. The subject of the 5^{th} World Congress was "Improving the innovative capacity of students and teachers, and new educational technique and technologies". It was presented within three thematic sessions:

- The image of the engineer in the 21^{st} Century
- Diagnosis of the present systems of education, training and professional development of engineers
- Directions of changes in the educational system of engineers – suggestions for the future

The purpose of the Congress was to present new educational techniques and technologies, to exchange ideas and experience and to improve innovative capacity of students and teachers. The Congress was patronized by the President of the Republic of Poland.

The World Congress was honored and addressed by Aleksander Kwasniewski, President of the Republic of Poland; video addressed by Prof. Dr. Ing. Jose Medem, President of WFEO, and addressed also by Konstantinos Alexopoulos, President of FEANI.

Beside their addresses several important thoughts of international experts are summarized in this number in that hope, that they may help the engineering educators to reshape – if necessary – their engineering programs, taking into account the new demands of the 21^{st} century.

I personally fully agree with Prof. Vernon John's proposal, („Engineering education – finding the centre or 'back to the future' ", European Journal of Engineering Education, Vol 25 – N. 3. Sept. 2000 p 215-225) who summarized in his article the main features for European engineering education at the start of the third millennium.

Dr. Nicole Becarud's lecture "La Formation des Ingenieurs" delivered at the International Symposium "Formation de l' Ingeniuer au 21^{E}

Siede et le Defi de la Mondialisation" Tunis 26-27 May 1999 is an excellent summary of the discussed topics too.

According to Prof. Xila Liu (CHINA), Fellow of Institution of Structural Engineers, the following three points should be emphasized for engineering education:

• Integrated knowledge structure in theoretic accomplishment, computation and practical training. This structure will act as a stable triangle to support a successful engineering career. In general educators have been focusing on theoretical and computational aspect. Construction practice attracts less attention even up to now.

• Multi-level knowledge in theoretical analysis level, systematic level, and social engineering level. As an engineer, it is important to consider problems from the point of view of systematic or social level, not only to concentrate in technical details. Generally, analysis emphasizes more quantification, while systematic or social level concerns more with qualified decision. For an engineering problem, the accuracy of analysis depends on the requirement of a correct decision making. For engineering students, skills for both quantified analysis and qualified decision making should be well trained.

• The ability of innovation, as well as the ability of adaptation, co-operation, communication and organization is all necessary. Engineering educators should understand that it is different from the graduated students from scientific school, the graduated students from engineering school would have two constraints in future, from nature and society also, rather than one constraint from nature only. Engineering education must cover certain non-technical subjects from an overall and versatile point of view. That is the case of Fundamentals of Economics and Finance, Globalization of the Economy, the Art of Negotiation, Basic Marketing, Basic Business Administration, Issues in Modem Societies, and the like.

A study commissioned by the Swedish Department of Trade and Industry and conducted by the Royal Swedish Academy of Engineering Sciences (IVA) already in 1992 reviewed the long-term requirements for graduate engineers in technology. The study that is actual today as well, "Engineers for the 21st Century" deals among others with the problem of maintaining the quality of **undergraduate** engineering education. Standards can be maintained and further improved as follows:

– Engineering education must continue to provide basic insight into scientific and technological fundamentals, creating the foundation for lifelong learning.

– Engineering education must provide thorough training in scientific methods of formulating and solving advanced technological problems.

– Engineering education must provide a holistic perspective of engineering activities, at the same time integrating an awareness of economics and the environment.

– To a greater extent than at present, institutes of technology must find ways of constructing programs that transcend the boundaries between faculties and departments.

– Links between undergraduate engineering education must be reinforced by involving full professors and other PhD. level staff in the teaching of basic courses.

– Salaries and employment conditions for professors must be market – related if teaching careers are to become more attractive.

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. David R. Reyes Guerra, Mr. Barry Grear* and *Prof. Dr. Ing. Vollrath Hopp,* and also for the Secretary of our CET, for *Mrs. Zsuzsanna Sárközi-Zágoni.*

Address by Aleksander Kwasniewski, President of the Republic of Poland

With satisfaction, I have accepted an invitation to participate at the solemn opening ceremony of the present Congress. I am extremely pleased that it is just Poland which has been chosen as a place for proceedings of the world forum, organised for the first time in Europe, and devoted to engineering education and training for requirements of the 21st century. I treat this as a token of appreciation and high esteem for the output of the host of this meeting—the Polish Federation of Engineering Associations and its particular involvement in the process of engineering education and promoting modern achievements of science and technology in our country.

This honourable distinction is at the same time a symbolic salute returned to the whole Polish Engineering Community, which should be proud of its rich traditions and accomplishments. With the great esteem and admiration I am recalling here all those who have greatly contributed to the modernisation and development of the economy after gaining independence by Poland in 1918. As within the period of merely twenty years, we have managed not only to create an efficient state organism out of the three sectors of the partitioned country. but also to start important industrial, power engineering- and transport investments. The reconstruction of the country from the war damage was the next great examination for our engineers and technicians who had survived the World War II. Those people have greatly contributed to the development of Polish higher schools and technical universities. And though during long decades, the said schools have had only limited research and technological abilities at their disposal, it is due to those accomplished educators that many of them have been capable to maintain the high level of education, securing their graduates good professional competence.

The process of economic transformation, initiated eleven years since, has thrown down important challenges for that Community. As the occurring changes, apart from numerous positive transformations, have also brought about an unknown hitherto phenomenon—unemployment. I am very upset, that such a big group of engineers and technicians has become work-less as a result of restructuring and privatisation. The lack of employment for people with such high qualification is not only a social problem. It is as well an enormous loss for the state, which is not capable to make proper capital of the own intellectual potential. My special anxiety has been awoken by the presence of the unemployed among young graduates from technical universities and engineering schools, who can not find job in a profession they have chosen. This substantially delays their start into life, is a source of frustration, decreases the effectiveness of public education.

Privatisation and modernisation of economy should not lead to diminishing of the prestige of the Engineering Profession, and its degradation. Since there are enormous creative powers that drowse in the properly used engineering personnel.

The dynamic progress, executed in the 20th century has been possible thanks to science and technology, developing on an unparalleled scale. It has an immense influence on many other branches. The countries, which can have the high technological culture to their credit find themselves in the forefront of technological development, they are achieving high living standards of their citizens, and play the leading role in a great civilisation race.

Therefore, it is in the interest of the state to properly utilise this precious capital which is the scientific and engineering community, to make its voice in social and professional issues not only heard, but also appreciated.

Time goes by. We are ahead of the third Millennium. The approaching 21st century brings further challenges along. It also imposes new needs on the State, determined by the social and economic transformations implemented at quick pace, and more and more advanced scientific achievements. A contemporary engineer should be well prepared for them. He should know the practical use of both experiments as well as the latest conquests of production engineering, should not feel himself lost at the junction of many different fields.

In order to attain that, one needs to improve a model of engineering education. It is necessary in the process of education to reach beyond the narrow specialist knowledge and extend it sometimes with distant from technology areas in the field of the Arts, economy or marketing. It is also necessary to facilitate an access to modern information techniques and the best methods of active training for educators and teachers of engineering schools and technical universities.

I am sure that the 5th World Congress while making a diagnosis on the present professional education and training, will simultaneously indicate trends of necessary changes in the system of engineering education. Participation of representatives of four continents in the Congress testifies that the more and more importance is being attached to these problems all over the world.

I am very particular on that these problems would find proper understanding and support also in Poland. Quite soon, our country will become full right member of the European Union. This imposes on us an obligation to work out such a system of engineering education which will satisfy the requirements of the Union; The system that will keep pace with globalisation, progress in production engineering and changes occurring at the labour market.

I should also like the accomplishments of the Congress and the trends of activities in education of engineering personnel that have been accepted there to evoke interest in future employers, who should care to employ most perfectly prepared engineers, possessing not only high professional qualification, but also capable of facing the challenges of the times.

I do wish the participants and organisers of the Congress that it comes up to their expectations. I am convinced that such a meeting, as a plane for exchange of experiences and the most modern trends in the field of engineering education, is at the same time favourable for tightening of international co-operation, contributes to heightening of the education level in a system of technical education.

I am greeting you all from the bottom of my heart. I wish all the guests of the Congress the most pleasantly recalled stay in Warsaw, and I wish all the participants of the Congress much success.

Video Address by Prof. Dr. Ing. Jose Medem, President of WFEO

Today unfortunately I am able only to be with you in spirit at the opening ceremony of the 5th World Congress "Engineering Education and Training", because of prior commitments.

For me it is a real honour and at the same time a great pleasure to send to the participants of this Congress this video address on behalf of our World Federation of Engineering Organizations and the only thing I regret deeply is my impossibility to be physically with you, specially knowing that this important Congress will be carried out under the auspices of the President of the Republic of Poland.

First of all I want to congratulate the promoters of this extraordinary event and particularly the Polish Federation of Engineering Associations for the tremendous effort done in order to organize this World Congress and at the same time I wish to express my gratitude for the kind invitation to participate in its celebration.

In any case WFEO will be well represented in this Congress by one of our Vicepresidents Prof. Janos Ginsztler, Chairman of our Committee on Education and Training, the members of this Committee and our Executive Director Mr. Pierre de Boigne.

Everybody is convinced of the increasing importance of the education and training of our engineers, and many existing national, regional and international organizations are trying to tackle this essential issue of our engineering profession.

In my opinion there are too many organizations, at a regional and international level, taking care of the engineers'problems, specially in a time of an accelerated globalization and internationalization of the World. And this is true also for the education and training of our engineers. In order to be more rational we should make a real effort to better coordinate the existing organizations related to the formation of the engineers, in order to reach a more efficient interchange of experiences and information and utilizing better the existing potentialities. Together we are significantly more effective than we are separately. The resulting synergy would be very beneficial for the whole profession and for the differet parts involved. In this sense I offer the active and positive collaboration of WFEO with all the above mentioned organizations, involved in the formation of the engineers, the initial education and the continuing professional development.

Globalization means an open world market for capital, goods, services, and ideas, including the education market. In this age of globalization the internationalized engineering education has highest priority, because industry increasingly needs employees with international orientation and stonger ties to diverse cultures. Therefore students should have more and better opportunities to complete a phase of their studies abroad.

We must be able to shape a truly global society, eliminating barriers to promote the free exchange of goods, capital, services, ideas, and professionals, developing routes for both physical and virtual mobility, preparing and qualifying people to handle global challenges. Engineers should work across all political, cultural, and ethnic boundaries.

In this sense universities and engineering schools should prepare their students for a globalized world, facing the challenges of globalization seriously.

The Sorbonne declaration of 25^{th} of May 1998 emphasised the creation of the European area of higher education as a key way to promote citizens'mobility and employability, and the joint declaration of the European Ministers of Education in Bologna on the 19^{th} of June 1999 ensures that this European higher education system acquires a world-wide degree of attraction equal to our extraordinary cultural and scientific traditions, with the adoption of a system of easily readable and comparable degrees, essentially based on two main cycles, undergraduate and graduate, and establishing a system of credits. I do hope that this initiative will get in the near future the necessary support for its correct implementation.

Last but not least I want to mention the issue of accreditation. There are many attempts to solve this problem locally, like the different proposals of FEANI, Washington Accord, Engineers Mobility Forum, APEC, etc, but by the time being there is still a long way to go in order to reach a reasonable solution. It is a very complex problem that requires the collaboration of all the experts. WFEO, conscious of the importance of this issue, has created recently a task group chaired by Dr. Fuchs from VDI (Germany) in order to tackle this problem, and we would be very grateful if all of you could cooperate with us in this important task.

To finish I wish you fruitful discussions during this World Congress, with interesting results for the benefit of the engineering education and training, and a pleasant stay in Warsaw.

Address by Eur. Ing. Konstantinos Alexopoulos, President of FEANI

Mr. President of the Republic of Poland,

I want to thank the Polish Federation of Engineering Associations for giving me the opportunity to address this 5th World Congress on 'Improving the innovative capacity of students and teachers, and new educational techniques and technologies'. I don't want to bring owl in Athens by emphasizing the importance of this congress in front of such a distinguished audience of academicians and leading personalities in the government and the society.

The students of today and tomorrow are the hope of humanity for the 21st century. The teachers of them bear the responsibility of giving the world of tomorrow the new creative personalities, the leaders, the producers and the citizens of the new era.

Man has entered into a period of considerable complexity in the modern technological society that will not permit a random process of problem solving. Crucial problems exist such as population growth and manpower needs at the same time, ecology, decreasing natural resources, haphazard application of technological developments, internationalization of the economy and increment of international competition and mobility to name some of them.

As an international society, we are no longer in the industrial period. The developed countries are in a post-industrial period with an increasingly smaller percentage of our people engaged in agriculture, manufacture and production. In addition, the old traditional production practices are changing rapidly in order to face international competition. The new processes require more and more highly educated personnel having in addition appropriate qualities in the affective and psychomotor domain. Millions of people are changing or losing their jobs all over the world or they are changing their job profiles. The technological changes are inserting our societies with tremendous speed and affect our lives.

The technological knowledge which is in use today is becoming obsolete with a rate of app. 7% per year. This means that in 14 years we will use completely new techological knowledge. Technological education has a major role to play within a contemporary educational system. The question is what kind of technological education is needed.

Since technology is subject to rapid change, the appropriate teaching strategy is not to give emphasis to the transformation of specific technological knowledge, which will become obsolete in a short period of time. The appropriate teaching strategy is to teach processes of problem solving based on a broad technological knowledge foundation.

An effective technological education program is centered on processes, clusters of knowledge and skills, which can be applied in any situation within our rapidly changing society through a problem solving process. A number of social, technological, environmental, economic elements must be interrelating in a contemporary technological education program.

It is interesting that a significant percentage of the literature in relation to technological education programs is referring to characteristics such as problem solving, creativity, adaptation to rapid change, taking into account societal and individual needs and the need for the familiarization of the students with the real world of work.

However most of the curricula applied in various countries are close to a step by step instruction in technology, which seems to be in complete contradiction with what many papers and publications support.

There is a clear-cut distinction between science and technology. Science studies the environment, which is given independently of man's will. The various chemical laws, the law of gravity etc. were existing independently of man and discovered through scientific research.

Technology creates an artificial environment according to the needs and interests of people. Through technology people have changed the world. In the drive to satisfy needs and wants, people have developed and improved ways to communicate, travel, build structures, make products, cure disease, and provide food. This has created a world of technological products and machines, roadways and buildings, data and global communications. It has been created a complex world of constant change. Each advance leads to additional potentials, problems, and more advances in an accelerating spiral of development and complexity.

In science we are recording "what there is". In technology we are concerned with what "is to be".

The growth of technology manifests itself through its ability to produce more and more diversified products to meet the needs of different groups and individuals, with more and more interesting features, in a more and more efficient way. The technological progress provides also the means for producing "better" objects of the same kind, for example more durable, more reliable, more sensitive, faster in performing its function, produced with less time and reduced cost, or a combination of the above.

Since technological issues and problems have more than one variable solution, decision making should reflect the values of the people and help them to reach their goal. Such decision making depends upon all citizens acquiring a basic level of technological literacy, and ability to use, manage, and understand technology.

Within the contemporary educational framework, technology students must learn how to utilize as many as possible informational resources in order to reach conclusions and applications through a process of problem solving and examination of alternative solutions.

Teachers will not transfer their limited knowledge but will instead be facilitators of the students in the learning process. Teachers must move from the traditional role of teaching specifics of a limited value to a contemporary role of designing suitable educational activities. Through these activities students will learn processes which can be applied to all possible situations.

The educational curriculum will have suitable coordination between broadness and specialization the so-called T question. The system represents the broadness of the curriculum and the vertical part the degree of specialization. If the broadness of the curriculum is excessive, the students will learn a little from many subjects without knowing something appropriately. If the vertical part is excessive, the students will develop specialization in a few subjects, which will become obsolete within the framework of our rapidly changing informational society.

The revolution of informational technology creates a new technological and societal environment and affects all the dimensions of everyday life. The European production corporations have a new organization. They have their central administration and economic headquarters at the so-called economic and administrative triangle London—Milan—Frankfurt, their research and development centers in more pleasant environment for the researchers and their production units performing routine processes to areas around the pacific.

That situation creates a new reality. The contemporary worker must have knowledge and skills of a high level in order to be competitive in the international society. They are more independent and operate on a more individual basis. All political systems of the past imposed uniformity. Line production systems within the framework of industrial society imposed workers to perform simple uniform production activities thousands of times per day. It was easy task for the governments and the unions to rule such a uniform population.

The new postindustrial informational society is composed of creative problem solving individuals utilizing a number of informational resources and examining alternatives. This kind of population is difficult to be ruled through a top down process. New organizational and societal schemes are developing around the world. Decentralization and informational technology are the two sides of the same coin. Informational technology imposes decentralization in production processes as well as in societal organization. History teaches us that centrally controlled systems, if they are not able to perform decentralization, are condemned to break apart.

What is happening today is a tremendous reconstruction of the techno-economic basis of international economy. This reality is to be understood by the decision-makers, so that they can apply effective policies in relation to employment, productivity, inflation, taxes, redistribution of income, etc. While traditional industries are moving close to the end of their operation, new industries are developing in the area of environmental protection, electronics, energy production, recycling, genetics, information technology etc. There is a need for continuous adaptation of the technical personnel to the new reality in order to survive at the market. Changes are affecting all the countries and they are revolutionary because they impose a new world.

During the industrial era the prevailing political systems influenced deeply the administration of the industrial system of production and applied in society labels such as 'left' and 'right'. Today as we are moving out of the industrial era rapidly, the relationships among the various groups in society are subject to continuous change. Technological changes create new political framework.

Humans should be prepared for the new reality in order to face critically and effectively the various problems. The educational systems have to play a key role for that evolution. The adoption of new educational strategy and techniques for the teacher and students is the pillar of the system.

The objective of learning should be to seek, analyze, correlate, and utilize information, have access to a lot of information resources, develop critical thinking of problem solving and examine alternatives for possible solutions. In this context the improvement of the innovative capacity of student and teachers is of paramount importance for the world of tomorrow.

We engineers and the technical society have an increasingly important role to play. In addition to our traditional involvement in the production process, we have the duty to develop the technologies needed for the evolution and the effective operation of our society and to create the tools for the educational system.

Poland

XXI[st] Century Engineer – Personality and Professional Profile

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ABSTRACT: The historical view on the evolution of professional profile and personality of engineers since the end of XVIII century has been presented distinguishing five generations of engineers. Author tries to answer following questions: What will the VI-th generation engineer (the beginnig of XXI-*st*) be like?, What challenges will be shaping his personality?, What needs and requirements will influence his professional profile? The phenomena which inspire the discussion on the mentioned above questions have been presented: globalization of technology, appearance of new technologies originating from the "borderland" of classical technological domains (mechanics, electric engineering, electronics) and disciplines like biology, medicine, chemistry (biotechnologies, nanotechnolgy, nanorobots, optical computers, neural networks), total computerization, communication revolution (internet, multimedial networks, telebanking, distance learning techniques), apperance of international (or transnational) managers and engineers, rapid devaluation of technological knowledge, creation of engineers' professional training systems within transnational companies and corporations (independent on traditional "national" systems), growing conflict between the necessity of broad synthesizing technological and managerial knowledge and traditional needs of deep, narrow specialization. Conclusions concerning the education and training of engineers have been presented.

INTRODUCTION

At the beginning of XXI-st century the world manufactures seven time more goods than it did as recently as 1950. Almost half of humanity lives in cities. The world of the XXI-st century will be a largely urban world.

As the first industrial revolution is tied to the transition from an agrarian society to modern industrial society, so today the second industrial revolution is responsible for the rise of post-industrial society. The term was introduced by the American sociologist Daniel Bell, who said that for centuries our consciousness of social reality was determined by our relationship with nature. Later, in the period of industrial society (during the last two centuries) it was determined by our relationship to technology we used to control nature. From Bell's standpoint characteristic of the post-industrial society is the fact that reality is determined almost entirely by our interaction with other people - it means: life transpires within organizations. The essence of the first industrial revolution was that man, interposing modern technology between himself and nature, gained power to control nature. The essence of the second industrial revolution is that social life has been absorbed into large organizational structures established and regulated by man. People and things are functioning as elements in comprehensively constructed systems. Man is more and more encapsulated within a self-designed world of organizational - technical systems. Independently on national states or political blocs the additional centres of power emerge within international environment. Large transnational corporations not only influence the governments of industrial countries but play an important role as owners, partners in joint ventures and as suppliers of technology in many developing countries. The assymetry grows in bargaining power between the large corporations and small, poor developing countries which suffer lack of information, technical unpreparedness, and political and institutional weaknesses. The concept of sustainable development of the world appeared as a response to threats of social and environmental catastrophes. Sustainable development is a process in which the direction of investments, the orientation of technological development and institutional changes are all in harmony, taking into account the stability of the ecosystem and keeping the natural environment non destructed.

GENERATIONS OF ENGINEERS

Taking into account the roles played by engineers on different stages of the evolution of technology during last two centuries - several generations of engineers could be distinguished (Fig.1). Since the end of XVIII-th century the set of the rules has increased significantly from the role of **inventor** and **constructor** of a single machine - to the role of **maintainer, manager** or **logistician** of a large scale humano-technical system like for instance: multimedial computer network, satelite communication or navigation system, aircraft instrument landing system, spaceships launching, guidance and landing system, disasters monitoring and relief system etc.. The set of technical objects with which contemporary engineer has to deal - extends from micromachine or microchip invisible by naked eye - to the worldwide system, which is also "invisible" in the sense of transparency and direct visibility of all the systemic relations, energy or information flows.

Particular generations of engineers also differ significantly from the "versatility - specialization" point of view. First generation engineer was versatile in the sense of technological knowledge as well as in his professional activity. Very often he had to be simultaneously inventor, designer and constructor of machine or technical device. Next generations evolve towards growing specialization in both: particular spheres of technology (mechanics, electric engineering, building engineering) and rules fulfilled by engineers (engineer designer, engineer constructor, engineer maintainer). Third generation engineers are already highly specialized in narrow branches of technology (electric engines, power engineering, telephone exchanges, aircraft engines, airframes, radio transmitting devices, sound devices, TV video devices, radars, sanitary devices, refrigerating devices, measuring devices) and play very specific rules (operating engineer, production engineer, tool engineer, resident engineer, site engineer, quality inspection engineer, engineer supervisor, engineer project manager, chief designer etc.).

Then a kind of return to versatility appears as a consequence of synthesizing trends in technological sciences (cybernetics, general systems theory, systems engineering).

Fourth generation of engineers occurs split: on one hand super-specialists of the very narrow and deep professional profile, on the other hand systems engineers - systems analysts, systems designers. At the end of XX-th century the integration tendencies go further - not only the integration of particular spheres of technology appears (optics and electronics, mechanics and electronics) but merging the technological and non-technological disciplines advances rapidly (biology and mechanics, medicine and electronics) as well.

Fifth generation engineers more and more frequently appear dual or even triple specialists with significant dose of systemic knowledge. Beside traditional technical objects (machines, plants, devices) they deal with new hybrid objects, technologies and procedures

ENGINEERS I. GENERATION (*End of XVIII—Half XIX-th Century*)

VERSATILE *(General Purpose)*	INVENTORS DESIGNERS CONSTRUCTORS	***OF***	MACHINES, FACILITIES, PLANTS, TECHNICAL OBJECTS

ENGINEERS I. GENERATION (*Half XIX—Beginning XX-th Century*)

SPECIALIZED *(Mechanics, Electrical Engineering, Construction Engineering)*	INVENTORS DESIGNERS CONSTRUCTORS **MAINTAINERS**	***OF***	PARTS OF MACHINES, ASSEMBLIES, MACHINES, FACILITIES, PLANTS, **INDUSTRIAL OBJECTS**

ENGINEERS I. GENERATION (*Beginning XX—Half of XX-th Century*)

HIGHLY SPECIALIZED *(Narrow Branches of Technology)*	INVENTORS DESIGNERS CONSTRUCTORS **MAINTAINERS** **MANAGERS**	***OF***	PARTS OF MACHINES, ASSEMBLIES, MACHINES, FACILITIES, PLANTS, **INDUSTRIAL OBJECTS**

ENGINEERS I. GENERATION (*Half XX—70-ties XX-th Century*)

SPLIT: PARTIALLY SUPER SPECIALI-ZED, PARTIALLY SYSTEMIC	INVENTORS DESIGNERS CONSTRUCTORS **MAINTAINERS** **MANAGERS**	***OF***	**MODULES,** MACHINES, FACILITIES, PLANTS, **INDUSTRIAL OBJECTS, INDUSTRIAL GROUPS, TECHNICAL SYSTEMS**

ENGINEERS I. GENERATION (*70-ties XX—End of XX-th Century*)

HYBRID *(Merging two or three Spheres of Technology or Other Disciplines: Bio-Mechanic, Opto-Electronic)*	INVENTORS DESIGNERS CONSTRUCTORS **MAINTAINERS** **MANAGERS** **LOGISTICIANS**	***OF***	MODULES, MACHINES, FACILI-TIES, PLANTS, **INDUSTRIAL OB-JECTS, INDUSTRIAL GROUPS TECHNICAL SYSTEMS, LARGE (WORDWIDE) SCALE HUMANO-TECNICAL SYSTEMS**

ENGINEERS I. GENERATION (*Beginning XXI-st Century*)

1. **What will the IV generation engineering be like?**
2. **What challenges will shape his personality?**
3. **What needs and requirements will influence his professional profile?**

Fig. 1. Generations of engineers

(micro scale bio-technical objects, large scale humano-technical systems).

Numerous phenomena and opinions appeared which spell for necessity of broad discussion on the next (sixth) generation of engineers - engineers of XXI-st century. This discussion should focus on following questions:

1. *What will the VI-th generation engineer be like?*
2. *What challenges will shape his personality?*
3. *What needs and requirements will influence his professional profile?*
4. *What changes of current educational and training programs should be introduced immediately?*
5. *What modifications of educational and training systems will be necessary?*

PHENOMENA INSPIRING THE DISCUSSION ON THE VI-th GENERATION ENGINEERS

Since at least 20 years we have watched the phenomena which inspire the considerations on the personality and professional profile of XXI-st century engineer as well as on the system of engineering education and training to meet the XXI-st century requirements. These phenomena are following:

– globalization in the realm of technology: increasing number and variety of given technical objects (machines, facilities, plants) and technological procedures simultaneously used in different parts of the world, appearance of the worldwide (global) technical systems;

– appearance of new technologies originating from the „borderland" of classical technological domains (mechanics, electric engineering, electronics) and disciplines like biology, medicine, chemistry (biotechnologies, nanotechnology, "nanobots" - nanorobots, optical computers, neural networks, neurochips - brain-computer interface implants, mapping human genome, genetical engineering);

– expansion of computers, computer science, total computerization (in XXI-*st* century there probably will not exist any machine, any engine or other converter of energy or kind of motion without microchips, microprocessors or controlling computers);

– revolution in the sphere of people's intercommunication (internet, multimedial networks, satelite transmission) and its consequences: appearing new methods of work organization, furnishing services, economic and financial activity as well as new systems of education and professional training (telebanking, distance learning techniques);

– appearance and increasing number of international (or transnational) staff of managers of their roots in engineering and engineers able to deal with the given globally spread technology, independently on the country or the region;

– rapid devaluation of technological knowledge, rising generation gaps between engineers prepared to deal with determined generations of machines and technical devices;

– creation, within transnational companies and corporations, professional training systems for engineers, independent of traditional „national" education and training systems;

– growing and intensifying conflict between the necessity of broad synthetising technological and managerial knowledge, and traditional needs of deep, narrow specialization of technological knowledge.

Broad discussion on the mentioned above phenomena as well as the international exchange of the views and experiences should result in conclusions concerning the essence, the programs and the methods of education and training of engineers, meeting the requirements of XXI-st century.

This discussion should strengthen the international consensus and agreement on the core educational program supporting the idea of "Euroengineers" (as well as in improving related legal solutions). It should also lead to shaping the new notion of „Worldengineers" and to working out the internationally accepted principles of its formal foundations.

REQUIRED PERSONAL CHARACTERISTICS AND EXPECTED PROFESSIONAL PROFILES

During the postgraduate logistics study in the summer semester 2000 author asked its participants - the engineers of different professional specialities (in average - people with

REQUIRED PERSONAL CHARACTERISTICS	EXPECTED PROFESSIONAL PROFILES
• PASSION FOR TECHNOLOGY • CREATIVENESS • INNOVATIVE CAPACITY • INITIATIVE AND COMMITMENT IN SCIENTIFIC AND TECHNOLOGICAL PROGRESS • ADAPTATIVENESS (FLEXIBILITY) • SELF-IMPROVEMENT CAPACITY • PROFICIENCY IN APPLYING COMPUTERS (COMPUTER NETWORKS) IN EVERYDAY WORK • COMMAND OF FOREIGN LANGUAGES • MASTERY OF PROFESSIONAL KNOWLEDGE AND SKILL • COMPETENCE IN MANAGEMENT AND LEADERSHIP ABILITY • COMPLIANCE WITH ENGINEERS' PROFESSIONAL ETHICS PRINCIPLES • CONVICTION OF CIVILIZING MISSION OF TECHNOLOGY	• STILL EXISTING „TRADITIONAL" PROFILES: MECHANICS, CIVIL ENGINEERING, CONSTRUCTION, ELECTRIC ENGINEERING, COMMUNICATIONS, ELECTRONICS, AUTOMATICS, AVIATION ENGINEERING, SHIPBUILDING, MINING ENGINEERING, CHEMICAL ENGINEERING • APPEARED NEW PROFILES: NUCLEAR ENGINEERING, SPACE ENGINEERING, COMPUTER (COMPUTER NETWORKS) ENGINEERING, ENVIRONMENTAL ENGINEERING, BIO (MEDICAL) ENGINEERING, QUALITY CONTROL (QUALITY MANAGEMENT) ENGINEERING, MECHATRONICS, ROBOTICS, SAFETY (RELIABILITY) SYSTEMS ENGINEERING • EXPECTED PROFILES: MICROENGINEERING (MICROMACHINES, NANOTECHNOLOGY, NANOROBOTS), ENERGY CONVERSION ENGINEERING, LOGISTICS ENGINEERING (STORAGE, DISTRIBUTION, TRANSPORTATION, SERVICING SYSTEMS), MANAGEMENT ENGINEERING

Fig. 2. Personal characteristics and professional profiles of XXI-st century engineer

5-6 years experience after getting the engineers diploma) for identification (during the brainstorm experiment) the required personal characteristics of XXI-*st* century engineer. Thus initial broad list containing 32 characteristics had been generated. Then as a result of the "expert assessment" procedure and discussion the list was validated and reduced. The outcome was a shortlist of 12 characteristics with ranking based on the adjusted participants' subjective criteria of „importance" *(Fig.2)*.

What seems interesting is relatively higher position of the characteristics like "adaptativeness" or "self - improvement capacity" than "mastery of professional knowledge and skill". The highest position of "passion for technology" together with the personal characteristics which are equivalent with versatility might spell for certain similarity of the situation (challenges, need, roles) between the first generation of engineers at the end of XVIII-th century and the sixth one at the beginning of XXI-st century (of coarse taking into account all the differences resulting from more than two hundred years progress of technology). Dealing with the new (so far unknown) cathegories of "objects": hybrid bio-technical devices or worldwide humano-technical systems - XXI-st century engineer will be, in certain aspects, similar to his predecessor - constructor of first steam engines, motor vehicles, looms.

The characteristics like "leadership ability" or "competency in management" reflect the growing tendency of employing engineers as

			CLASSICAL ENGINEER	ENGINEER RESEARCHER	ENGINEER MANAGER
1	GENERAL NON-TECHNOLOGICAL KNOWLEDGE	MATHEMATICS, PHYSICS, CHEMISTRY, BIOLOGY (BIO, MED.ENGINEERING), ECOLOGY, GENERAL SYSTEMS THEORY	15%	20%	15%
2	GENERAL TECHNOLOGICAL KNOWLEDGE	MECHANICS, MECHATRONICS, ELECTRIC ENGINEERING, ELECTRONICS, COMPUTER SCIENCE, COMMUNICATIONS ENG., ROBOTICS, MICROENGINEERING TRANSPORTATION ENGINEERING, ENERGY PRODUCTION AND CONVERSION ENG.	20%	30%	20%
3	SPECIALISTIC TECHNOLOGICAL KNOWLEDGE		50%	40%	25%
4	MANAGERIAL KNOWLEDGE	ECONOMICS, MANAGEMENT THEORY, MARKETING, BANKING, LOGISTICS, LAW (LEGAL REGULATIONS FOR ORGANIZATION)	10%	5%	25%
5	HUMANISTIC KNOWLEDGE	PHILOSOPHY ETHICS PSYCHOLOGY SOCIOLOGY FOREIGN LANGUAGES	5%	5%	15%

Fig. 3.

managers. Most of managers of small or medium companies in Poland are engineers. In Germany more than a third of all engineers hold management positions. The notion of "engineering activity" will probably gain the considerably broader meaning. Engineers-managers should be educated not only in technological sciences but also in those related to economics, law, marketing, banking and finance, logistics as well as sociology and humanities.

At the beginning of XXI^{-st} century there will probably still exist „traditional" professional profiles *(Fig.2)* of engineers (mechanics, electric engineering, civil engineering, communications etc.). The new profiles which have appeared since the half of XX^{-th} century (nuclear engineering, space engineering, computer engineering, environmental engineering, mechatronics, robotics) will probably extend their range (in different countries, schools, corporations) and strengthen their position and authority - step by step replacing the „traditional" ones.

As a result of the discussed above phenomena and trends influencing the requirements for engineers' professional profiles—following profiles could be expected:

– microengineering, including: micromachines, microdevices, microsystems, nanotechnology, nanorobots;

– energy conversion engineering, including: new sources of energy, new methods and means of transmission and conversion of energy;

– logistics engineering, including: storage, distribution, handling, transportation, servicing systems;

– management engineering, including: management structures, management procedures, management information systems, managers' decision making support systems, management tools and equipment.

CONCLUSIONS

In any discussion concerning the future personality and professional profile of engineers it is difiicult to avoid the questions on the educational and training systems, which will be preparing engineers for meeting the challenges and requirements of XXI^{-st} century.

Following questions are still open:

– what should be the consecutive stages of education and training for engineers like and which institutions should participate in particular stages (national institutes of technology, private - owned schools, national engineering associacions and agencies, international engineering federations, national companies' and enterprises' training branches, large transnational corporations training centers);

– what should be the proportions of general and specialistic technological knowledge like as well as the proportions of technological and non-technological (economical, managerial, humanistic) knowledge given to modern engineer;

– which domains and disciplines of technological science should be the subject of: basic polytechnical education, bachelor's and master's level education, post-graduate education courses, training courses, distance learning courses, self improvement;

– how to share the total education time (e.g. 4000-4200 hours) into general domains of knowledge necessary for modern engineers.

The proposal presented at *Fig.3* resolves itself into distinguishing five spheres of non - technological and technological knowledge. The disciplines proposed to be included in every sphere have been also indicated. The suggested proportions of knowledge connected with particular spheres have been presented for three categories of engineers: "classical" engineers, engineers researchers, engineers managers. Presenting the proposal author realizes how difficult is to demarcate the area of every sphere and discipline and to mark out the border between particular spheres and disciplines.

Nevertheless it is also difficult to discuss on sharing the education and training time without any assumptions whatever as of the kinds and proportions of necessary knowledge. The transformation of suggested proportions into education and training programs still remains the complex activity in which not only the requirements should be taken into account but also present and future possibilities (the scientific and educational potential) of technical universities, schools, educational and training centers.

The proportions presented at *Fig.3* could be the startpoint of the discussion on further international co-ordinations and agreements concerning the comparability and mutual approvals of engineers diplomas as well as the exchange of students and teachers and international distance learning programs.

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Poland

5th Word Congress „Engineering Education and Training for 21st Century Requirements"

W. Miszalski, Z. Adamczewski and A. P. Wierzbicki

REPORT ON SESSION I:

"THE IMAGE OF THE ENGINEER IN THE 21ST CENTURY"

by Wlodzimierz Miszalski

The participants of the 5th Congress sent 16 papers assigned by the Program Committee to session I. The introducing presentation by session leader was given during the first day of the Congress.

During the second day 14 papers have been presented. The session has given an occasion to exchange data, opinions and controversies regarding the image, personality and professional profile of the 21st century engineer as well as the educational systems and techniques able to shape the required image of the 21st century engineer.

Following problems have been the subject of discussion:

- what challenges will shape the 21st century engineer's personality,
- what needs and requirements will influence his professional profile,
- what changes of current educational and training programs should be introduced immediately,
- what modifications of educational and training systems will be necessary.

The participants of the Session I gave many examples of the attempts undertaken in their countries to solve the mentioned above problems.

The interesting proposals have been presented by Turkish colleagues (Engineering education for social responsibility and sustainable development). The representative of Argentina has focused on the new programs of managerial training of engineers. The broad view on the proportions of engineering and business education has been presented by the representative of Australia.

The presentations given by Polish colleagues focused on the models of engineering education (Warsaw University of Technology) and on the new techniques and technologies in education of engineers (Cracow University of Mining and Metallurgy) as well as on the education and improvement of the engineers in different industries.

I think that we have presented some new ideas. By combining the theoretical considerations regarding the image of the 21st century engineer with practical solutions we have helped to develop the rational approach to the problems formulated in conclusions which are following.

The improvement of international co - ordination and agreements on the comparability and mutual approvals of engineers diplomas need consensus on the consecutive stages of education and training for engineers (which domains and disciplines of technological science should be the subject of: basic polytechnic education, bachelor's and master's level education, postgraduate education courses, training courses, distance learning courses, self-improvement).

The proportions of general and specialist technological knowledge as well as the proportions of technological and non-technological (economical, managerial, humanistic) knowledge given to modern engineer should be established.

The sharing of total education time into general domains of knowledge necessary for modern engineers should be the subject of further discussion in order to strengthen the international consensus and agreement on the core educational programs supporting the idea of "European Engineer" (as well as to improve the related legal solutions). It should also lead to shaping the new notion of "World Engineer" and to working out the internationally accepted principles of its formal foundations.

REPORT ON SESSION II:

"DIAGNOSIS OF THE PRESENT SYSTEMS OF EDUCATION, TRAINING AND PROFESSIONAL DEVELOPMENT OF ENGINEERS"

by Zdzislaw Adamczewski

The delivered papers presented the following problems:

1. International trends in accreditation of engineering education ,
2. Civilization collisions and their implications in the process of engineering education,
3. The role of technical universities in economic development,
4. Attempts to quality and efficiency evaluation of engineering education (including continuous education),
5. Vocational education at the Secondary School level,
6. Testing of educational aspirations and expectations of students.

The authors - B. S. Oberst and R. C. Jones (U.S.A.), in their paper, well documented and presented in an attractive way, gave the outcomes of research on development of engineering education accreditation procedures in countries with different cultural backgrounds and representing diversified levels of economic development. The problem of accreditation in highly developed countries as well as some developing countries was considered. The Central-and East European countries were not dealt with. The authors identified six factors shaping the accreditation procedures, namely:

- decreased deference on the part of public officials to the resource needs of higher education,
- public demands for accountability,
- impact of globalization,
- the requirements of on-the job training,
- competition from new educational institutions,
- changes as a permanent global phenomenon.

The said factors stimulate development of four types of strategies:
1. Engineering educators are looking to accreditation as a means of quality assurance,
2. Quality criteria specification progresses,
3. Professional engineers are being accepted as partners in engineering education,
4. Accreditation becomes the basis for cross-border recognition of graduates.

The authors -Z. Adamczewski and A. S. Kwiatkowski (Poland) made an attempt to identify civilization collisions at the turn of the 20^{th} and 21^{st} centuries and their diversified implications for education of engineers. In their paper, they tried also to determine the impact of the achievements of the technological civilization on universal civilization . The paper indicated the development of new educational utopias and, in connection with them, the necessity to formulate adequate educational response in the form of new efficient educational curricula and techniques. The sociological and economic background of educational processes and emergence of severe civilization disproportions, increased by the progressing globalization, were presented. In the contemporary world of human existence one may distinguish four basic spheres:

- immense (unimaginable wealth),
- supervised prosperity,
- supervised indigence,
- immense (unimaginable) poverty.

The term "supervised" has the meaning that an individual can not get from one sphere to another one in a spontaneous way, but there is a strong provision to his/her passage. The authors have drawn pragmatic conclusions out of that model. They identify the process of building and developing of the engineering personnel in great economic corporations.

Attention was also given to the decreasing numbers of candidates for the engineering professions and increase of interest among the youth in economic studies as well as some of the humanities. And especially, great popularity have, at present, studies in the field of management, marketing and business techniques. The problem of education in business engineering was presented by D. M. Duse (Romania) on example of the reformed education at the University of Sibiu.

The paper presented by C. A. Rios (Argentina) included clear-sighted considerations on relations between activity of universities and economic development. Examples of close relations between academic education and economy in Argentina were given.

The problems of quality and effectiveness of education were dealt with in some papers. Factors of assimilating knowledge were identified and analyzed by L. Kieltyka and W. Jêdrzejczyk (Poland). Perception, concentration and memorizing were recognized as the main factors. The advantages and disadvantages of multimedia educational techniques were analyzed from that side. It was acknowledged that the "traditional" point of view, according to which the level of effectiveness in the process of teaching, still largely depends on a teacher, and often, to a lesser degree—on equipment facilitating the tuition process.

S. Przewlocki and B. Wolski (Poland) pointed to purposes and limitations, that should be taken into account while working out educational curricula (e.g. level of generalization, student's overload, relations between compulsory and facultative subjects, formal and economic limitations). The authors cited illustrative instances from the Technical University of Lodz and Technical University of Cracow.

The problem of the so-called pro-technical education at secondary level was dealt with by K. Okraszewski and B. Rakowiecka as well as by K. Symela (Poland), who focussed their attention on developing innovative attitudes of the youth in technical secondary schools, which brings effects in their further engineering education at academic level.

Two Polish papers coped with problems of evaluation of the quality of education and testing preferences of students from different years of study (Z. Kurowski and R. Golba presented results of those tests).

Generally speaking, it may be stated that the course of proceedings of the Session II was adequate to the organizational assumptions. Out of their synthesis, there emerges a diagnosis of the present status of engineering education. Discussions on all of the problems presented by the authors presenting their papers enlightened the proceedings.

REPORT ON SESSION III:

"DIRECTION OF CHANGES IN THE EDUCATIONAL SYSTEM OF ENGINEERS —SUGGESTIONS FOR FUTURE"

by Andrzej P. Wierzbicki

This Session contained 17 papers (15 presented) from 4 countries. Not all papers related directly to "suggestions for future" as proposed by the title of the session. The organizers put in this session all more controversial papers, classifying them as "futurologist", which has a negative connotation in Polish; however, this had positive consequences since it contributed to the intensity of discussions in this session.

Concerning futurology and forecasts of the future, there is a tendency (in Poland, but also international) to negate the possibility of forecasting and to quote long lists of examples of errors in forecasting. The proper answer to such quotations is: only that few errors of forecasting? The theory suggests there should be much more errors: the probability of any specific prognosis becoming true is zero if we assume continuous distributions of perturbations. Yet, forecasting is essential for human civilization. Why, when travelling by air, we go to an airport before the departure time of the aircraft? Because we forecast the aircraft will depart on time, subject to (hopefully) only minor errors. Why do we take an umbrella when rain is forecasted? Most of scientific activity is aimed at forming knowledge that might be useful when forecasting.

We might stipulate that forecasting is very difficult. Moreover, social sciences, such as economics, business management, quality management etc., tend to be fascinated by the possibilities of data processing by computers and by deriving statistical models from these data - without deeper knowledge of the methodology of forecasting that stresses the dangers of interpreting such models. A statistical model is not a causal model, to specify causes and effects in such a model we need deeper, fundamental knowledge, external to the statistical data. The best example illustrating this fact is the strong statistical relation between magnetic storms on Earth and solar spots. Based only on statistical data, one could advance a theory that magnetic storms perturb our vision and thus we see spots on Sun. Such a theory is false, but consistent with the data. In order to specify correctly that solar spots cause magnetic storms, we need a theory of elementary particles emitted by solar eruptions and their impact on the magnetic field of Earth -a deeper theory , external to the data.

This example illustrates also a conclusion advanced by several papers of the session: *modern engineers should have sufficient knowledge in basic sciences and scientific methodology, without them they will not understand modern world and might be prone to errors.* Several papers contributed to this conclusion: the excellent paper of Prof. Galetto from Italy, papers from Prof. Rakowski and Prof. Kozlowska from Poland.

Several papers - by Prof. Kieltyka, Prof. Blach and others from Poland - stressed the role of modem technology in future education of engineers. These papers advanced an interesting conclusion: *modern technology is not sufficient in itself, it must stimulate a holistic (including visual, audio, etc.) perception by the student.* Such conclusion is consistent with a modem, rational theory of intuition that defines intuition as non-verbal, holistic subconscious perception and evaluation of complex information, supported by training. Thus, we might say that modem technology should be used to support intuition formation by future engineers.

Two papers - by Prof. Jones and Oberst from USA and Prof. Przybylski and Wojciechowski from Poland - stressed the trend of internationalization of engineering education: *a modern engineer cannot be educated only on own national engineering examples, (he) must understand diverse national approaches and international experiences.* The approach of specialists from the USA to this issue is somewhat different than the European approach. European tradition takes cultural diversity, also in engineering, as a granted and highly positive value. For American specialists, this value must be stronger stressed; a rational argument for cultural diversity is that it creates a systemic resource for dealing with unforeseen crises.

Many papers were devoted to the future of several engineering specialties: more broad such as mechanical engineering or more narrow such as specialists on corrosion protection. Together with the expected changes of the basic character of engineering professions, we must also expect further discussions and changes of the character of training engineers in more narrow specialties. Although all specialists defend their specialties as worth a specific training program, the amount of knowledge necessary for a modem engineer increases and -as stressed above - we cannot save time by shortening education in basic sciences and methodology. Thus, *one possible solution of the dilemma of engineering specialization is a more diversified and broad post-graduate and continuing education, possibly with the use of knowledge represented by specialized research institutes.*

It is difficult to say which of the above conclusions is most important; possibly, the conclusion on *the necessity of educating engineers in fundamental knowledge and concepts* might be most essential. However, the entire session was very valuable and inspiring.

Germany

Engineering Education for the 21th Century

Dr. Kruno Hernaut Senior Director, Siemens AG, Munich (Germany)
Chairman, European Monitoring Committee, FEANI

Lecture delivered at the FEANI General Assembly in Hamburg on the 6th October 2000. The lecture deals with the idea, how could the FEANI-approach of "EUR ING" fit into the Bologna Declaration signed by the Ministers of Education from 29 European Countries in 1999.

The Ministers of Education from 29 European Countries agreed in Bologna on the 19th of June 1999 to establish the EUROPEAN AREA OF HIGHER EDUCATION.

European Area and European System of Higher Education

The Bologna Statement. While affirming our support to the general principles laid down in the Sorbonne declaration, we engage in co-ordinating our policies to reach in the short term, and in any case within the **first decade of the third millennium**, the following objectives, which we consider to be of primary relevance in order to establish **the European area of higher education** and to promote **the European system of higher education** world-wide:

Adoption of a system essentially based on **two main cycles, undergraduate and graduate.** Access to the second cycle shall require successful completion of **first cycle** studies, lasting a **minimum of three years.** The degree awarded after the first cycle shall also be relevant to the European labour market as an appropriate level of qualification. The second cycle should lead to the master and/or doctorate degree as in many European countries.

According to this new European standard based on the Bologna-declaration a so-called first cycle course (FCC) and second cycle course (SCC) should be introduced to get the first cycle degree (Bachelor, FCD) or the second cycle degree (Master, SCD). In Germany the traditional courses in engineering lead to a long degree (after 5 year "long" engineering courses) at "Research type" Universities, or to a short degree (after 4 year "short" engineering courses) at "Applied type" Universities.

Global Standard for Bachelor/Master System

According to the Global Standard minimum 3 year study is necessary to achieve the Bachelor level (undergraduate study) and further 2 years to achieve the Master level (graduate study), where compatible mobility channels should exist.

According to the Bologna-declaration "the adoption of a higher education system essentially based on the two main cycles, undergraduate and graduate education. Access to the second cycle shall require successful completion of first cycle studies and last a minimum of three years. The degrees awarded after the first cycle shall also be relevant to the

European labour market as an appropriate level of qualification. The second cycle should lead to the master's and/or doctorate degree as it does in many European countries.

The establisment of a system of credits – such as in the ECTS system (European Credit Transfer System) – as a proper means of promoting the most widespread student mobility."

The *Table 1.* shows the number of students from ASIA-Pacific countries studying abroad in 1985 (230000 students) and in 1995 (470000 students).

It is more than probable that the new compatible mobility channels – based on the Bologna-declaration – will strenghen the role of European countries in the global higher education arena.

NEW GERMAN LEGISLATION

According to the new German legislation the duration of studies means for Bachelor degree 3-4 years, for Master degree 1-2 years and for Bachelor + Master degree maximum 5 years.

Since 1998 universities in Germany are eligible to introduce new Bachelor and Master courses in addition to or replacing the traditional courses. Since then some 470 new Bachelor/Master courses have been initiated.

The new variety of engineering courses at German universities is to be seen on the *Fig 1.*

Modern curricula in engineering education should be created so, that 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

Some requirements on engineering education for the 21st century:

- Adapt studies to international standards
- Define and introduce a core curriculum for engineering
- Win mutual recognition for studies done abroad
- Offer products (i.e. programs) 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

Table 1.

	1985	1995	Increase
1.	**USA** ....140.000 = 61%	**USA** ....260.000 = 55%	+86%
2.	**Great Britain** ....16.000 = 7%	**Japan** ....50.000 = 11%	+488%
3.	**Canada** ....15.000 = 7%	**Great Britain** ....48.000 = 10%	+220%
4.	**Germany** ....12.000 = 5%	**Australia**................36.000 = 8%	+260%
5.	**Australia** ....10.000 = 4%	**Germany** ....18.000 = 4%	+50%
6.	**Japan**......................8.500 = 4%	**Canada**.................15.000 = 4%	0%
7.	**France** ....5.500 = 2%	**France** ....7.000 = 1%	+27%
	Other countries....23.000 = 10%	**Other countries** ....36.000 = 8%	+50%

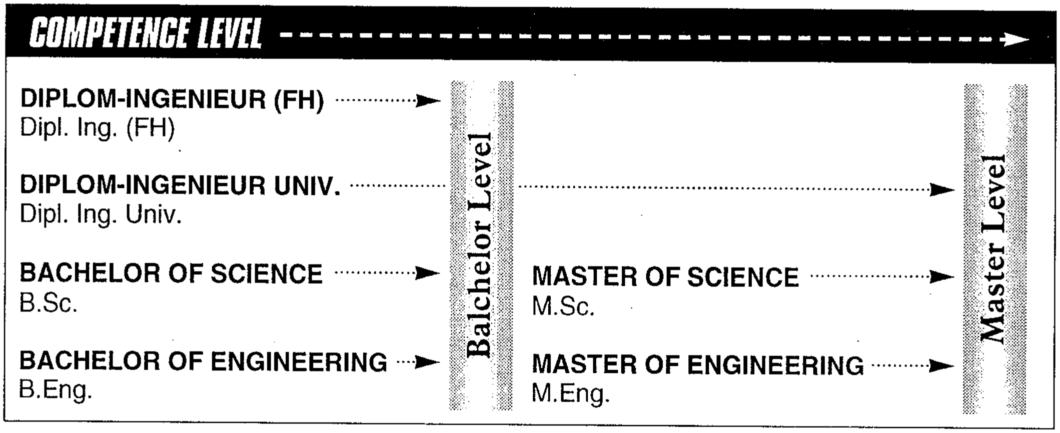

Fig.1.

- Introduce market-oriented administrative and organizational structures in the universities
- Treat students as customers who pay for their education and deserve commensurate services and product quality
- There is a need for quality assurance systems which are transparent and are based on mutual recognized minimum standards
- These should be responsive to changing technology and world conditions
- National/regional systems should set up compatible accreditation structures for engineering programs

China

Predicaments and Expectations of Civil Engineering Education in China

Prof. Xila Liu Vice, Secretary of China Civil Engineering Society (CCES)
Fellow of Institution of Structural Engineers (I Struct E)
Board Member of International Council for Research and Innovation in Building and Construction (CIB)
Prof. Dongping Fang, Dept. of Civil Engineering, Tsinghua University (China)

ABSTRACT: Based on the demands of qualified civil engineers in China, integrated knowledge structure, multi-level knowledge and abilities of innovation, adaptation, cooperation, communication and organization are set forth to be the goals of civil engineering education. Predicaments of civil engineering education are discussed. Three challenges, that is student-centered education, dynamics of education organization, and open education were pointed out in this paper to draw the attentions of educators, construction practitioners, industry leaders and legislators.

DEMANDS FOR QUALIFIED CIVIL ENGINEERS IN CHINA

China, with a population of more than one billion, has maintained the highest economic growth rate in the world for several years. The planned economy is been shifted to market economy. After the Asian economic crisis, the government initiated a huge investment programme in public infrastructure construction to re-mobilize the declined economic growth in 1998. Many huge projects, some of them are the largest in the world, are either under construction or planning. Contractors from all over the world rushed into this attractive market, trying to share the cake. But at the same time, construction accidents caused by poor technology, poor management and corruption occurred more frequently. A high way was damaged the same day it was open, a bridge collapsed during construction, etc. Many construction projects were designed and constructed by people without relevant capability. The civil engineering projects are no longer only a labor-intensive works, technological advancement, complexity, and competitiveness of society make it more challenging than before. So, there is a great demand for qualified civil engineers in China to construct a reliable future.

The increasing complexity of the technical, social, legal, and economic environment in which civil engineers must practise their profession has focused renewed attention on the need for graduates who possess competencies far beyond that which can be acquired in a traditional, basic level, civil engineering degree program. Among these competencies are enhanced ability to synthesize and innovate; better appreciation for the realities and constraints of engineering practice; deeper understanding of the cultural, social, and business environment in which they must function; greater depth of knowledge of civil engineering discipline; capability to operate in an environment characterized by rapid technological and economic change; greater breadth of knowledge of related engineering and scientific disciplines; ability to communicate, both orally and in writing; and ability to function in a team environment.

The intellectual foundation of civil engineering should be broad, well rounded, multidisciplinary, and strong in technology and scientific knowledge. It should also be supplemented by exposure to:

1) a global vision and approach to problem identification and problem solving in areas such as infrastructure, environmental, facilities, and systems;

2) a basic management knowledge base in areas such as business, resources, costs, and time management;

3) a solid foundation in personal and interpersonal attributes, ethics, and humanities-social (sciences);

4) an involvement with the practice (of engineering) as the formal education evolves.

Under this definition, civil engineering education should continuously evolve to higher and higher levels of quality and at all times incorporate new technologies and practices into the civil engineering process. (R.D. Kersten,1996)

EDUCATION IN CIVIL ENGINEERING

The Characteristics of Civil Engineering Discipline

The most outstanding characteristics of the area its individuality and its comprehensiveness. The individuality can also be termed as indigenous. Unlike TV set manufacturing, none construction project in China can copy the foreign precedent. Even though it was designed and its production managed by foreign experts, the design has to be adapted to the local conditions and requirements, of course with Chinese professionals' assistance in the process. Needless to say, a civil engineer must face a sophisticated Human-Machine project; comprehensive knowledge of different disciplines is required.

Goals for Civil Engineering Education (Xila Liu, 1998)

Before talking about civil engineering education, the different requirement for scientist and engineer must be distinguished. The main task of scientist is to probe the nature and they are restrained by the natural principles. As to the engineers, who mainly focus on transfiguring the nature, the constraints are social principles as well as natural principles. There will never be a unique solution to a certain project, in most cases; there exist a series of feasible solutions, among which we will choose the satisfactory solution that, however, is often subject to modification. Therefore, the requirement for scientists is originalities, while for the engineers is seeking for resolutions to accomplish the project.

The following three points should be emphasized as the goals for Civil Engineering Education:

1) Integrated knowledge structure in theoretic accomplishment, computation and construction practice *(Fig. 1)*. This structure will act as a stable triangle to support a successful engineering career. In China, educators have been focusing on theoretical and computational aspect. Construction practice attracts less attention even up to now.

2) Multi-level knowledge in theoretic analysis level, systematic engineering level and social engineering level *(Fig .2)*. As a civil engineer, it is important to deal with problems from systematic or social level, not only to concentrate in technical details. Generally, analysis emphasizes more on quantification, while systematic or social level concerns more with qualified decision. For an engineering problem, the accuracy of analysis depends on the requirement of a correct decision making. For civil engineering students, skills for both quantified analysis and qualified decision making should be well trained.

3) The ability of innovation, as well as the ability of adaptation, cooperation, communication and organization is all necessary. Civil engineering education must cover certain non-technical subjects from an overall and versatile point of view. That is the case of Fundamentals of Economics and Finance, Globalization of the Economy, the Art of Negotiation, Basic Marketing, Basic Business Administration, Issues in Modern Societies, and the like.

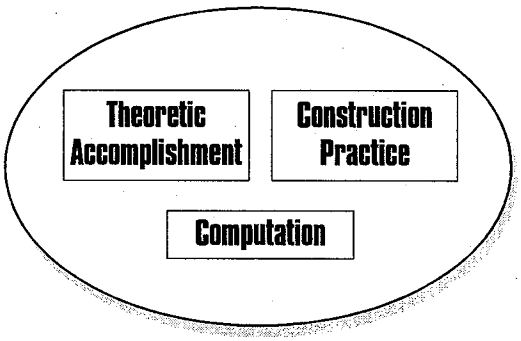

Fig.1. Integrated Knowledge Structure

PREDICAMENTS

Universities

For many years, the universities in China experienced a lack of money supply to support their educational activities. The universities' education role is weaken, because they have to consider their own survival issues and professors have to do profitable research projects to support their innovative researches and education to which, of course, only limited effort can be put forward.

Faculties

Because universities in China were closed from middle of 60's to the end of 70's for political reasons, there is an obvious fault in faculties: mid-aged research and education elite are quite few. Young researchers have to be promoted quickly to take important positions

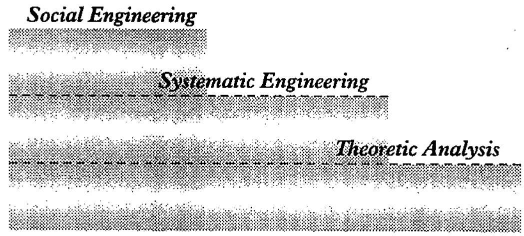

Fig.2. Multi-level Knowledge

to refill the vacancies that exit then. The renounce of the dilapidated hierarchical system in universities is good for the development of some young talents. But it also resulted in the lack of engineering experiences, which is extremely important for these young civil engineering professors. Further more, the teaching positions are not attractive to the engineers from industry. Nowadays, by means of information technology, they possess all kinds of information, just like their counterparts elsewhere in the world. But information could not become innovation, because they have no enough time to ponder on research and education. Some of them even have no interest in doing any innovation work on their cramming teaching methods.

University Curricula

In China, universities belong to different ministries such as Ministry of Construction, Ministry of Education, Ministry of Hydraulic and Ministry of Transportation, etc. Each ministry sets up its own requirement for uniformed curricula and textbook based on its demands. The undergraduate civil engineering courses were "Vertically" set up. There are no inter-connections amongst architecture, structural mechanics, and construction management even in Engineering structure courses, steel structure and reinforced concrete structure are totally independent. There is no any "lateral connections". Nevertheless in construction practice, any resolution relates to multi-disciplinary professions. If this character can not be reflected into our education consideration, it will not be possible for students to be trained in a comprehensive way.

Students

Since a small portion of teenagers could be selected to get into universities in China, we have qualified source of students. But they get used to oriental education philosophy that student must follow up their teachers and textbooks. They are interested in new way to learn, but prefer the cramming teaching methods for better records.

EXPECTATIONS

Students-centered

Our present education system is a uniform model in which students are trained in-group. Everything is arranged by educator, uniform standards are set up to all the students for evaluation. It is actually an educator-centered system. Less attention was paid to the individuality of students. However, the development of computer science and information technology provides us a possibility to lead an education revolution: collective education mode is changed to individualized education. Students may select their favorite education program according to their individuality, academic interest, and expectation. Some thing like Chinese old-style private school hundreds years ago, from there many great poets, novelists, scientist. And politicians had had been educated. At present, oriental cramming education must be changed. Edification education should be encouraged. Students also need to change their attitude from passive study to aggressive type. Professors should share their teaching time with students for discussion and to encourage students to present themselves.

Dynamic Organization of Faculties

In universities, education level can not be better if the team can not implement innovative researches in the same area. Based on the above mentioned characteristics of civil engineering discipline, an innovative effort has been conducted in the Department of Civil Engineering of Tsinghua University. Teaching and research divisions, which used to be the cell organizations, have gradually been smeared. Instead, a two dimensional network was set up (Fig. 3). Each faculty member functions as a node, to which other nodes connect, with his or her graduate assistants. Active nodes may have more connections with other nodes for cooperation. This network is supported by three functional sectors of the department. They are experimental center, computer center and ventures. In case of a big research project request more people, faculties (nodes) may come out of the two-dimensional plan to form a project oriented, multi layered and well-organized team. This kind of organization provide more cooperation of faculties from different discipline, provide equal competition opportunities to faculties regardless of their positions, it also provide more stimulation for innovation. The authors are convinced that it is only this way that would multi-disciplinary education be furnished by multi-disciplined faculties.

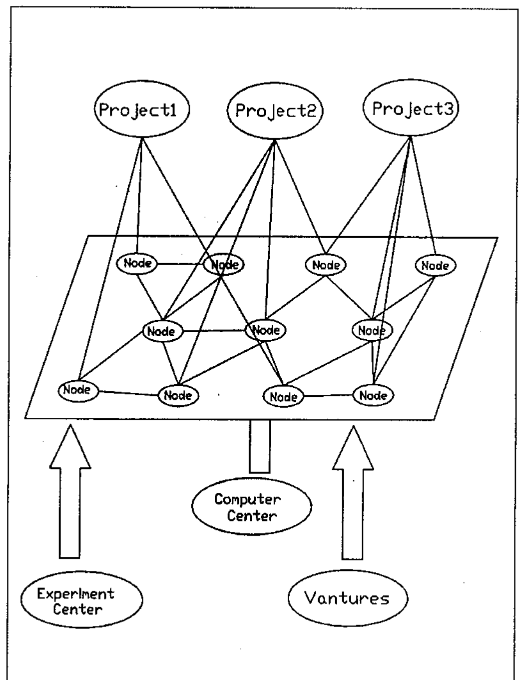

Fig.3. Dynamic Network of Organization

Open Education

There are two points for open education. Firstly, curricula should be interacted and opened to meet the requirement of construction industry. Innovative efforts should be made to re-structure a synthetically curricula in which three goals as mentioned above should be reached. Secondly, universities must try their best to connecting civil engineering education with construction practice. For years, the Department of Civil Engineering of Tsinghua University has been trying to cooperate with construction industry for construction practice training. An agreement was signed with Kvaerner Cleveland Bridge Co. Ltd., in which 8 students being dispatched to their construction site for 8 months each year to work as engineer assistant. Their graduate dissertation is completed by the direction of both university professors and site engineers. Their works were highly evaluated by the company as well as the university. Practice gives students more opportunities to train their abilities of originality and cooperation.

CONCLUSIONS

Based on the above discussion of civil engineering education in China, both hopes and crisis are in front of civil engineering educators. Three challenges, that is student-centered education, dynamics of education organization, and open education were pointed out in this paper to draw the attentions of educators, construction practitioners, industry leaders and legislators.

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El Salvador

Education and Accreditation in the Republic of El Salvador, Central America

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INTRODUCTION

El Salvador is a very unusual country. It is located in the small neck that joins North and South America. Its only coast borders the Pacific Ocean. It is shaped more or less like a rectangle, approximately 200 by 100 km by side. By land it borders Honduras and Guatemala. On the remaining side it is separated from Honduras and a tip of Nicaragua by a Gulf - named Fonseca - which is a very safe harbor where a major port is on the planning stage.

The population of El Salvador is estimated at six million. Because of massive immigration: legal and illegal (caused mostly by the civil war that lasted over 13 years, starting in the early 70's); the lack of employment opportunities; and a difficult political climate; there supposedly are one million Salvadorans living in the United States - the land of opportunity! These "immigrants" contribute to the economy of El Salvador, by sending dollars every month to their relatives remaining in El Salvador. These inputs are estimated to account for more than ten percent of the available income in the country...

There is an ongoing effort to industrialize and the old economy which was centered in agriculture is slowly being replaced. The main agricultural product has been coffee. This has been very successful, as the country physically is mountainous - the best coffees are those grown at high altitudes. There are large sugar cane plantations in the lowlands next to the ocean. Cotton and other crops are also cultivated.

Industry, mostly assembly type is growing through "free zones", which are free of import taxes for the components it requires. Apart from the assembly type industry, there are a number of industries which manufacture their products from raw materials. The products of the "transform" industries are exported on a global scale, competing with those of other countries. The high productivity and low labor costs of the Salvadoran workers, make El Salvador, a good prospect for investment by industry.

Since the conclusion of the civil war in 1992, with a peace accord between the government and the rebels, El Salvador has been struggling to maintain a peaceful country. However, this has not yet been accomplished. There are constant kidnaps - of members of so called "wealthy" families as well as executives - who are held for ransom; there are corruptive practices among many government officials; and there have been major scandals by embezzlements in financial institutions. The government is trying to remedy all these problems through strong enforcement of pertinent laws.

The above is a situation associated with the transition, from a country recovering from a long period of turmoil brought about by a civil war, which is now headed to establishing a law abiding modern democracy. Such transition takes considerable time, usually from one to two generations. Making the transition more difficult is the United States, which is pressuring the government to change its laws (both civil and criminal) to conform to those of the US. This change ignores the education, culture, standard of living, and many other factors that affect the people and the country. The US model is not appropriate nor enforceable.

EDUCATION

Education in El Salvador is under the control of the Ministry of Education. This is a cabinet position similar to that of the Secretary of Education in the US. There are public and private schools. The private schools are very expensive in relation to the average income of the population. Only a few can afford private schools. The private schools sponsored by the catholic church are less expensive and give an opportunity for students from poor families to attend. Public education, which is free, is mostly deficient, through the many obstacles in its path: lack of adequate facilities (infra-structure), poorly trained teaching staff; lack of proper texts and school supplies.

El Salvador has a social structure that is slowly changing. There is a large segment of the population on a marginal income. There is an upper class of less than five percent which is well off. A middle class of professionals is slowly developing. They comprise about 15% of the population.

Though education is considered essential for the development of the country, there does not appear that it is given high priority in the government developmental plans. This is not true, education is a most important part of the effort made by government in improving the country. The problem is so large, that any remediation efforts seem wanting. There is a need for a crash program. Just as the saying goes "Rome was not built in one day", the same can be said about education. One of the critical issues is that as education is not being given or received, there is a growing population that misses the opportunity that education offers. As we stand still, discussing and planning, time marches on and the affected population keeps increasing and growing. Aging does not stand still!

Poverty is a condition that must be eliminated. Education is a key link in the chain which helps to provide opportunity for employment and thus helps to eliminate poverty. There are many other social and health issues that need attention, but all of them require education as a base.

In El Salvador there are several components to the education system:

- pre-school
- basic or primary
- middle
- secondary
- vocational / technical
- normal (teacher training)
- higher education (university)
- adult (for those who never went to school and must learn basic skills: reading, writing, arithmetic)

All of them are being addressed within the limits of the government's budget. There is a growing awareness that educational needs of the country have to be solved to enable El Salvador to become a developed country. Financial institutions, foreign governments (through their financial organizations), foundations, and other sources of economic aid, are contributing to the educational efforts.

HIGHER EDUCATION

One of the areas that is receiving special attention is that of Higher Education. Aware of the need to have quality programs at the universities which will produce the needed professionals, the government has created a

"Commission for the Accreditation of the Academic Quality of Institutions of Higher Education (CdA)". It consists of seven members and appropriate support staff.

On December 28, 1995, a Higher Education Law was passed. One of its purposes being that of establishing a framework for higher education reform. It also set conditions to govern the creation and functioning of both private and public higher education institutions.

The Ministry of Education established a "System for Supervision and Improvement of the Quality of Higher Education", within the National Directorate of Higher Education. This is one of several Directorates, under the Minister, staffed with appropriate personnel, and, overseeing one or more of the components of the education system. Within the Directorate a "Council of Higher Education" was also established whose membership came from a broad spectrum of interested and affected publics: government, industry, professional associations, technical institutes, and universities. The Council is not only a policy recommending body but has broad powers, including that of closing institutions that did not comply with the educational requirements established by law.

The educational system has as sub-systems three major components: Qualification, Evaluation and Accreditation. The first two are mandatory for all institutions. The last one is to be voluntary.

Higher education (university/college level) was based and assigned to the National University of El Salvador. This was an autonomous institution that set its own goals and objectives. All programs at other institutions were to conform to, be equivalent in content to, and be approved by, the National University. It controlled all degrees granted or recognized in the country. Foreign credentials had to be approved by the National University before the holder of such credentials could be licensed to practice his/her profession. The National University was completely independent, self administered, and protected with zeal such autonomy. It was "sacred ground" in which the government did not dare step into. The law protected the university. Any changes in policy came from within the university itself.

A few private universities were created. They mostly dealt with a student population that could afford the expense of a private university. The National University had very small fees.

During the civil war period - 1972 to 1992 , the National University was taken over (invaded by the army) and closed by the government. It was occupied by the military. Previously and during the occupation the facilities were ransacked. To add to the problem an earthquake did irreparable damage to many of the structures. All these events caused an educational chaos. Students and professors - as well as other personnel - were left "homeless".

Some professors got together and founded a number of private universities to take care of the demand and need for higher education. The government licensed them to operate, but had no real control or standards to apply. The number of private universities grew in a disproportionate number.

The National University was re-opened after 1992 and has gone through a difficult period of being re-born and seeking "adulthood". Meanwhile some of the private universities attained a maturity and respectability - as well as educational competence - that they became the leaders in higher education. This status may appreciably change as the National University moves along in its path of re-construction.

The government was aware of the many problems in higher education, both internally in the institutions and the country, as well as the external ones, which changed the work environment for professionals, such as: globalization, free trade agreements, equivalency of credentials, registration or licensing of professionals, and several others. Efforts were made to address these and others which influenced many facets of education. Studies were commissioned and financial support - including consultants - was obtained. The

Law of Higher Education passed in 1995 gave a number of directions to be implemented and followed in subsequent years. Its main focus was in establishing systems that would be important in improving the quality of higher education offerings. The Law was not of a punitive character, it was meant to be constructive and leading to improvement.

QUALIFICATION AND EVALUATION

Statistical data on Higher Education was almost non-existent. The subsystem of qualification was created to obtain base data on what was present in the institutions. The qualification was in the form of an annual self-study done by the institution, answering certain quantified indicators or coefficients which covered the following areas:

- Quality Indicators (students, faculty, texts, computers)
- Infrastructure (various space allocations-academic, recreational)
- Cost (student fees)

In addition to the qualification data, which is a quantifiable number, an evaluation system was established which was on a two year cycle. The evaluation data - also coming from a self study - implemented the qualification data with the following criteria items:

- Institutional Mission
- Governance and institutional administration
- Faculty
- Careers and other programs
- Investigation (research) and Social Projection
- Educational Resources
- Financial Administration
- Physical Infra-structure
- Institutional Integrity

Over all there were over 50 criteria items to consider. The evaluation phase included a visit by a team of evaluators, followed by a process which concludes with an evaluation report including the findings - both positive and negative - and the decision by the National Directorate of Higher Education, signed by the Director, as to what changes, if any, the institution must make to comply with the requirements of the criteria. Time lines for compliance with each specific item are given.

The evaluation process is not adversary. The whole exercise is aimed at showing ways in which the academic quality can be improved. However, if it is determined that the institution is not able to comply with the requirements, it can be ordered to cease operations. Between 1997 and 1998, 49 institutions of higher education were evaluated. Of this total only 42 were allowed to continue functioning subject to their meeting the compliance findings communicated to them by the National Directorate of Higher Education.

The institutions that were evaluated are as follows:

• Public (State) Universities	2
• Private Universities	34
• Public (State) Technical Institutes	6
• Private Technical Institutes	2
• Specialized Institutes	5
• TOTAL	49

The total number of students in higher education does not seem to appreciably change, even though there is an increase in the population.

The distribution of students and faculty in broad numbers is **(students/faculty):**

• Universities	**112,000/6,600**
• Technical Institutes	**5,700/480**
• Specialized Institutes	**900/130**
• TOTAL	**118,600/7,210**

These numbers are approximate as they are taken from two different years. In the case of faculty it does not reflect full-time faculty. Many faculty hold appointments in two or more institutions. It is estimated that the numbers given above for faculty should be reduced by one third, to account for multiple appointments.

ACCREDITATION

Accreditation is the third component of the System for the Supervision and Improvement of the Academic Quality of Higher Education. There is no experience or background in the country for accreditation. It is a new concept which naturally had to overcome many biases and objections. There was a feeling that the autonomy and independence of the institutions was being eroded. However, reason prevailed regarding the need for a quality control mechanism. The institutions of higher education faced the challenge of having to show the publics they serve the quality of their offerings. Accreditation was the selected and accepted mode.

With the help of the Agency for International Development (AID), the Interamerican Development Bank (BID) and the strong interest and commitment from the government through the Ministry of Education, the accreditation element of the higher education system was developed. A consultant team from the United States was retained to design the accreditation system.

The project moved on through several stages. A Commission for the Accreditation of Institutions of Higher Education (CdA) was appointed on March 23, 2000 and took the oath of office, given by the Minister of Education on the 31st of May, 2000. The Commission has seven members on four year terms.

Support staff was employed and office space was given within the area of the Directorate of Higher Education. The CdA has been busy developing all the necessary documents that are required in order for it to operate. These include internal operating procedures and regulations. The accreditation process and the criteria; the time lines and many housekeeping details are being addressed.

The CdA has started from zero. However it has the advantage of being able to relate to other accrediting agencies which have functioned for many years in other countries. Regardless, care must be taken to relate any actions to the cultural and academic environment in El Salvador. The university "climate" is unique and different from that of other countries - even those in Central America - and much more so from the United States and European countries.

El Salvador chose to limit accreditation to institutional accreditation, and use the data from the Qualification and the Evaluation components as the basis for the voluntary accreditation system. The accreditation criteria to be used, the process, and other important details are being carefully designed and reviewed. Accreditation actions are not expected until 2001.

One of the major considerations for accreditation is that there is only institutional accreditation, and there is no provision made for program accreditation. The universities are organized on the French model. They have independent professional schools. Each school offers a professional curriculum. When a student enters the university he/she goes directly to a professional school. According to the system of higher education in El Salvador, a university must offer 5 careers (professional programs) to be considered a university, otherwise it is a technical or specialized institute.

One of the problems envisioned with institutional accreditation being the only available accreditation, is that of handling a university where one or more programs are not of sufficient quality to warrant accreditation. Will this mean that the institution will fail accreditation even though some of its programs are accreditable? This is one of several issues that the CdA will have to handle as the accreditation system goes into effect and experience in the accreditation process is obtained.

Accreditation has become recognized as a measure of quality in the academic world. Many accrediting agencies in countries with a well established accreditation system are offering to either accredit institutions or programs in other jurisdictions, or to provide consultancy visits to determine equivalency of institutions or programs to theirs. As countries develop their own accreditation systems, the possible conflict with foreign accrediting agencies may become a serious issue. The credibility and acceptance of the national accrediting agency over the external one, may cause legal as well as other problems.

ACCREDITATION IN CENTRAL AMERICA

Central America is constituted by six different countries - Belize, Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica. Though Panama appears geographically to be part of Central America, it is considered as a separate country. This concept comes from the Spanish colonial times when Panama was a part of the Vice-Kingdom based in Colombia, while the other Central American countries came under the Vice-Kingdom of Mexico.

Though each country has different characteristics, there have been many attempts to integrate Central America. Politically this was accomplished at one time, but did not succeed. A Central America Common Market flourished for a few years, in the late 1940's and early 50's, but did not last due to political changes in some countries (there was even a war between El Salvador and Honduras). At one time, in the mid 1800's an attempt was made to create a United States of Central America, following the example of the United States, Mexico and Brazil. A President was elected and took office. However he was deposed and eventually shot. The federation came apart.

As the area and the countries move towards the next century, the governments explore areas of compatability for which they can come together. Free trade and common market agreements have been subscribed. A Central American Parliament - somewhat similar to the European Council - with its location rotating every few years among the participating countries deals with common issues.

The practice of a profession in each country was controlled by the National University which had the authority to recognize degrees and diplomas issued by other universities. Usually the recognition and acceptance of foreign degrees obtained by citizens of the Central American countries, in foreign countries was not overly complicated. The recognition of foreign degrees by non-citizens was and is a more complicated process, which in some cases involves examinations as well as other proofs of professional competence.

In 1948, the Central American University Higher Council (CSUCA) was created. It involved the 13 main State Universities in Central America and Panama. One of its main objectives was that of cooperating in furthering the integration and sustainable development in Central America through academic cooperation in the region.

There were several agreements covering professional practice and recognition of university studies, 1962, 1974, 1993. This last one named the "Guatemala Protocol" was signed by the Presidents of the Central American countries, but was only ratified by El Salvador, Guatemala, Honduras, and Costa Rica. The agreement recognized the equivalency of the university studies among the recognized universities in each country as well as the rights to professional practice for native born citizens of any Central American country.

As a result of the XLVI Meeting of CSUCA held in Costa Rica, in June, 1995, a Committee was created to develop "A Central American System of Evaluation and Accreditation of Higher Education (SICEVAES)". By 1998 the Committee had published two very comprehensive Guides for Self Evaluation, one at the Institutional level and one for Academic Programs.

The "Permanent Secretariat for the Central American Economic Integration (SIECA)" developed a "Proposed Regulation for Service Commerce" this included Professional Services. These efforts were generated as a result of the free trade agreements (GATT) and the several regional agreements involving different countries.

The efforts to establish quality control systems to improve the academic quality of higher education offerings have top priority in the agendas of the governments, ministries of education, the professional associations and the universities. Obtaining recognition for the graduates of the professional schools in other jurisdictions so that they can move freely to practice their profession is a goal worth pursuing and reaching in this global economy and market place. The quality of the system itself must be beyond criticism and has to be controlled and accepted. Different systems must be submitted for equivalency among the various jurisdictions to insure compatibility and acceptance.

As each country moves to establish its own quality accreditation system, there will be a need for regional cooperation and coordination of efforts. In Central America the work of SICEVAES and CSUCA will play an important role in this integration, respecting the individual countries rights, responsibilities, and systems. A good example of this coordination and cooperation can be found in the European Community where the engineering profession has reached a professional practice and university education equivalency through the FEANI organization (the European Federation of National Engineering Associations). The European Engineer designation is a "passport" for professional practice accepted across the countries of the European Community.

The work of the Commission for Accreditation of the Academic Quality of Institutions of Higher Education (CdA) of El Salvador is poised and ready to meet the challenge of creating the environment that will aid and assist the universities to improve and meet the highest demand for quality in their offerings, and insure the nation of highly qualified professionals to answer both personal and market expectations objectives of higher education.

It is noteworthy to learn that "registration" or "licensing" is not universal in the Central America countries. The issue is very complex and subject to many objections by interested parties who see this as an infringement on their rights and status - almost the same can be said for "mandatory" Continuing Education as part of proof of competency on a periodic time frame. The many professions that would have registration because of their involvement with the life, health, and welfare of the public they serve, are cognizant of the need for some sort of registration or licensing. A profession is mostly defined as being based on specialized knowledge attained at a higher education level. Thus the prudent approach is to insure the quality of the professional education (accreditation being an acceptable mode) before considering licensing or registration. This is the approach being followed in El Salvador, though there is an ongoing discussion by many groups on registration, it is an important topic.

Mexico

Engineering in the Knowledge Society

Diodoro Guerra Rodriquez, President, UMAI (Mexico)

Reflections about importance of engineering in the knowledge society realized by the Union Mexicana de Asociaciones de Ingenieros (Mexican Union of Engineers Associations) are the core of this paper which has been delivered to this Asamblea General de la Federación Mundial de Organizaciones de Ingeniería (General Assembly of the World Federation of Engineering).

In this briefing we analyze the impact of exogenous and indigenous in the training of engineers considering the engineering role facing the cultural and economic globalization and the advancement of knowledge and technology. Also we stress its influence in the development of countries and we conclude with a set of proposals oriented to impulse both training and professional work of engineers.

THE KNOWLEDGE SOCIETY: WORLD PARADIGM

Today there are many ideas and concepts with the aim to explain what is happening in the world: there are hypotheses to discover the world transformations and the present society, but also to anticipate the future path of the next millennium.

It is clear that we are facing a modification of our life, since the elements that determine transformations are related, so economic globalization is burst by scientific advancement and technological development, with the purpose to build a society in which information is vital.

There are implications between education, science and technology; however, in the global social scale, start a new relations system in society, economics and technology.

Under the knowledge society paradigm, human resources are fundamental including of course professionals in the field of engineering, it is important to stress that a great part of the scientific advancement and applications world over, are possible by the work of scientist and engineers.

Prospective in the Training of Engineers

At world level looks like if it is possible consider two factors which deal with engineers training. One is endogenous since it concern with adjustments in the operation of schools and universities such as curricula, teaching and learning methodologies, role of graduate studies and the controversy specialization-generalization.

The second is related basically with professional engineering practice, and the way on which the above mentioned global conception alter engineers profile, so the accreditation and certification institutions are taking more relevance for the operation of universities in the way to realize adjustments in curricula (partial or total) because the new knowledge which has to be with engineering.

ENGINEERING AND ITS ROLE IN THE DEVELOPMENT

Engineering is no doubt, a human activity that has been taking part in the welfare of population. The world in which we live is due, in part, as an engineering product. If we speak of basic elements of satisfaction for social needs: food, housing, health, education, energy, information and communication, to cite some, in all of them engineering are vital.

In our countries, engineering is so extent that performance of professionals in such field is highly (efficient) efficacious in many activities so distinctive as projects design to build ports, highways and huge engineering complexes, for one side, or genetic engineering and applications, or molecular matter structure handling, all this through planification and management of enterprises oriented to research and development of environmental and urban welfare.

Accordingly with above, engineering is strongly linked with each project's nation and support productive and service structures which is vital for social and economical development.

In spite of the importance of tradition and results in engineering, international references show significant differences between countries, for instance in Mexico there are 333 graduate scientists and engineers for each 100,000 people between ages of 25 to 34 and in the OECD countries, this figure is higher. The same is if we consider the number of scientists and engineers working in research and applied development, we have 1/10 of the number of those working in USA or Canada, which are two of our more important trade partners.

IMPORTANCE OF ENGINEERING FOR DEVELOPMENT AND WELFARE

If we share the idea that engineers are essential resource in any development proposal, we should have in mind that those students in engineering schools must have a solid core of multidisciplinary instruction, including technological and humanistic, and considering the concept of "engineering of Knowledge" which deals with cognition aspect in the way in which is conceive of, built and transmit, and above all, the way is follow up.

Engineering professionals should have in mind toward next century's development field, working in new technologies which deal in reduction of waste of natural resources or any environmental aggression, this means sustainable development; item more, work with technologies which allow increase productivity level in energy, materials, food, mining, manufacture, information technologies, ... all of them vital for national welfare.

We must say that in the process of technological change in all engineering fields they have a first order role: history of technological revolutions, show a joint evolution between top level industries and knowledge creation. As a matter of fact they show the role engineers have been played in the process of the industry's technological transformation besides of their important contribution to creation of knowledge which promote change of paradigms and ways of economic activity administration.

SOME PROPOSALS FOR ENGINEERING STRENGTH AND BURST COUNTRY'S DEVELOPMENT

Next we present three sets of proposals. The first set about engineering education, the second set are oriented to help engineer's performance and work, and the third set establish series of strategies with the aim to obtain a greater participation of engineering in the country's development.

Education in Engineering

Planning. It is important strength the participation of engineers in engineering teaching planning for the purpose of careers offer design and professional profiles.

Teaching Strength. Training for future engineers require flexibility with scientific basis and also provide generic and multiplevalued capacities.

Increase Academic Level. Training engineers requires comply with competitive conditions inherent in the actual world, for that reason it is recommended to increase their academic level and go forward to specialization and graduate level.

Quality. Education in engineering must look for processes oriented to search quality standards support by projects and actions which will warrant graduate certification and curriculum accreditation as establish by international standards.

Life Long learning. This concept, strategically valid in all education areas, must be encouraged in engineering because requirements impose by advance and follow up knowledge.

Professional Performance

Professional Performance. It is necessary promote integral studies about the relation between training-labour performance for which it is desirable analyze from training systems through curriculum and study programs in all education levels and also ample proof of capabilities, abilities and knowledge acquire in the academy.

Accreditation of Professionals. It is a must, permanent accreditation of the quality of engineers work through evaluation of levels of performance and determine needs of follow up training and specialization and also professional development. Through professional committees or groups must be promoting the active participation in national or international organisms for accreditation and certification of engineering teaching.

Research Impulse. Scientific and technological research must be burst in order to impulse creativity and performance of engineers, invite graduates of educational institutions, create employment opportunities as a consequence of the professional influence and look for the possibilities for develop technology in the country.

Applied Research and Technological Management. It is a must, promote investment in share risk projects between educational institutions, enterprises and social sectors with engineers participation.

Industrial Technology. Through engineers capacities, knowledge, creativity they should introduce innovations to impulse technological modernization of productive processes.

New Technologies. It is a must, promote engineers participation in integrate process of knowledge creation and its applications in the field of so called new technologies with the premise of rational exploitation of ecosystems.

Reward and Encourages. It is desirable establish rewards for engineers professionals engaged into development of technological creativity and innovation with the participation of all social sectors.

National Development

Economy and Productivity. Academy, colleges and professional associations, economic sectors and society in general, must develop conditions to obtain greater engineers participation in the economic processes with the aim to introduce technologies to allow productive sectors rise productivity and competitiveness.

Infrastructure. Engineers creative potential and knowledge must be utilized for continuing impulse of the development of basic infrastructure which at the end help the development of each nation.

Rural Development. There are two paths for rural development, food production and social underdevelopment accumulation, and is in agricultural land where there exist some of the greatest challenges for knowledge application, so for this reason it is necessary develop concrete actions for impulse productivity and easy access to new alternatives for agricultural productions.

Urban Development. For urban development planning engineers participation must be encouraged whom will propose solutions to environmental contamination problems, housing shortage, insufficient basic service (water, transport, drainage...) insalubrious places, and also for co-ordinate engineering areas which for the next century must solve problems related with lack of space and energy.

Human and Social Development. It is of the most importance the engineers' participation in the improvement of human factors development. Social compromise they have is to strength aspects related with the education, increase of the Gross Domestic Product and improvement of conditions of social health.

Environmental Sustaining. It must be created in professionals and associations a sense of environmental protection supported by highest level of knowledge and fine capacity of learning which will impulse the process of integral and sustainable development.

National Agreement for Scientific and Technological Development. Engineers' participation must be encouraged for define and develop national agreement for technological development as a framework for national, regional, sector, or institutional planification.

Prospective Vision

Prospective Studies. Prospective analysis and realization of studies for determine engineers requirements in a 15 years period, so as professional profiles and professional qualification standards and design strategies for strength linkage between engineering developments and country requirements.

New Knowledge Areas. Participate in the new knowledge areas which are developing in the world, promote and support engineering studies according to scientific and technological advances of our time.

Technology for Natural Resources Management. Promote advice from engineering associations for obtain satellite data which must be use for improve management and use of natural resources.

Reflections put in writing above are related for the Mexican case only, taking considerations of Mexican engineer's characteristics and potentialities, as members of UMAI, but it is important establish that an integration factor with all these proposals take place in the frame of a linkage between academy, engineers associations and societies, and also all this, together with the productive sector in close relation with society as a whole.

Truly in this strategy is particularly important to look for collaboration with engineering international organizations such as UPADI and FMOI.

All this with support of the new information technologies, data base, engineering networks which allow promotion of knowledge exchange, and technical experiences between groups of engineers of distinct countries, this would be the final proposal coming from UMAI, our profession is no doubt, responsible of new communication technologies; let us use them for interrelations and feedback our union organization work and our professional performance for the benefit of our countries development.

Germany

Suggestions for the Basic Knowledge of Engineering Study at University Level

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Member of the WFEO Committee on Education and Training

HISTORY OF INNOVATION AND INDUSTRIALISATION

Kondratiew (1892–1930) was the most famous scientist of political economics in Russia. He was imprisoned in Moscow and later murdered on the orders of Stalin. Kondratiew developed a theory about the economic and technical cycles, to say better it is innovation cycles. The frequences last approximately 40 years and the amplitudes swings between innovationbooms and regeneration.

The industrialization began in England.

This model is transferable to biological and sociological processes, that includes the processes in nature all together and the life of men. We should not think simply in terms of high and low, but in terms of human activity and regeneration. If I may speak analogically the natural processes.

The natural processes in activity and regeneration replaced the drama between highs and lows. This cycle will continue to develop in spite of increasing globalization.

In future the sociological and psychological problems will be one of the biggest in the world. It may be the 7th Kondratiew *(Fig. 1)*.

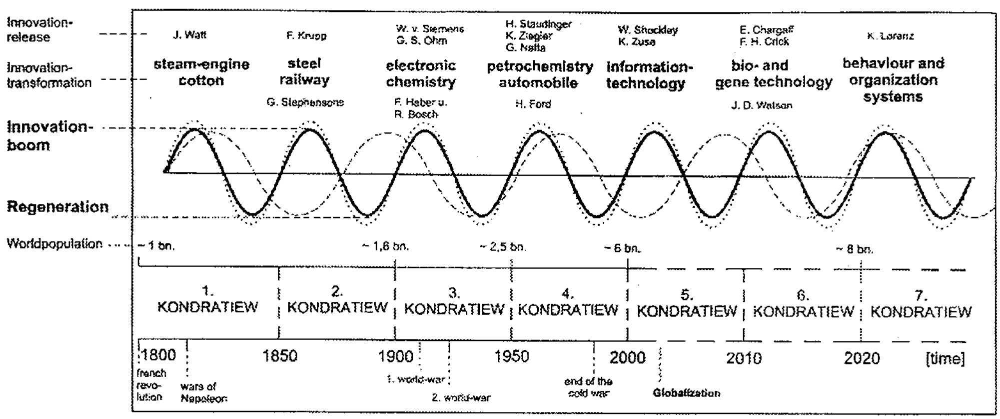


Fig.1. Rhytmical sequences of innovations in the course of the population growth and industrial

nach L. A. Nefodow

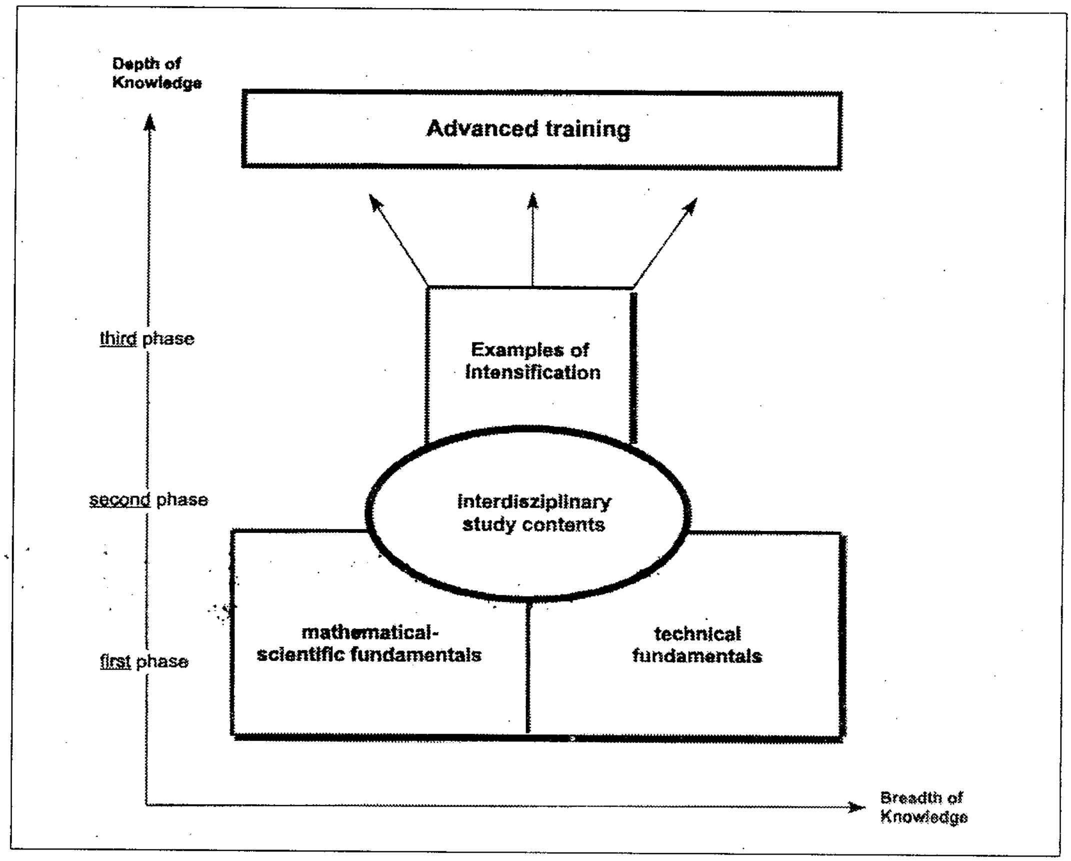
THE ORGANIZATION OF ENGINEERING STUDIES INTO THREE PHASES *(Fig. 2)*

We need engineers who can think in terms of international, technical, social and financial relationships in addition to possessing expert knowledge. The world's engineers should have the same level of knowledge but different specializations.

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.

Fig.2. Education concept for engineers



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 and inerdisciplinary thinking *(Fig. 3)*.

Complex System ↑ Increase of density of matter ↑ Increase of quantity and quality

	All knowledge written language	Economic and technical knowledge	Biological reproduction	Biological structural system
Text	Books Libaries	Programs Data files	DNA (genetic information)	Organism (complex cell structures)
Sen-tence	Speech and writing	Programing language	Gene (part of DNA)	Cell structures (Organelles: mito-chondria,chloroplastes)
Word	Variable length	Instruction word Data	Structural gene (part of a gene)	Biopolymers natural rubber, nucleic acids, ATP, proteins, carbohydrates, fats
Syl-lables	Variable length Combinations of 36 characters Infinitely many possibilities	Unitary length 8 Characters (1 byte) $2^8 = 256$ possibilities e.g. 00110101 AABBABAB	Unitary length 3 characters (triplet) $4^3 = 64$ possibilities ACG, ACC, CGT etc. AA_1, AA_2, AA_3	Biomonomers:isoprene, amino bases, simple sugars, phosphoric acis, amino acids, porphyrin
Code	36 characters 26 letter A -Z 10 digits 0 - 9 special characters	2 characters (binary system) e.g. A and B or 0 and 1	4 characters (amino bases) A T C G	Primordial building blocks CH_4; NH_3; H_2S; H_2O; CO_2 Elements H; C; N; O; P; S
Symbols and Moduls				

Complex Systems ↑ Increase of internal energy ↑ Decrease of entropy

Fig.3. Analogies between the Alphabet, the binary System and Bio-Information

Czech Republic

The Education for Total Quality Management at VSB-TU Ostrava

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ABSTRACT: The Total Quality Management is one of the advanced approaches to the organisation´s management systems now. The most of Czech companies are in bad need of skilled specialists for implementing such systems. The Department of Quality Management at VSB-TU Ostrava offers the engineering study in such branch.

The paper describes essential features of this branch of study and curricula derived from Leonardo da Vinci research project. The linkage between the engineering education and a personnel certification is discussed too. An example from Ostrava is enclosed.

KEYWORDS: *Total Quality Management—EFQM Excellence Model—education—personnel certification*

Present day trends of the management systems development in industrial plants and services indicate the key area of management for the start of the next century: the so called Total Quality Management (TQM).

This management approach is based on these common principles:

a) customer focus,
b) supplier partnership development,
c) people development and involvement,
d) management by processes and facts,
e) results orientation,
f) leadership and constancy of purpose
g) continuous learning, innovation and improvement,
h) public responsibility.

To support these principles The European Foundation for Quality Management (EFQM) developed and in 1999 improved the very important model, the so called "The EFQM Excellence Model".

An efficient implementation of these principles and successful introducing of the EFQM Excellence Model closely depends on knowledge and skills of managers and technicians. The "people quality" represents a vital condition for TQM implementation within all types of the industrial companies. Unfortunately, a level of these skills and knowledge is insufficient in the meantime and the most of Czech companies are in a bad need of specialists for building, maintenance and improvement of TQM systems. This shortage can be overcome by special and systematic education at universities and on site too. The Department of Quality Management at VSB-Technical University Ostrava has been developing this kind of education for some years.

As for the engineering education for TQM, the range and level of it are very different from one university to another.

Unfortunately there are still some branches of engineering studies without any subject regarding to TQM at Czech universities on the one hand, but some advanced curricula in this field already exists on the other hand. We can say the most worked out curricula are offered by The Department of Quality Management at VSB-Technical University Ostrava. This department covers a unique branch of study "Quality Management". It reflected an important proposal of the European Organisation for Quality (EOQ) dealing with title quality engineer as a person who is able to develop, to implement, to assess and to maintain an appropriate quality system for industries, services, public sector and other organisations.

The curricula of this branch of study was improved two years ago as a principal result of an international research project Leonardo da Vinci titled "The University - Enterprise Partnership for TQM". The solving of this project (with partners from Great Britain, Belgium, Finland, The Netherlands, etc.) included a research of the companies needs within the total quality management also. The outputs of this research served as an important basis for our curricula improvement.

The branch of study "Quality Management" has two main stages now. The first stage takes four terms and it includes common subjects as mathematics, physics, chemistry etc. The second stage takes six terms and offers special courses or subjects as:

- Metrology and Testing
- Theory of Probability and Statistics
- Quality Systems
- Quality and Human Factor
- Environmental Protection
- Quality Planning
- Special Statistical Methods
- Value Engineering
- Design of Experiments
- Theory of Econometrics
- Logistics
- Reliability
- Environmental and Safety Management Systems
- Computer Aided Quality
- Production and Conformity Assessment
- Management of Change
- Marketing
- Testing and Certification
- Process Management
- ...and many other voluntary courses.

The graduates should:

- master quality systems principles,
- apply requirements of ISO 9000 and 14 000 and EN 45 000, QS 9000, AQAP and other systems standards in practice,
- use all modern tools of Quality Management within every phase of technical life of products or services, including statistical methods,
- access the process capability and variability,
- manage teams for quality improvement,
- act as a Management representative for quality,
- perform internal and client's quality audits,
- develop and introduce various methods and procedures for the support of quality,
- use software for computer aided quality etc.

We are aware of the fact that we must introduce other subjects such as Risk Management, Product Liability Assurance, etc. so that this kind of engineering education might be a serious education towards to the Integrated Management Systems.

The mentioned branch of study has 40 graduates or so till now. This number of graduates cannot eliminate a great shortage of skilled specialists in Czech companies of course. We suppose that all educational systems must be created with regards to the latest trends:

a) many companies have been implementing a philosophy of organization learning for some years,

b) a large quantity of professionals in Europe are more mobile now and they can work in various countries,

c) a many engineering education at universities prefers theoretical knowledge only and practical skills are missing.

Therefore, another form of the education for quality, which is offered by our department, are three - term postgraduates studies "Quality Management". This type of study corresponds with EOQ Harmonised Scheme...requirements for the so called "EOQ Quality Managers". It is considered as a suitable preparation for personnel certification. The Department of Quality Management VSB-TU Ostrava with co-operation with the House of Technology Ostrava founded a certification body for personnel certification within quality management systems.

The personnel certification is a form of a third party assessment of skills for doing some managerial jobs. The Department of Quality Management at VSB-TU Ostrava with co-operation and finance support of The House of Technology Ostrava established a certification body for this kind of certification four years ago. This certification body is accreditated by the Czech Institute for Accreditation (this is a national accreditation body) for personnel certification of these functions:

- quality manager
- quality professional
- quality auditor
- standardisation manager
- quality statistician
- director of testing laboratory
- quality manager at testing laboratory
- head of testing laboratory
- technician of testing laboratory
- EMS manager
- EMS auditor

More than 190 specialists from the Czech and Slovak Republic have taken use services of this certification body since 1996.

We suppose that the number of certified people is still limited by the fact that personnel certification is fully voluntary in the field of TQM. It is used as a tool of human resources management very seldom in Czech organisations nowadays. In spite of this present experience, we consider a personnel certification as an excellent approach of skills assessment for the next century.

The TQM will be certainly an unseparable component in a process of deep changing of our society. And the EFQM Excellence Model will influence the environment of our organizations very deeply. We are fully aware of the fact that competent education for TQM influences significantly not only the company culture but also it is a determining standard of living condition and criterion within the whole society.

The activities mentioned above could be understood as a small contribution of our department for people´s knowledge development towards TQM principles.

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