ANNUAL 2004
OF THE CROATIAN ACADEMY
OF ENGINEERING

CROATIAN ACADEMY OF ENGINEERING

Annu. Croat. Acad. Eng. ISSN 1332-3482

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Editor-in-Chief
Zlatko Kniewald

Zagreb, 2004

Published by:
Croatian Academy of Engineering
Kačićeva 28, 10000 Zagreb, Croatia

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ISSN 1332-3482
Annual 2004 of the Croatian Academy of Engineering
Annu. Croat. Acad. Eng.

Printed by:
ITG, Zagreb

Circullation
500

Foreword

Dear Reader,

The Croatian Academy of Engineering is especially glad to welcome you to examine the «Annual 2004 of the Croatian Academy of Engineering», hoping that you will find here a lot of interesting and mostly new information. At this moment we can say that, in the 12th year of our existence, we are a rather young institution, but with the strong orientation and desire to be an active partner to the Croatian Government, industry as well as to the educational system and all international institutions and individuals.

Besides lot of recent information at our website, we would also like to present some up-to-date new information about the HATZ efforts to be present in the ongoing «Bologna Declaration» procedures. Therefore, the first part of the «Annual» comprises the discussions held during the Colloquium «Current Approaches to the Education of Engineers», which took place on February 27, 2004, the same day as the Annual Assembly of the HATZ. We hope that you will find this part of «Annual» to be very informative and interesting. Considering the fact that the first part consists of the communications of our members and is not an official position of the Academy itself, we are open for all your possible comments and discussion on the subject. However, we are fully aware that the engineering education is one of the crucial points in the future higher education in Croatia, because this, at the same time, is a prerequisite of the future industrial modernization.

The second part of the «Annual» is also a kind of novelty, because each year we will inform you about the up-to-date status of all categories of membership and the names of the members of the Governing Board, the Presidency and all Departments, Standing Committees and Centers of the Academy. We would like to inform you that the members of the Academy, aside from their rich scientific and educational experience and international recognition, are also participating in the activities of the Government of the Republic of Croatia and the Croatian Parliament as ministers and state officials, ambassadors, parliamentary representatives. Our members are also directors of the state institutions, members of the Croatian Academy of Sciences and Arts, deans of the faculties, rectors of the universities, experts of the UN and the EU, members of the international bodies, laureates of domestic and international awards for scientific and professional achievements... and it would take too much time and space to mention all duties and functions that our members are or were engaged in.

Beside this, we are particularly proud that we have been welcomed as a Member Academy to the International Council of Academies of Engineering and Technological Sciences (CAETS) at the Beijing Meeting 2000, and that, starting from January 1, 2005, we are to become an Associate Member Academy of the European Council of Applied Sciences and Engineering (Euro-CASE).

We are particularly grateful to our Supporting Members for providing their financial support that helps us realize our annual programs, but also for their awareness that among the HATZ members they can find internationally recognized experts to solve any problem related to the production, monitoring or technology and *know-how* transfer. In the future we shall make further efforts to realize the closer relations with the supporting members, but also to promote their participation in all contacts that our Academy is engaged in abroad. Serving the Academy, we are serving the better future of Croatia.

Zlatko Kniewald
President of the Croatian Academy of Engineering

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Part I

Current Approaches
to
the Education of Engineers

Problems Enforcing the Bologna Declaration

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Abstract

In this presentation a short review on the aspect of the Bologna Declaration is given. Some problems which can arise during the implementation are described and in particular those originating from the changes existing structures of educational programmes for engineering. Some of these problems may be specific for different countries depending upon the particular educational system. The problems may even differ from one progamme to the other.

Introduction

No other international or bilateral agreement before has ever influenced universities in as many countries as much as the Bologna Declaration. In many countries in Europe some objectives of this political agreement between governments did not receive the full support their universities. However, industry was and is very much interested in restructuring of the traditional engineering programmes for various reasons as there are shorter study time, more practice oriented graduates, mobility of students and engineers etc. In fact the consequences of such re-structuring are manifold leading to a change of paradigms which sometimes could not be foreseen.

Over centuries universities were developing very independently and so were the various faculties and curricula. The quality was very much defined by the teachers and most of the students were primarily interested learning as much as possible in order to increase their knowledge and skills in the scientific or technical field of their choice. They also attended lectures of professors of high reputation in a different discipline and registered at universities abroad where these professors were teaching. We still find this approach at students of music and art who want to get to a high level of their skills in order to have a promising future. In most other fields

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and, in particular in science and technology I sometimes get the impression that an increasing number of the students study in order to get a degree as fast as possible which very often is recognized for employment by industry and governmental institutions without sufficiently checking the quality of the graduate.

Variety of European Programmes

The European universities were based on the freedom of research and teaching, however, without too much interference or involvement by the government. Engineering programmes evolved very much individually and organically within geographical and/or political units, (e.g. Skandinavia, Austro-Hungarian Monarchy, COMECON States etc.). As a consequence, of course, this lead to a confusing variety of systems and degrees within Europe (see *Table 1* and *2,* respectively).

Table 1. Some European degrees in engineering (Hernaut, 1991)

Akademiingeniør Bachelor of Arts BEng BSc Civilingeniør Civilingenjör Diplom-Ingenieur Diplom-Ingenieur ETH	Diplom-Ingenieur (FH) Diplomi-Insinöör Doktor-Ingenieur Dottore in Ingegneria Engenheiro Europa-Ingenieur Ingenieur (grad.) Ingeniør	Insinööri Ingénieur civil Ingénieur diplomé Ingénieur industriel Ingénieur technicien Master of Arts MEng MSc Okleveles mérnök	Okleveles üzem-mérnök Sivilingeniør Teknikfræðingur Teknikumingeniør Verkfræðingur etc.

In *Table 2* I tried to classify and group engineering educational programmes in Europe into 4 major groups which differ more or less from each other:

It can be seen that the average time until graduation as a Diploma Engineer from universities is 5 years. Exceptions are the “Anglo-American” system, where the Master degree would be the equivalent to the „Dipl.-Ing.“ in the German system as well as to the “French” system where for the Diploma 5 years are foreseen and another year for the “Magister” on top. Some programmes also introduce an intermediate level similar to the Bachelor in the “Anglo-American” structure.

In the past only in a relatively small number of countries in Europe had engineering programmes which were structured similar to those in the “Anglo-American” system.

Recognition of programmes of universities from different countries was mostly on a bilateral basis. Some years ago accreditation was more or less unknown in most of the European states or had a different meaning. In the past as mentioned above the programmes were approved by the government or professional organizations within the respective country. Mutual recognitions between countries, universities and/or programmes were mostly defined in bilateral agreements. This was and still is the procedure applied in many countries. In recent years, however, also in Europe accreditation became more and more important.

Table 2: European Programme Structures before restructering according to the Bologna Declaration

1. “Anglo-American” System
   Bachelor (3-4 yrs) ⇒ Master (1-2 yrs) ⇒ PhD
2. “German” System
   Diploma Engineer (4.5-5 yrs) ⇒ PhD (~3 yrs)
3. “Modified German” System
   Diploma Engineer (4.5-5 yrs) ⇒ Master (1-2yrs) ⇒ PhD (~3 yrs)
4. “French” System
   Baccalauréat (degree after lycee) ⇒ Diplôme Universitaire de Technologie (2 yrs) ⇒
   Diplôme d'Etudes Universitaires Générales (2yrs) ⇒
   Maitrise Universitaire (2yrs) ⇒
   Diplôme d'Ingénieur (1yr)
5. “Old Russian” System
   Diploma Engineer (5 yrs) ⇒ Dr. univ. ⇒ candidate of academy ⇒ doctor of academy
6. “New Russian” System
   Bachelor (4 yrs) ⇒ Diploma Engineer (1 yr) ⇒ Magister (1 yr)

However, due to the fast changes in technology and globalisation an adjustment of all these versatile systems in Europe became necessary. Also changes of the working place of engineers (Wick 1998) have to be taken into account considering modern educational systems for engineers in Europe. (see *Table 3*).

Table 3. The changes (Wick, 1998)

Workplace	Old	New
The Work	Done by individuals within a department	Done by teams across departments and functions
Education	Finite	Continuous learning
Job Skills	Mostly static	Always changing
Career advancement	The career ladder	Multiple strategies
Worker expectations	*Security*	Personal growth
Career management	Company directed	Individually owned and shared

The unsatisfying situation concerning the existing programmes and their transparency became more and more obvious. In particular in the European Union the pressure for a reform of the existing programmes increased over the time leading to the Bologna declaration.

Bologna Declaration

The Bologna Process started with the Sorbonne Declaration in May 1998. The Bologna Declaration itself "…….. is a pledge by 29 countries to reform the structures of their higher education systems in a convergent way".

It was signed by representatives from 29 European governments in May 1999.

This process is a voluntary rapprochement of European higher education systems, and not a binding set of agreements. It leaves it to the individual states to match the implementation with national conditions, rather than limiting it to the smallest common denominator. It is believed that due to the international trend towards "competition for students" only a true European university will be able to continue to exist. I, personnally, have my doubts that "unification" of the system helps to attract more students to a particular university. I still believe that the quality of programmes and lecturers are the most important parameters for attracting students who want to get the best education possible. In particular for educational programmes in engineering the feedback concerning the quality of a particular programme and the graduates, however, can not be the number of students but the response from industry employing them. Unfortunately, this evaluation is delayed by at least 7 to 10 years after implementation of a new programme.

The Bologna Declaration stands out against similar declarations without any binding force because of its clear objectives and the schedule of the implementation. The implementation should be completed until 2010.

Some of the specified objectives are:

- the adoption of a common framework of readable and comparable degrees, "also through the implementation of the Diploma Supplement";
- the introduction of undergraduate and postgraduate levels in all countries, with first degrees not shorter than 3 years and relevant to the labor market
- ECTS-compatible credit systems also covering lifelong learning activities;
- a European dimension in quality assurance, with comparable criteria and methods
- the elimination of remaining obstacles to the free mobility of students (as well as trainees and graduates) and teachers (as well as researchers and higher education administrators).

These objectives are reasonable and logic. However, the problems of course arise in particular with respect to the first professional degrees and the undergraduate and postgraduate level or in other words the Bachelor – Master structure (B-M structure) of the programmes. This objective turned out to be the most controversial objective of the Bologna declaration.

Introduction of Undergraduate and Postgraduate Levels

As could be seen from *Table 2* a great deal of the programmes in Europe provides the first professional engineering degree after a 4.5 or 5 years programme.

In *Table 4* the adoption of the Bachelor-Master structure (B-M structure) is shown as it was in 2003. Many universities of these countries, however, face many problems verifying the implementation.

The adoption of the B-M structure was and is a problem at many universities. Restructuring can not be just a re-shuffling and a re-distribution of lectures of within a programme without adaptation of the total programme. Unfortunately, this is sometimes ignored in order to fulfil formally the requirements for implementation of the BS-MS structure as fast as possible together with a minimum effort. Then the didactic and educational aspects are neglected.

Several universities install the B-S structure in parallel to the former "diploma engineer" scheme (4.5 – 5 years). This means additional costs and different structures of the programmes.

Table 4: Adoption of the Bachelor – Master Structure *(Source: TRENDS II Report)*

Traditional:	**Established**:	**Consolidated**:	**Newly introduced:**	**Under discussion:**
United Kingdom, Ireland, Malta	Iceland, Sweden, Norway, Denmark, Latvia, Lithuania, Estonia, Turkey	Czech Republic, Slovak Republic, Finland, Bulgaria, Poland, Cyprus	Italy Germany Austria Switzerland Liechtenstein Belgium (Flanders) France Netherlands, Spain Hungary	Belgium (Wallonia) Croatia Greece Portugal

Many of the "old" programmes are structured for education of future engineers in research and development. However, only a limited number of engineers graduated from a university will work in research and development. The others and it is the majority will be employed in positions concerned with production and management.

In the United States and Canada the situation is quite different since a large majority of the graduates leave the university as Bachelors and do not continue for a Master degree. In many states in Europe, however, it this is not the case. Not too long ago in a discussion the successful implementation of the B-S structure at a university of high reputation in Europe was reported. However, the question how many of the graduated Bachelors continued for the Master degree was answered that an extremely high number of the Bachelors continued their study in a Master programme. This does not meet the requirements of industry who is interested in young engineers who may use their skilles in practice as early as possible. Under these circumstances it is hardly understood why a transition from the 5 years structure to a 3 +2 years structure is worth the effort and costs.

I believe that the only way to change this situation is to provide strict entrance examinations and a limited number of students permitted to continue with Master programmes. The other possibility would be that the industry pays salaries which are attractive enough for Bachelors to leave the university and to start their industry carrier. In some countries the first possibility must excluded since according to the respective laws and regulations each student who graduated from one programe as a Bachelor is entitled to continue his studies with a Master programme. The other way of higher salaries is not very welcomed by industry mostly because of economical reasons. As a consequence of globalisation engineers may be employed for lower salaries from low income countries when the immigration regulations permit or the production may be transferred to these countries.

Besides of the difficulties implementing the new structure described above further problems can arise depending on the system of the engineering schools in the respective country. For instance in Austria the situation became complicated because of its educational systems for engineering and the three types of engineering education units each of which prepares the students differently in order to meet different engineering requirements. In this environment the Bachelor study has to be positioned. The existing structure is:

1. The Technical Middle Schools

According to the Austrian regulations and respective laws normally students start their studies in these Technical Middle Schools when they are 14 years old and finish after 5 years with a final examination (Matura). After some years in practice they are entitled to be called “Ingenieur”. The graduates from these schools are educated in basic engineering and have a high reputation because of their practical skills in engineering. Many of the graduates of this type of schools made excellent carriers in industry as well as in middle sized or small sized companies.

2. The “Fachhochschulen”

In „Fachhochschule“n there are entrance examinations provided and the number of students per class is limited (numerus clauses). They were introduced in Austria for 2 major reasons:

a. Technical Middle Schools were not recognized in the European Union from the beginning. Of course this changed some years ago.
b. Industry was pushing forward the “Fachhochschule” which existed already in Germany for a rather long time. The goal was to graduate engineers from the “Fachhochschule” as “„Dipl.-Ing.“ FH” who are educated in engineering with strong practical skills.

3. Universities of Technology

By law at universities there is no entrance examination meaning all graduates from middle schools may enter the university. Also those who failed the entrance examinations at the „Fachhochschule“! In Austria, but also in many other countries, the graduated engineers of these universities are educated to be ready to enter industry laboratories for research and development. They have a strong theoretical background and less practical skills.

Therefore due to the existing regulations the number of graduates from universities is much larger than that from the Fachhochschulen. However, this is not quite what industry needs. In almost all countries, however, the demand for engineers with respective practical skills is much higher than that for developers and researchers.

According to the Bologna Declaration in Austria the BS-MS structure is or will be implemented at universities either substituting the 5 years programme („Dipl.-Ing.“) or in parallel to it. As a consequence the question arises: What is or will be the difference in the programmes between a “„Dipl.-Ing.“” FH programme at a “Fachhochschule” and Bachelor programme at a university? Is the Bachelor from a university a practical skilled engineer as the “„Dipl.-Ing.“ FH” or is the graduate a “low level” developer or “half educated” scientist? In many institutions these questions are not answered yet.

Conclusions

In conclusion I believe that there was and is a need for restructuring the educational systems in order to make the programmes more transparent enabling an easier transition of students from one programme to the other as well as to increase the mobility of them. Furthermore, the implementation of the 3 + 2 years structure provides a platform for graduates to leave the university entering industry in an earlier age when the respective conditions are given. However, considering all the problems mentioned in this paper the transition to the new structure has to be performed succesively based on well considered planning in which competent representatives of all groups at the unversities and from industry must be involved. Only then the transition will be successful and the quality of engineering education will be assured.

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Reform of the Education in Croatia

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Abstract

The educational system as a whole, as well as its higher education segment, should be considered a public good and a part of civil responsibility from economic and social but also political perspective. At the same time, higher education is to be considered as a harmonious part of the complete Croatian educational system as well as a segment of the European Higher Education Area (EHEA) and European Research Area (ERA).

The existing educational system in Croatia, from pre-primary, primary, secondary and tertiary level to life-long education, needs to be reformed on the content level and in order to assure the vertical and horizontal mobility. The dominant issues in the field are the increase of the length of compulsory education, later introduction of subjects in primary education, education of teachers (including life-long education) and especially introduction of state high school leaving exam and other. The education levels need to be harmonized with the International Standard Classification of Education (UNESCO: ISCED 1997). We believe that the changes should be implemented gradually and thoroughly, with well balanced changes on the content level, even if they occur more slowly, without major changes on the formal level.

In Croatia about 7% of population has higher education, and within working able part of the population (aged 25 to 64) this percentage is higher – 15,9% (in the European Union – 21,6%). From about 60.000 young people of appropriate age in Croatia, 47.000 of them complete any secondary level of their education. Out of that number, 31.000 students obtain a diploma from grammar, technical or similar schools enabling them to continue their education on tertiary level. About 80% of them enroll in study programmes at one of the 102 higher education institutions in Croatia (6 universities, 5 polytechnics and 22 independent institutions of higher education). There are 70% of students enrolled in university programmes and 30% in the programmes of polytechnic type institutions of higher education.

There are numerous weaknesses in our educational system and we still have to achieve integrity, quality and mobility in it. Among other things, from the higher

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education point of view, the issues of state high school leaving exam, enrolment policy, student scholarships and grants as well students' living standard are of great importance. The current situation in which an average length of studying is too long and about 60% of enrolled students do not graduate at all, is very disturbing. The enrolment policy is not harmonized with the capacities or with the unemployment rate in certain professions. For example, in the last ten years, among all the graduated students there has been an increase in the field of social science and humanities (from 45,6% to 62,5%), and a considerable decrease in technical (from 31,0% to 21,8%) and biotechnical (from 6,9% to 4,4%) sciences etc. An additional negative example is the disharmony between the increase of the number of students and teaching staff in the last ten years. The number of students increased from around 70.000 to 110.000 and at the same time the number of teaching staff did not change considerably. Teacher-student ratio during the last ten years has become more and more unfavourable and from 1:14 it dropped to 1:10.

The conditions should be fulfilled to make higher education truly and not only declaratively available to everyone and to increase the percentage of the population with higher education. We believe that it is more important to enhance the quality of the higher education, and only then to increase the percentage. Higher education should be a matter of national and individual interest. It is necessary to establish the needs, financing and real cost of study programmes and to fulfil certain conditions (capacities, equipment and staff). Both state and private institutions of higher education must continually be subject to internal and external evaluation. The need to establish a binary system in higher education, as opposed to the current "mixed" system, also exists, and this means ensuring conditions in terms of space and staff as well as equipment. Special attention needs to be paid to modernizing study programmes and developing new ones. Moreover, when implementing the Bologna declaration, the structure of study programmes needs to be adapted not only to corresponding European studies but also to the relevant programmes of Croatian universities and our own.

Key words: *Croatia, education, higher education, reform*

The higher education is organized through university and polytechnic programmes and through independent institutions of higher education. It forms a part of the complete educational system of the Republic of Croatia and in the near future it needs to become more functionally and naturally connected to it. Higher education (tertiary level) in Croatia needs to be considered as a part of the European Higher Education Area (EHEA) and European Research Area (ERA). The internationalization of the higher education and research also means greater mobility and competitiveness in these fields in the national as well as international context.

The existing educational system in Croatia, from pre-primary, primary, secondary and tertiary level to life-long education, needs to be reformed on the content level and in order to assure better vertical and horizontal mobility. The dominant issues in the field are the increase of the length of compulsory education, later introduction of subjects in primary education, education of teachers (including life-long education) and especially introduction of state high school leaving exam and other. The education levels need to be harmonized with the International Standard Classification of Education (UNESCO: ISCED 1997). We believe that the changes should be implemented gradually and thoroughly, with well balanced changes on the content level, even if they occur more slowly, without major changes on the formal level.

The education should be considered a public good and a part of civil responsibility from economic and social but also political perspective. That should be relative to tertiary as well as all other forms of education. In Europe changes from the "elite" to "mass" enrollment policy in tertiary education occur on a daily basis. In Great Britain and in Denmark the goal of 50% of the population of appropriate age is to join the higher education programmes until 2010. In Great Britain that percentage today is 45% and it was 12,4% in 1979. In the United States about 60% of the population having completed the appropriate education continues their education on the tertiary level and in Poland about 44% of the population (in 1990 – 13%).

Although in many countries the percentage of population with higher education is rising, the total expansion did not have an important impact on the students of lower socio-economic status, except in a very few countries such as the United States and Ireland. Access to the higher education should be equally made possible for all the groups of population, in accordance with capacities of the institution and needs for professionals. In relation to that, living and studying conditions should enable to everyone to study freely and prepare themselves for their vocation. The difference in socio-economic status should not be an impediment to an equal mobility of all the students.

In Croatia about 7% of population has higher education, and within working able part of the population (aged 25 to 64) this percentage is higher – 15,9% (in the European Union – 21,6%). From about 60.000 young people of appropriate age in Croatia, 47.000 of them complete any secondary level of their education. Out of that number, 31.000 students obtain a diploma from grammar, technical or similar schools enabling them to continue their education on tertiary level. About 80% of them enrol in study programmes at one of the 102 higher education institutions in Croatia (6 universities, 5 polytechnics and 22 independent institutions of higher education). The increase in percentage of people with higher education should be made possible by introducing certain social measures and by stimulating the education of the other half of the appropriate population but bearing in mind the adverse effect of negative demographic predictions.

There are numerous weaknesses of our educational system and we still have to achieve integrity, quality and mobility within it. Among other things, from the higher education point of view, the issues of state high school leaving exam, enrolment policy, student scholarships and grants as well as students' living standard (student residences, restaurants, health and life insurance, counselling) and later on possibilities of employment etc. are of great importance. The current situation in which about 60% of enrolled students do not graduate at all (about 40% in the European Union) is very disturbing. Besides ensuring the above mentioned studying conditions and circumstances, it is necessary to improve contents of study programmes, enhance their quality etc.

The enrolment policy is not in accordance with capacities or the unemployment rate in certain professions. For example, in the last ten years, among all the graduated students there has been an increase in the field of social science and humanities (from 45,6 to 62,5%), an increase in natural sciences (from 2,3 to 3,2%), a considerable decrease in technical (from 31,0 to 21,8%), biotechnical (from 6,9 to 4,4%) and biomedical (from 14,2 to 8,0%) sciences.

Due to the fact that in Croatia a state high school leaving exam has not yet been introduced, enrolment to higher education institutions is conducted through an entrance exam. The enrolment procedure includes the following achievements: high school grades, results at the entrance exam, special achievements in school and particular ability needed for some studies (music, dentistry etc.). The faculties and academies value these components differently in the overall procedure, depending on the nature of programme and vocation. At the University of Zagreb high school grades bring 20-40%, special achievements 0-8% and results at the entrance exam 53-80% of points. The 10% of students who achieve the best results at the entrance exam are directly enrolled regardless their high school grades and special achievements.

The issue of quality and harmonization of knowledge and how well the students are prepared for university studies are frequently raised. The introduction of state high school leaving exam would solve this problem. In some countries there are no constraints regarding the number of enrolled students because it is considered to be an issue of democracy and equality of citizens. In other countries a number of enrolled students is regulated on a basis of their achievement at the high school graduation exam and/or entrance exams. There are also countries where all the mentioned models are applied depending on study programmes.

At the University of Zagreb about 60% of students are financed by the Ministry of science, education and sport (former Ministry of science and technology) and about 27% of students finance their studies on their own. There is a similar ratio at other Croatian universities. At the individual faculties of the University, these ratios are different, even reversed, which shows different approaches to this important issues. It is not acceptable that some students pay their studies and others do not and with this respect all the students should be treated equally. It is necessary to calculate the real cost of individual programmes bearing in mind all the objective differences among faculties/academies. At the same time models of scholarships, subsidies and loans for students, depending on their success, employment rate and so on and determine the reimbursement plan. It has to be taken into account which fields are scarce and which ones "produce" too many experts and use this situation as a possibility of encouraging or discouraging students by determining the tuition amounts. There are already such examples worldwide.

The conditions should be fulfilled to make higher education truly not only declaratively available to everyone and to increase the percentage of the population with higher education. It should be a matter of national and individual interest. It is more important to enhance the quality of the higher education and only then to increase the percentage. Special attention needs to be paid to modernizing study programmes and developing new ones according to interests of changeable market and development of society, research and technology. There are examples (Great Britain) of a great increase of population with higher education, but young people are more and more cautious when enrolling in programmes on a tertiary level because of the problems in finding a job due to the lack of corresponding working posts or lack of interest in the labor market because of the low quality of education. Therefore, the increase in studying costs and problems with employment force the new generations to reconsider the "feasibility" of studying because of the length of studies and low salaries after the completion of university programmes.

It is necessary to establish the needs, financing and real cost of study programmes and to fulfil certain conditions (capacities, equipment and staff). An instructive negative example is the disharmony between the increase of the number of students and teaching staff in Croatia in the past ten years. The number of students increased from around 70.000 to 110.000 and at the same time the number of teaching staff did not change considerably. Teacher-student ratio during the last ten years has become more and more unfavourable and from 1:10 it dropped to 1:14. It is extremely important to improve that ratio through employment policy and stimulating young research and teaching staff.

Both state and private institutions of higher education need to be accredited and they must continually be subject to internal and external evaluation. Special attention needs to be paid to modernizing study programmes and developing new ones according to interests of changeable labor market and development of society, research and technology in Croatia. Moreover, when implementing the Bologna declaration, the structure of study programmes needs to be adapted not only to corresponding European studies but also to the relevant programmes of Croatian universities and our own. During that process, our own culture, where applicable, should not be disregarded. It is desirable to develop specific qualities of regional institutions of higher education in Croatia but at the same time not to fall in the trap of mediocrity and uniformity.

The need to establish a binary system in higher education, as opposed to the current "mixed" system, also exists, and this means ensuring conditions in terms of space and staff as well as equipment. From the total number of students in Croatia, there are 70% enrolled in university programmes and 30% in the programmes of polytechnic type institutions of higher education. In numerous countries there is a greater number of students in polytechnics.

Conclusion

It is necessary to ensure conditions which would provide access to higher education programmes to everybody, not only in a declarative way, and to increase the number of persons with higher education degrees. Therefore, higher education must be a matter of national as well as individual interest. However, I think that increasing quality of higher education is the most important goal, prior to increasing the number of highly educated persons, having in mind some other facts, like low birth-rate in our population, estate assets, finances, human resources and other relevant circumstances in the area of education in Croatia.

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Role of Engineers in the Modern Economy

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Abstract

Education of engineers is facing a difficult period of strong challenges from different approaches. The interest in engineering education has declined in recent years. Business and industry need entry–level engineers with the ability to learn, reason, think creatively, make decisions, solve problems and of course provide profit for private owners. How the state universities and government, still managing the low GMP, could respond to such heavy requests?

Keywords: *engineering education, employment, university curricula*

Introduction

In the past decades there have been different noticeable social, political, economic, industrial and environmental changes in Croatia and its surroundings. These changes, together with the globalization of economy, the rapid development of information and communication systems and the rapid technological changes have generated the urgency to create new approach to higher education of engineers in different fields and disciplines. It has been increased after the rapid expansion in key disciplines of engineering, resulting with the considerable stress among the professionals/experts. Engineering education is a synonym for Technology education. Technology education is a combination of intellectual and practical activities, such as starting planning, researching and coming up with ideas, testing those ideas in reality, designing the product and searching the market for possible commercialization. This is possible mainly by team learning, listening to the ideas of others in team and respecting and critically evaluating them. Science, as the only knowledge base of all technological solutions, is no more applicable. The "Bologna Declaration" is just an orientation toward this goal, but not a model to be applied all around in the same manner. The efforts should be made in order to educate engineers that would be able for immediate incorporation in the production, based on the high technology model of work, instead of (as it is now praxis) starting to develop their skills after the graduation. The postgraduate study cannot be a replacement for un-

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employed engineers, but it must, through their curricula, open specific possibilities for highly motivated and proven creative persons to reach the highest knowledge based on the top technology level. This approach should be in force at the near future to enable Croatia to meet challenge of accession to the European Union. The implementation of a new educational process and restructuring of economy will take at least next 10-12 years of time.

How to do it?

Recognizing the urgency of the need for reform and already initiated activities, the Croatian Academy of Engineering and the University of Zagreb have jointly organized the Colloquium "Current Approaches to the Education of Engineers", having in mind that within the same educational process different engineering fields could express their specificity in the program of education. The engineers are educated in different fields (e.g. agriculture, civil engineering, mining and geology, geodesy), and the new technologies request new subjects in the curricula of education, new branches and specialties. In order not to overload the students, the reduction of the majority, previously "very important" information, should be provided. These "very important" information are very often repeated at the universities after secondary school, but also from undergraduate study to postgraduate students. It means that the new generation of students, which, in the future, in Croatia would be significantly smaller than in the previous time (due to the strongly reduced number of the newborn babies), should be stimulated to choose the engineering education. These programs should provide a full satisfaction and fulfillment of their aspiration and increase human resource competitiveness with strengthening the conditions of equal opportunities in education, training and employment.

The higher degree of democracy reflected also in education has altered the elementary and secondary school climate, and the new students approaching the study have new requests towards the faculty's infrastructure as well as vocational and experimental education level. If we consider that our universities are old, that the middle generation of engineers is mostly educated on the previous less productive level, that the current "teachers" are mostly still oriented "to install knowledge into the student's head", the serious problem is how to guide him or her to acquire knowledge, through active participation and accession and not through transmission.

The experience of students from the elementary and secondary school using the workbooks (beside of textbooks) is interrupted at the university. A workbook integrates the following major elements: classroom analysis, the use of workbook beside of textbook, the team or group work and the use of information presented on the "blackboard" (today mostly substituted by a PowerPoint presentation). The major point of workbook is that it provides all the essential verbal and visual learning elements of the course material in an organized manner, and relates the fundamentals to applications.

Very important issues that influence and determine the education reform are professors and their training. Is it possible that a teacher in the elementary school and a professor in the secondary school must be educated how to transfer knowledge to the children and how to prepare the lectures, but for the university professors in engineering education just a formal "habilitation lecture" in front of three members of a commission is sufficient to get the "teaching license"? The knowledge of pedagogy and didactics must be prerequisites for future teaching personnel throughout the universities.

Therefore the new candidates for "teaching license" must upgrade their knowledge with three basic ingredients:

- Experience philosophy and methodology of active learning, receiving education not through face-teaching and passive listening, but through active participation and involvement,
- Practice in self-control and self-evaluation by searching and evaluating the process and the results of their own work, presenting it in order to receive feedback and readjust their own action plan, judging the final result and modifying reaction accordingly,
- Active participation in research activities by planning and performing their own projects in connection with other scientists (but he or she must be a project officer or a principal investigator highly specialized for the narrow topic).

The advantage of such methodology in teacher training is obvious.

Today we have two European projects within Socrates program, the aim of which is to grant:

- Quality assurance in education of technical teachers,
- European laboratory of educational software production

The projects are active this year with the participation of different EU members.

What the industry needs?

The most important question for the employers is the quality of future engineers. The employers have two possibilities:

- to participate in the education process or
- to select the available people from the labor market without the geographical or political frontiers.

The employer's today request that the engineers must have evidence of:

- leadership and vision,

- ethical and social responsibilities,
- team working,
- managing self/time, projects/events and motivating people,
- communicating, verbal and written,
- learning, developing and improving relevant knowledge.

The migration of high-qualified people today is present all around the world. It is present in sport, culture and science but in the last decade, due to globalization, also in industry. Beside these facts, more and more research is currently being conducted by “non-academic” institutions (multinational companies, public or private SME, independent research centers. Therefore the future engineers and scientists should be trained and prepared to entered worldwide endogenous academic market but also exogenous industrial market. The quality of the Croatian higher education was in the last decades of the 20th Century very highly positioned and internationally acknowledged. It seems today that this type of education is old- fashioned and it requests the orientation towards new skills. These requests will increase the competitiveness of the teaching personnel all around the world. But this is much easier to predict than to find a proper and fast solution. The language barrier could be a serious reason for the European universities, but the industry must also count with them or to accept English as a major EU language.

Conclusions

Croatia as a small country with a very sensitive geopolitical position, but with more than 300 years old university education, and more than 80 years of engineering education, is not allowed to make any wrong steps because it can damage whole system. Even if the current situation is not the best, restructuring the terms of study will not provide new curricula. The better way would be to prepare new curricula, educate the new generation of teachers and then with the industry to select the best duration of first and second level of study. The industry today, suffering with its place on the market and how to survive the different “waves” from the different parts of the world, is not able to help university in the formulation of the future structure and quantity of engineers. The decrease of interest for engineering education in Europe soon will be present also in Croatia, and only standard for teachers, for students and for the faculties equipment could help avoiding serious crisis in the country. The clear criteria of standard in the Croatia higher education would also have to include solving the existing problems of income amount as well as number of assistants employed, the laboratories´ facilities and the criteria for assets allocation, including the assets for proper functioning of the laboratories, etc.

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E-Learning Paradigm & Intelligent Tutoring Systems

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Abstract

WWW service has enabled development of thousands of systems that are considered to be direct application of modern information and communication technology, and they base their work on a static presentation of a subject matter. Educational systems capabilities incensement is gained by adding interactive, adaptive and intelligent functions and those features enable development of Web oriented intelligent authoring shells. E-learning, new paradigm enabled by electronic technology, seems like universal replacement for all researches and development that have been conducted in the last fifty years, in a field of computer systems' applications in education. E-learning is closely related to intelligent tutoring systems. Influence of intelligent tutoring systems on learning and teaching process is again actual because researchers have seen importance and relation between these systems' pedagogical paradigm and Bloom's "2-sigma" problem. Bloom's "2-sigma" problem is related to the efficacy in a knowledge acquisition while comparing individual and team learning. We present some research findings and we indicate their relationship with our own research that has been conduced over ten years. Also, we present our latest work related to Tutor-Expert System model, an authoring shell for intelligent tutoring systems development in freely chosen domain knowledge.

Key words: *World Wide Web, E-learning, Intelligent Tutoring Systems, Learning Management Systems, Standards in e-learning systems, Shareable Content Object Reference Model, The Two-Sigma Problem*

1. Introduction

Information and communication technologies (Budin et al, 2001) have become integral part of educational systems as a support for teachers in realization of traditional education as well as replacement of traditional education with one of many new methods for realization of learning and teaching process. Information and communication technology combined with multimedia, networking and software

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engineering, have enabled development of new learning and teaching computer systems. Last great milestone in educational technology was made by introducing Internet and WWW service, and it anticipated all educational systems to be reengineered. Computer networks technology, i.e. Intranet, Internet, WWW and specially hypermedia, have all influenced on founding so-called advanced learning technologies (ALT, 2004). Phrase advanced technologies should be observed in a context of technological diversities from computer systems for presenting subject matter to books and textbooks that support traditional learning paradigm. New learning paradigm is learner - centred. Learner is "placed" in centre of the learning environment with regard to the time as well as the place and way of learning (Wasson, 1997) and everything is embraced by single phrase – learning resources (people, knowledge, technology, medium, organization,…). In this paper we discuss e-learning because we believe that this is new learning paradigm based on electronic technology seems like universal replacement for all researches and development that have been conducted in the last fifty years, in a field of computer systems applications in education. Besides, as stated in title, we bind e-learning paradigm with on-site and Web intelligent tutoring systems (ITS) that enable individualized approach to learning and teaching. It is known that WWW service has enabled development of thousands of systems that are considered to be direct application of the modern information and communication technology. Most of these systems have very limited learning and teaching capabilities because they base their work on static presentation of subject matter. Educational systems capabilities incensement is gained by adding interactive, adaptive and intelligent functions. Those functions can be implemented by using some techniques of dynamic generation of Web content which depend on students' answers to asked questions. Usage of those technologies enables development of Web oriented authoring shells for constructing Web based ITS. The individualised learning and teaching approach is now enriched with e-learning paradigm and, what is more, it makes fundaments of our research. E-learning accents two significant determinants: (i) *Learning Management Systems (LMS)* and (ii) *standard*s *based on SCORM model* (Sharable Content Object Reference Model) (SCORM, 2003). E-learning paradigm as well as previously mentioned determinants will be analyzed in this paper and will be related to ITS. Intelligent tutoring systems are generation of computer systems aimed for the support and improvement of learning and teaching process in certain domain knowledge, respecting individuality of the learner as in traditional "one-to-one" tutoring. Nowadays, when information and communication technologies and Internet have become inevitable, ITS emerge again because researchers have seen importance and association between these systems' pedagogical paradigm and Bloom's "2-sigma" problem (Bloom, 1984) related to the efficacy in knowledge acquisition through comparison of individual and team learning. Far from any doubt, ITS show the best results in evaluating students' achievement when being compared to existing technological learning and teaching process support, both traditional and individual (Fletcher, 2003). Thereby, we imply on connectivity of e-learning paradigm with our own ten-year research related to development and implementation of *Tutor-Expert System*, TEx-Sys (Stankov, 1997) an intelligent hypermedial authoring shell for generating ITS in freely chosen domain knowledge. The TEx-Sys authoring shell was initially developed and implemented as an on-site system, and afterwards followed research, development and finally implementation of TEx-Sys's distributed version *Distribited Tutor-Expert System,* DTEx-Sys (Rosić, 2000). The TEx-Sys and the DTEx-Sys have been used on some of our university classes in the last few academic years (Stankov et al, 2002), (Stankov et al, 2003). We have created our own learning and teaching model by using knowledge bases developed by TEx-Sys. Achieved results have been used for further research that relies on Bloom's experiment (Stankov, 2002) with a view of developing our own research methodology. However, we have been working on implementing a prototype of extended version of the TEx-Sys, *extended Tutor-Expert System*, xTEx-Sys (Stankov, 2003), within a technology project founded by Ministry of Science and Technology of the Republic Croatia. This paper presents achieved results concerning research and implementation, briefly describes e-learning environment, learning management systems, standardization of learning technology, e-learning systems' pedagogical paradigm and overview of the xTEx-Sys architecture.

2. E-learning and its environment

Improvements in Internet access availability and speed as well as computational power of personal computers, have dramatically increased possibilities for interoperability and usage of other distributed learning technologies. Consequently, different companies and associations have been developing different products for distributed learning. New products are continuously being developed and combined with existing products that define new functionalities. That became challenge for the development of the new e-learning environment. Emerson of new e-learning paradigm does not imply that existing software applications as well as traditional educational methods should be forgotten. On contrary, existing student administration, human resources and library management represent critical components in e-learning environment. Real challenge is to integrate all those components in e-learning system and its services. E-learning presents intersection between world of information and communication technology and world of education. This fact is valuable particularly when it is being used as a part of well planed and organized learning environment, but nevertheless e-learning is not a "magic ball" that will replace existing pedagogical theories, principles and standards. American Society for Trainers and Development (ASTD - *www.astd.org*) defines e-learning as a subject matter or a learning experience delivered or enabled by the electronic technology (ASTD, 2001). Formally, e-learning includes numerous learning strategies and learning support technologies such as CD-ROM, computer based instruction, videoconference, subject matter delivered by satellites and networks for virtual education. In other words, it does not include only Web based education or distance education, but it includes different approaches in order to individualize information interchange and knowledge acquisition of participants. In principle, e-learning is based on the electronic technology, designed for enabling knowledge and skill acquisition, not only for students in formal learning and teaching process, but also for all participant categories in long-life learning and teaching process (learning while working, qualification for new avocations and new systems and techniques, etc.). While considering e-learning environment, Khan assumes that e-learning should be able to answer the question: "What should be done to accomplish successful e-learning for different categories of students?" and he suggests multidimensional space made of pedagogy, technology, user interface, assessment, management, on-line support, ethics and institution (Khan, 2001).

In conclusion of this paragraph, we are going to mention few more relevant features of e-learning paradigm. One of them is related to dynamic growth of commercial space (*www.brandon-hall.com*). It has performed an explosion from barely existing in 1996. to about ONE billion dollars in 1999. and foreseen about 10 to 12 billions dollars in 2003. to more than 200 billions dollars in 2010. Last two features imply that learning and teaching process benefits from e-learning and globally relates formal education (at all levels) and long-life education to the two new determinants (IsoDynamic, 2001) that can be summarized in: (i) development of integrated systems for learning management, and (ii) development and promotion of standards for sharable content objects for e-learning or learning objects.

Following paragraphs present e-learning systems configuration and architecture that relies on standards for developing e-learning systems. However, it should be emphasised that introducing standards in e-learning systems will probably "neaten" e-learning area and ease the work for newcomers.

A. E-learning systems configuration

We describe some actual e-learning systems configuration classes because this area is very dynamic and it is very hard to foresee what will happen in the future. Thereby, according to numerous literature references that represent actual e-learning systems configuration, our analysis focus is placed on *learning management systems* and *learning content management systems*. These systems have one thing in common: they are both Web based systems for supporting learning and teaching process during student's knowledge and skill acquisition.

Learning Management System (LMS) presents software that globally enables total learning and teaching process administration. LMS enables student's registration, courses sequencing in courses catalogue, describing student's data and reporting everything that has been done. Besides, LMS is usually designed in the way that it can manage courses delivered by different publishers and service providers. Usually LMS configuration does not include authoring tools for creating subject matter. LMS vendors offer some additional tools for creating subject matter. Reusability relates to the whole course (one course can be delivered to many students whose accomplishments can be tracked down).

Learning Content Management Systems (LCMS) enables creating, storing, using and reusing subject matter. Subject matter consists of knowledge grains that are called learning objects. LCMS structure can be observed as upgraded LMS structure extended with *Content Management System* (CMS) or *Reusable Learning Ob-*

jects (RLO) (Nichani, 2001). Term CMS comes from on-line publishing industry that enables creating and administering different contents (articles, reportages, pictures, etc.). CMS article is made of many knowledge grains called content components and they guarantee reusability. One component can be included in many articles which can afterwards be read by many readers. When compared to learning, we work with reusable learning objects that can be used in different domain knowledge and by different students. This reusability and content structuring is employed in LCMS. Content component in learning domain is called reusable learning object.

In spite of numerous definitions for reusable learning objects we cannot avoid having impression that essence is in applying object-oriented model of conception in the "learning world". Alike LEGO blocks, learning objects are reusable components (the knowledge grains) – text, presentation, animation, picture, HTML document, used not for building fairytale castles but for knowledge building and acquisition. According to ASTD, learning object is reusable medium independent information used as building block for subject matter in e-learning systems. Learning objects are more efficient if they are organized and qualified by using metadata and stored in data repositories like those in LCMS. IEEE Learning Technology Standards Committee – IEEE LTSC (*itsc.ieee.org*) defines *learning object* as: „*…an entity, in digital or non-digital form, that can be used, reused or referenced during subject matter design* ….". Ministry of Defence of USA and White House Office of Science and Technology at the end of 1997. started an initiative called Advanced Distributed Learning - ADL (*www.adlnet.org*) for the advancement of information and communication technology application in learning and teaching and they proposed standardization of subject matter, so called SCORM model. Structure component is learning object, so called Sharable Content Object (SCO) along with its attributes: reusability, durability, accessibility and interoperability.

B. Standards for designing e-learning systems architectures

Alike initiatives in other areas, standards applied in learning technologies should enable reusability and interoperability among different platforms. To accomplish that reusability and operability, consensus in *architecture, services, protocols, data models and open interfaces* should be made. This task is difficult and overwhelming because of the development of learning technologies infrastructure which has its historical dimension and in the last decades was associated with development of computer systems. It presented difficulty to interoperability because, with time, different platforms and architectures were more "fashionable", and speaking in technological sense they depended on era they were developed in. Dynamic development process in the last few years constantly brings up new recommendations, and, as a consequence, there is a steady progress in designing, development and application of learning and teaching systems' architecture standards. E-learning systems' architecture is designed according to the three-tiered architecture made of data tier, application tier and user interface tier (see Fig. 1 modified according to Anido-Rifón et al., 2002).

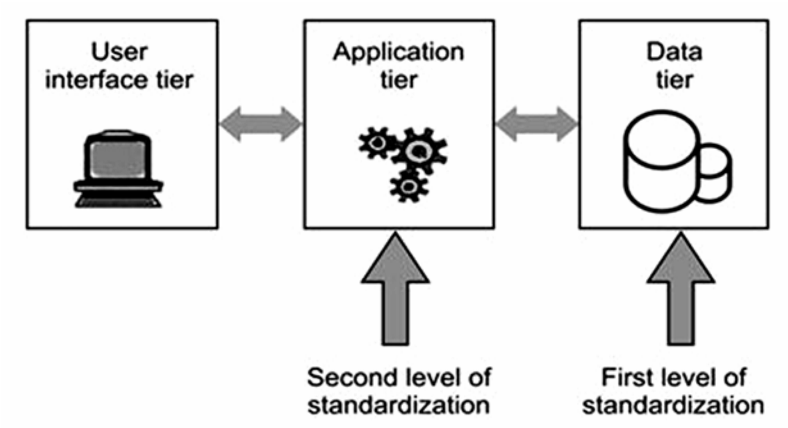

Fig. 1. Three-tiered architecture and levels of standardization

1) – First level of standardization – data model

The most mature results are achieved on the first level of standardization. In most cases XML (eXtend Markup Language) is used for defining information model which enables WWW interoperability.

At this level, standards can be seen as common specification that has to be used by different learning objects vendors which create learning objects by using different systems for supporting learning and teaching process. Relevant specifications on the first level of the three-tiered architecture standardization are: (i) *Metadata* used for precise description of a subject matter. The most notable contribution in this field is done by IEEE-LTSC (*ltsc.ieee.org*) in a form of Learning Object Metadata (LOM) standard specification considered to be de-facto standard. This field is believed to be one of the most active parts of standardization process. (ii) *Profile and student record* that present information about knowledge and preferences included in learning and teaching process. IEEE LTSC Public and Private Information (PAPI) specification describes student's record. (iii) *Organization of subject matter* is oriented on description of a course structure that can be static or dynamic. Static course structure defines a priori relations inside subject matter structure (lessons, paragraphs, assignments…). Dynamic course structure determines certain sequence depending on student her/himself and his/her previous interactions with subject matter. This information is used in learning and teaching environment in order to create future student's activities. Predominated standards for organization of subject matter are based on AICC (*www.aicc.org*) and ADL SCORM (*www.adlnet.org*).

2) – Second level of standardization – common software components and open architecture

On this level standard defines expected behaviour of system components responsible for learning object management in on-line environment. System interface enables construction of new educational systems avoiding building them from start and through improvisations, and besides that, it enables interoperability among systems with different platforms (different operating systems). Nowadays, not many institutions have developed architecture with common components that enable generic learning environment. In respect to the management and administration we have identified three learning system categories: (i) *Educational delivery systems* or support for accessing subject matter by using Web. These systems do not require performance measuring and learner administration. The representative of these systems is Placeware Auditorium (*www.placeware.com*). (ii) *Computer managed instruction systems* that include: subject matter delivery, integrated system for tracking and measuring achievements during learning and teaching process, individual or group work. The representative of these systems is WebCT (*www.webct.com*). (iii) *Learning management systems* were discussed in previous paragraph. One of the representatives of these systems are Docent (*www.docent.com*) and ISOPIA that is considered to be an intelligent learning management system (www.isopia.com).

3. Pedagogic paradigm of e-learning

In period between 1982. and 1984. Anania and Burke at the University of Chicago in USA had conducted a research in which they compared three ways of learning new subject matter: (i) *Conventional learning* where group of 30 students lead by one teacher had to master certain domain knowledge. Students' knowledge was examined through few tests that were used in gaining final mark. (ii) *Mastery learning* where group of 30 students lead by one teacher had to master certain domain knowledge. However, tests were used as a feedback and every test was followed by procedures for correcting way and pace of presentation of a new domain knowledge. (iii) *Tutoring learning* where students master certain domain knowledge guided by personal tutor (one teacher lead one to three students). This way of learning is followed by periodic tests, corrective procedures, feedback and parallel testing as in mastery learning. It is important to propound that need for corrective procedures in this way of learning is very small (Bloom, 1984). Using a standard deviation, it was found that an average student in tutoring group was about two standard deviation more successful than average student in control group (the average tutored student was at a level above approximately 98% of the conventionally instructed students). An average student in mastery learning group was about one standard deviation more successful than average student in control group (the average student under mastery learning attained final achievement above approximately 84% of the students in conventional group instruction). Tutoring learning showed that the majority of students had potential to reach this high level of achievement. An important task of this research was to find ways of accomplishing this high level of achievement under more practical and real conditions than too expensive one-to-one tutoring. This is known as *2 sigma problem*. Numerous researches tried to determine if, and in what measure, computers and related technologies can contribute to students' knowledge and skills acquisition improvement. One of those researches (Fletcher, 2003) is specific because it is oriented on collecting and systematization of other case studies related to students' achievements in learning and teaching process by using information and communication technology.

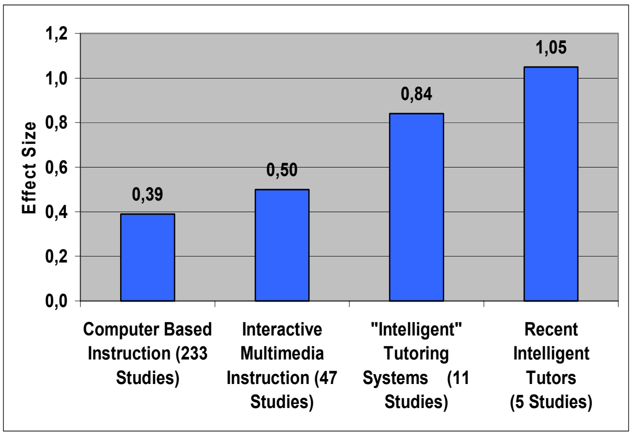

Fig. 2. Some Effect Sizes for Technology-Based Instruction

The research has determined following facts (see Fig. 2.): (i) achievements of an average student in traditional classroom (so called 50 percent student) are equal to achievements of 64% students (64 percent student) who used computers with simple user interface, and that improvement was presented with standard deviation of about 0.39 sigma, (ii) students who used computers with interactive multimedia (integrated pictures, sounds and animations) showed achievement effect of 60%, and that improvement was presented with standard deviation of about 0.50 sigma, (iii) students who used intelligent tutoring systems showed achievement effect of 80%, and that improvement was presented with standard deviation of 0.84 sigma, (iv) students who used resent intelligent tutoring systems showed achievement effect of 85%, and that improvement was presented with standard deviation of 1.05 sigma. Fletcher concludes that effect of traditional tutoring learning has not yet been reached, but results are promising.

4. Intelligent tutoring systems

Intelligent tutoring systems are generation of computer systems aimed to support and improve learning and teaching process in certain domain knowledge, considering individuality of a student like in traditional one-to-one learning and teaching process. Using the results of researches as well as the experiences in applying hypermedial authoring shell TEx-Sys and its distributed version DTEx-Sys, that are both based on cybernetic system model (Pask, 1965, Wiener, 1948, Božičević, 2001), we have approached to development of *Web oriented intelligent authoring* *shell* called xTEx-Sys, which is extended with some new actors and functionalities (Stankov, 2003). *Web oriented intelligent authoring shell* will have the following users: (i) students who will be involved in knowledge and skills acquisition process, (ii) domain knowledge experts who will create knowledge bases, (iii) teachers who will didactically design subject matter by using created knowledge bases, and finally (iv) system administrator who will monitor system, users and ways of using system. Furthermore, all users' categories will be able to cooperate while creating knowledge bases or during learning and teaching process in certain domain knowledge. Final phase of the project will include some trial assessment with all student categories: high school students (especially those in final grade for their preparation and selection of college), (ii) university and college students, and (iii) teachers who take complementary courses during their long-life education related to applying information and education technology in subject matter realization. During our work on this project we have defined following functionalities of xTEx-Sys: user login into system, learning and teaching, knowledge testing using overlay method, knowledge testing using quiz, domain knowledge design, subject matter design, adding users into system (different categories of students, teacher and domain knowledge expert), user overview, changing data about user, adding group of users into system, user group overview, changing data about user group, adding users into user group, adding teachers to user group or individual user, adding courses to user group or individual user, user collaboration (e-mail and on-line textual conference - chat), and finally system administration.

Hereafter we present description of a subject matter design functionality that is preformed by teacher during creation of her/his course structure. Courseware is internationally accepted term for subject matter designer for execution on computer. Subject matter is defined for certain course that is related to a certain student groups. Courseware has multilayer structure consisted of: *units*, *lessons*, *topics*, *instructional items* and *tests of quiz type* (TQ). These elements of courseware structure have been identified according to our pedagogical tradition extended by one new expression, an instructional item, which is considered to be undividable element of subject matter. We want to indicate that undividable element of subject matter is in its essence subject matter object, that is, previously mentioned SCO according to SCORM model. A unit in principle includes more lessons, a lesson includes more topics and finally a topic includes more instructional items. Test of quiz type is appointed to a unit, a lesson or a topic. Teachers freely design the courseware structure, and it includes both vertical and horizontal decomposition of subject matter elements structure. That means that courseware, being built by a teacher, has a tree structure and its elements can be sequenced. Nodes of courseware structure tree are subject mattes elements, and they are divided into four levels: (i) first level – *a unit;* (ii) second level - *a lesson;* (iii) third level - *a topic;* (iv) fourth level – *an instructional item.* Tests of quiz type are specially considered to be appointed to every subject matter element except instructional item. Quiz testing can be done in two ways: for testing using static questions generated by teacher and for testing using dynamic questions generated by computer employing randomized selection applied on domain knowledge base. Total number of questions during testing is defined by the teacher. Questions, that are related to a set of knowledge nodes appointed to certain subject matter element, are combined into pairs (two questions in every cycle), and number of cycles is defined by teacher for every subject matter structure element that is a test of quiz type.

The xTEx-Sys is developed by using an object-oriented methodology of software engineering called Rational Unified Process, and tools for visual modelling and implementation Rational Rose and Unified Modelling Language. Implementation is based on the .Net technology and Microsoft SQL Server system for the managing data bases.

5. Conclusion

E-learning presents intersection between the world of information and communication technology and the world of education. This fact is valuable particularly when it is used as a part of a well planed and organized learning environment, however e-learning is not a “magic ball” that will replace existing pedagogical theories, principles and standards. E-learning is a new learning paradigm based on the electronic technology related, as we see it, with individualized learning and teaching paradigm that relies itself on intelligent tutoring systems. We have presented e-learning as an outcome of a modern information and communication technology and we have pointed out some configurations (LMS and LCMS systems) and standards for designing e-learning systems architecture. Standards for designing both e-learning systems architecture (three-tiered architecture) and subject matter (sharable content objects) presented on those systems, will contribute to the clarification of this area and maybe, at this point, after more than fifty years, make computer technologies application in education a real contribution to didactic and methodical subject matter design and new knowledge acquisition. New knowledge acquisition nowadays is of great significance for success of the individuals as well as society.

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Mining Engineering Education – A Vision for the Future

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Abstract

The mining production in Croatia is based on the production of nonmetal and energy mineral raw materials. These are in the first place technical construction stone, gravel and sand, raw materials for cement industry, architectural building stone, petroleum and gas. The necessary knowledge and skill for their production is provided by the study of mining and petroleum mining engineering at the Faculty of Mining, Geology and Petroleum Engineering (RGN) of the University of Zagreb. The requirements of the minig industry, environmental concern and the prerequisites for sustainable development, as well as integration processes in Europe and the global market, call for engineers who will be able to meet these challenges.The paper presents the actual mining study programs and a vision of their indispensable restructuring in the coming years.

Key words: *education, mining engineering, future trends*.

Introduction

The greatest part of the material goods created through centuries used to be produced by utilization of mineral raw materials. There is hardly any product in modern civilization manufactured without utilization of a material produced on the basis of some metal or nonmetal ore. About 80% of primary energy is produced from fossil fuel, thereof 62% for the production of electric energy. The food products industry is based on the utilization of mineral raw materials to a great extent. The annual world output of various mineral raw materials is 160 to 180 billion tons or 25 to 30 tons per capita. The production volume of nonmetals exceeds by far that of metals, in fact the nonmetals share in the financial value with 2/3 and the metals with 1/3. Thus for instance, it is estimated that in the U.S.A. more than 50% aggregates (technical construction stone, gravel and sand) produced in the 20th century were consumed in the last 25 years of the century. In the first 25 years of the 21st century

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the production of about 36.3 Gt is expected, which is equal to the output of the whole 20th century (Karmis, 2002).

According to the records of the Ministry of Economics, 23 kinds of mineral raw materials are produced in Croatia. In the year 2002 there were produced about 30 Mt of various nonmetals (technical construction stone, raw materials for cement industry, construction gravel and sand, brick clay, architectural building stone etc.), 937,695 m^3 petroleum, 1,880,480,000 m^3 gas and 26,520 t metals (bauxite), while coal was not produced. The value of that production ranged from 650-670 mil. US$, whereof petroleum and gas shared with 56% and the other raw materials with about 44%. The production of nonmetals keeps increasing, thus in the period of 1998/2002 the production of gypsum increased by 87.7%, the raw material for cement industry by 56.6%, technical construction stone by 43.8%, quartz sand by 36% etc. The petroleum production in that period decreased by about 38.2%, while gas production increased by 19.7%. Particularly drastic is the decrease of probing bores in meters. While more than 200,000 m/a were bored about twenty years ago, nowadays there is practically no probing boring. In Croatia about 350 trading companies and craftsmen with about 8,000 operating personnel are involved in the research and exploitation of mineral raw materials.

Demographic estimates show that, if the present trend of growth is maintained, the number of 6 billion earth inhabitants will rise by 50%, possibly even by 100%, within the following 50 years. Such upward trend can persist only by increased consumption of vital products, such as food, energy, materials. A characteristic indicator of the quality of living is the energy consumption per capita, which is in the most developed western countries 25 times greater than in the developing countries. This disparity clearly points to the necessity for a higher production of energy as well as of other goods indispensable for reaching a higher living standard. A reduction of production, the recycling and the energy conservation may merely slow down the expected energy consumption growth, but without satisfactory result. The production of mineral raw materials is and will always be the essential prerequisite for our survival and future growth.

The Study of Mining Engineering in the World and in Our Country

The study of mining engineering, like most other engineering studies, such as metallurgy, mechanical engineering, chemistry, is in crisis. The interest of young generations is directed towards informatics, telecommunication, biotechnology, which can easily be understood when we know that scientific and technological achievements at our parts are almost daily present in the media. Mining, metallurgy or mechanical engineering are very seldom the subject of discourse and if so, in the context of various economic, social, ecological or other problems. Such situation is not a specific one for our country. Degree granting educational institutions in many European countries, in the U.S.A. and Canada are confronted with similar problems, but due to the relatively complex situation in Croatia that has been actual for more than 10 years, the problem is even more difficult. The study of mining engineering is in some way specific for its problems, not only because of the bad economic situation but also because of the public standpoint that mining does not exist in Croatia anymore and that a great part of ecological problems is to be imputed to mining. The worldwide attitude towards mining is not better either. It is regarded as being useless, damaging nature and causing ecological problems.

Mining engineering education in western Europe is in a critical situation. Students enrolments keep decreasing and established study programs are closed. A similar situation is in the U.S.A. and in Canada (Marušić, 1997). In former East-European and post Soviet countries fundamental restructuring of economy has taken place with notably lessened interest in the mining industry. Financial funds to faculties and institutes, particularly to mining, have been cut down in the latest years. In the U.S.A. even 700 mining engineers used to graduate annually in the eighties of the last century, which number dropped to about 140 in 1999/2000. Since some years ago new students enrolments have been decreasing by about 15% per annum. In Great Britain, not so long ago, about 600 students used to enrol for the study of mining, while less than 300 nowadays. As a consequence, in the U.S.A. the number of mining education high schools dropped from 25 to 17, and in Great Britain from 8 to 4. In the latest five years the average annual students enrolment for the mining engineering study at the Faculty of Mining, Geology and Petroleum Engineering, Zagreb has been 66 for the mining engineering program, while the annual number of graduates in mining engineering has been 15.

In the course of the nineties, somewhere even earlier, the mining engineering colleges have been gradually revising their curricula, introducing courses concerned with various aspects of environmental protection, recycling, waste disposal and the like, respectively offering to students the knowledge of their interest. It is even possible to graduate with graduate diploma in environmental protection engineering. In some curricula merely the titles of the course, such as geotechnics or georesources, refer to mining. The names of mining departments are changed, thus for instance in Caligary *Department of Geoingeneering and Environmental Technologies,* in Torino *Dipartimento di Scienze della Terra,* in Delft *Department of Raw Materials Technology* resp. *Faculty of Applied Earth Sciences,* in Aachen has been established a department called *Rohstoff-Gewinnung und Abfall-Entsorgung.* Recent years have shown that the undertaken changes have reestablished the interest in education at mining high schools, particularly at those offering restructured courses or a certain specialization in one or two final half-year terms, in which the environmental protection courses dominate at present. Unfortunately, the interest in mining engineering study with the former classical conception is still slack.

Due to decreased interest in mining at Westeuropean universities and for the sake of rationalization, some of them were actuated to organize a joint study taking into account certain specialistic specific diversities (de Ruiter & Dalmijin, 1999). The initiators were the *Faculty of Applied Earth Sciences* in Delft and the *Imperial Colledge-Royal School of Mines* from London. The former decided so because there used to enrol no more than 4 to 7 students per year in the nineties, and the latter one because, for instance in the academic year 1995/96, just two British, one French and five Dutch students were enrolled there. The discussions were initiated in 1995, and in 1996 the RWTH from Aachen and the *Helsinki University of Technology* from Helsinki also joined them. The idea and the cooperation program were supported by the European Commission through the program Socrates. The program was concepted in the way that students, after studying three years at their parent institutions, spend the last year in the way to study two month at each of the above mentioned four institutions, chosing their best developed disciplines, respectively those that contributed to their being regarded as centres of excelency. The study is completed by the elaboration of a graduation or masters thesis within the following three to twelve months, during which period the students have to spend some time in a mining industrial company, where the subject of the thesis is also defined.

The official title of the program is *The European Mining Course* (EMC*)*. The first 8 students started studying in academic year 1995/96, and already in 1997/98 the number rose to 18. In academic year 1998/99 students from Austria and Canada joined the course, thus the planned number of 20 to 25 students was approached. Encouraged by the success of the EMC program the mentioned colleges from Delft and Helsinki, in cooperation with the *Camborne School of Mines* from Camborne, started in 1998/99 a new program called *The European Mineral Engineering Course* (EMEC*)* with the emphasis on raw material processing and recycling. The great importance given in those programs to the cooperation with mining industry, particularly in the part foreseeing students presence in mining premisses, consultations on the design of courses, definition of graduation resp. masters theses, prospects for employment and the like, should be pointed out.

The possibility to introduce open and distant learning technique is also a subject of consideration. Namely, in that way Delft and Helsinki have linked up with some universities in the U.S.A., within the program entitled ATLAS, for the purpose of European and American students exchange.

Curricula and Courses for the Current Undergraduate Study at the Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb

The curricula and courses for current undergraduate study of mining engineering have been applied since the academic year 1998/99 and new programs for postgraduate scientific study since academic year 2001/02. They have been conceived in the way to provide mining engineers with the volume and level of knowledge indispensable for the work in mining industry and other related branches (geotechnics, environmental protection) for the first ten to fifteen years of 21st century. The undergraduate study lasts 8 half-year terms and the postgraduate at least 4 additional half-year terms for the Master of Science Degree, respectively 6 for Doctors Degree. The eighth term of the undergraduate study is made up of optional modules *Extraction of Mineral Raw Materials, Construction of Underground Rooms and Tunnels,* and *Recycling and Waste Disposal*. The postgraduate study offers three courses: *Mining, Geotechnics* and *Environmental Protection* (Salopek, 2000).

Conception and Goals of the Program

The conception of the program as well as the goals of the study of mining are based on the following guiding principles:

- uniform mining study with three optional modules in the eighth half-year term, which are the indispensable part of optional courses in the program,
- gathering of integral engineering knowledge for accomplishing the tasks classified in scientific fields and branches,
- vocational teaching courses in a satisfactory degree and quality to enable future engineers posessing the graduate diploma in mining for independent and creative professional work,
- shortening the time of study, yet maintaining the necessarily needed quality,
- widening knowledge by efficcient further perfection through specialist training and postgraduate studies.

According to the rules on the formulation of scientific spheres and fields in Croatia (Official Gazette No 29 of 14th March 1997), in the scientific sphere of technical sciences there is field 2.10. mining, petroleum and geological engineering. The goal of the curriculum put down in the mentioned field is training of professionals for branch 2.10.01. mining. Besides, in view of the character and the orientation of the included modules, that curriculum covers in a part also branch 2.05.01. geotechnics in the field of civil engineering and branch 2.15.07. environmental protection in the field of other technical science.

Comparison with Foreign Curricula

At composing educational plans and curricula the experience of renowned mining colleges, such as *Montanuniversität Leoben* in Austria, *Technische Universität R*WTH Aachen, *Technische Universität Claustal* and *Bergakademie Freiberg* in Germany, *Technical University Miskolc* and others, was used again and again at design but also at later elaboration. This time it has been done like that too, but at the same time the program of *Colorado School Mines* from U.S.A. was also taken into consideration.

The examination of the programs has shown that all of them contain compulsory, optional and noncompulsory courses and a two months lasting practical work in industry, which is to be accomplished in the course of the study. Besides, the study at European colleges lasts 9 half-year terms, while 8 half-year terms in the U.S.A. Thus our program resembles the one at American colleges, as regards its duration. For closer comparison of the programs we have chosen the one of *Montanuniversität Leoben* (MUL) having the most similar conception to our RGNF, and the *Colorado School of Mines* CSM program as representative of the American mining colleges tradition. An analysis has been made with respect to the content of distinct groups of courses and the total duration of the study.

Based on the analysis of the plans and curricula we can state as follows:

- the share of hours referring to humanities, social and economic courses at RGNF and MUL is approximately the same, while at CSM it is by 36% greater;
- the number of hours for the group general technical education courses is the greatest one at CSM, i.e. 28% of the total time-table, while at MUL and RGNF it is somewhat smaller, i.e. 92% respectively 83% of that quantity;
- Vocational technical courses (mechanics, thermodinamics, mechanical engineering etc.) share with the greatest number of hours at the RGNF (18% of the total time-table), while at the CSM they are represented with the smallest number of hours (13% of the total time-table);
- Geoscientific courses (mineralogy, petrography, geology, ore-beds) take the greatest share at MUL, namely 14% of the total time-table, while at RGNF this percentage is 11%, and at CSM 8%.
- Specialized courses of the mining profession are included in RGNF plan with the highest portion, constituting 36% of the total time-table, whereas at CSM and MUL that percentage is somewhat lower and amounts to 35% and 33% respectively.

We can conclude that the mining study at the RGNF is very similar to that at MUL and CSM, most similarity being found in the group of vocational specialistic courses, while least in the group of geoscientific courses.

The program for mining education was presented at the symposium entitled *Problems at Education and Scientific Work in Mining and Metallurgy* within the Third European Conference of Rectors at Mining and Metallurgic Academies that took place in Krakow in the year 2000. Our program proved to be compatible with most of the other programs, in particular with those from Austria, Germany and the Czech Republic.

Vision for the Future

As already mentioned, the current curriculum for mining engineers has been applied since the academic year 1998/99. It means that this year the third generation of students is going to complete the foreseen program of study. Theoretically, the first students could have graduated in the academic year 2001/02, but this is just a theory since there were no graduates that year. Namely, so far only two students have graduated. On the assumption that they have got a job, the first relevant information about the quality of the study program, respectively about how efficient proved to be the acquired knowledge at practical work, cannot reach us before year 2006/07.

In the meantime the Bologna Declaration has been issued, which does not foresee the possibility to get the graduate diploma in engineering after the four-year study. Now the students have got the option to chose the three-year, respecively four-year study without diploma and defined qualification or the five-year study with the diploma and defined qualification. It means that the study lasts one year longer, new disciplines are inserted, the number of examinations is increased, the quality of "educational resources" keeps dropping (or stagnating in the best case), the costs of study rise and the inflow of funds is cut down year in year out.

There are no comments from industry, neither from competent official institutions or authorities, nor from professional associations or similar establishments. We shall have to adapt ourselves, proceed as did the majority and elaborate a new curriculum in compliance with official "instructions", respectively conform our high-school education to the European system. Approaching Europe is expensive and becoming a member probably even more.

What should be done? The future seems to approach faster than expected. The RGNF has decided in favour of the program 3+2+3, but it has still not been thoroughly elaborated. For instance, the kind and level of complexity of the jobs for which the three-year education graduates would be qualified, how many and what specialization subjects should be offered in the additional two years of study and the like. The application of the new programs is foreseen to start in the academic year 2005/06. Until then it is necessary to complete the plans and programs, to accomplish their accreditation and, what is of particular importance, to get the opinion of the mining industry representatives, of competent official institutions and bodies, of professional associations and others.

With regard to the subject and schedule the study has to be designed in the way to:

- assure a balanced professional and personal development;
- enable the students to include themselves into broader sphere of applications and specialization at the postgraduate study;
- develop the wish and capacity for life-long study

The expected results of such engineering education are:

- ability to apply general and engineering disciplines
- thorough knowledge in at least one engineering discipline;
- ability to identify, analyse and solve problems;
- ability for systematic approach to design and operative undertakings;
- ability for individual and team work with the capacity to be a leader or manager as well as a useful member of the team;
- ability to communicate with fellow-professionals but also with broader community;
- awareness of social, cultural, global and environmental responsibilities and the need for sustainable developmant;
- understanding of principles for sustainable design and development;
- accepting the obligation for professional and ethical responsibility;
- willingness to accept life-long study.

In order to achieve the set goals, the following actions have to be undertaken in addition to the changes in the study design:

- to provide balanced teaching of pedagogical, research, professional and communication skills;
- to promote the engagement of the teaching staff from other faculties, institutes and from industry:
- to promote cooperation with faculties educating equal or similar engineering profiles, in order to secure students mobility and to maximize the access to “educational resources”;
- to encourage greater engagement of industry in the engineering educational process (fieldwork, professional training, employment during summer months, scholarships etc.);
- to increase the share of social and humanistic subjects, and of economic sciences (management, marketing);
- to make possible the application of computer program packages (data processing and analyses, design of technological processes, modelling, simulation etc.);
- to facilitate the access to utilization of informatic technologies;
- to develop a system for life-long study, including open and distant learning (ODL);
- to introduce contents from the sphere of automation and robotization, animation and virtual reality.

Conclusion

New spheres of activities are opened to mining engineers, primarily under direct or indirect influence of ever growing concern for environment, for protection of natural resources and for realization of the sustainable development conception. There is still not any profession that would be better qualified than mining to solve, for example, the complex and demanding problems of constructing underground rooms, waste recycling, providing waste deposits and so on. The mining profession must not fail to grasp this advantage. It should be done either by forced presence in places where these problems are discussed or by offering such curricula that may skill the future mining engineers for the new challenges.

By accepting the above proposed study design, by maximizing the utilization of, respectively the access to the “educational resources” and by introducing a certain number of new courses, it is possible to accomplish the set goals, namely to educate engineers for the 21st century.

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Trends in Chemical Engineering Education

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Abstract

The education of chemical engineers tending to retain its identity has to adopt on the changes on the global market. A necessary progress is concerned with the understanding and development of systematic procedure for the design and optimal operation of process systems, ranging from nano- and microsystems to industrial scale processes. The future of chemical engineering requires the integrated approach presented at the triplet "molecular process-product-process" engineering. The core content and electives have to include generic subjects only. Holistic thinking is essential for process and product design. The life-long education and internationally recognised standards have to be accepted in order to fulfil technological and societal challenges.

Key words: *Unit operation concept; Transport phenomena; Multiscale approach; Process and product engineering; Chemical engineering curricula*

Introduction

For the purpose of this document the following definition is used: Chemical engineering is the conception, development, design, improvement and application of processes and their products. This includes the economic development, design, construction, operation, control and management of plant for these processes together with research and education in these fields (Gillett 1999).

Development of chemical engineering education

Chemical engineering as we know emerged as a separate discipline at the start of the twentieth century. During his studies chemical engineer learns that complex processes should be divided into simple processing steps (such as heat transfer, distillation, fluid flow, filtration, crushing and grinding, crystallization etc.) of well defined functionality, the "unit operations" (Figure 1).

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The description of each unit operation is a more or less idealized picture of a real system.

According to this First Paradigm a chemical engineer should study the major equipment for chemical manufactoring, including construction and performance. The first book to present this knowledge was Principles of Chemical Engineering, published in 1923 by Walker, Lewis and McAdams. The authors said “We have selected for treatment basic operations common to all chemical industries, rather than details of specific processes, and as far as it is now possible, the treatment is mathematically quantitative as well as qualitatively descriptive.”

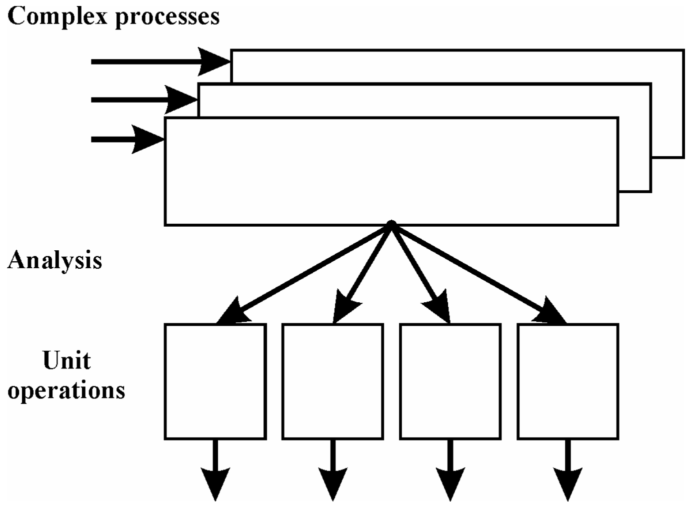

Fig. 1. The structure of chemical engineering knowledge according to the First paradigm

Chemical engineering educators adopted unit operations as the basis for the curriculum, and no one should be called a chemical engineer without knowing unit operations. In this time subjects such as stoichiometry, multicomponent thermodynamics and applied kinetics rounded out the curriculum. This dominant paradigm gave the profession prestige and success until the end of World War II. Later, chemical engineers extended the unit operations approach to include chemical reaction engineering, particulate systems, and other process systems. Initially the processes involved were continuous, but as chemical engineering science evolved from a mainly physical basis to include more chemistry and chemical reaction engineering, batch processes were involved. Finally, in this time, industrial-scale research problems were solved by the largely empirical approach of the unit operation model (Wei 1996).

In the mean time another method of solving problems using molecular explanations of macroscopic phenomena was adopted. The event that captured most attention and symbolized the Second Paradigm of Chemical Engineering was the publication of the textbook Transport Phenomena in 1960 by Bird, Stewart and Lightfoot. The authors said: "Herein we present the subjects of momentum transport (viscous flow), energy transport (heat conduction, convection and radiation), and mass transport (diffusion)… Because of current demand in engineering education to put more emphasis on understanding basic physical principles than on blind use of empiricism we feel there is a very definite need for a book of this kind." The result of the Second Paradigm in the chemical engineering curriculum was a new standard based on more advanced mathematics and fundamental physics and physical chemistry (Figure 2).

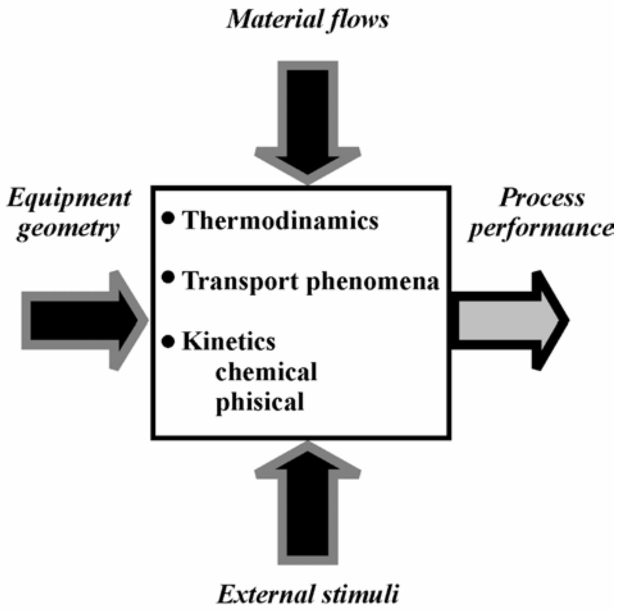

Fig. 2. The general structure of design and analysis

The development occurred at three scales-equipment level, particle level and molecular level. The process simulators encompass all three scales to calculate transport coefficients and thermodynamic properties, transformation kinetics and mass, momentum and energy fluxes. At the same time, the need to optimise processes economically prompted a systems approach to overall process design that became a core element of chemical engineering**.**

The typical undergraduate chemical engineering curriculum consists of foundation courses in mathematics, physics and chemistry in early years. The chemical engineering courses typically include mass and energy balances, thermodynamics, transport processes, separations, reaction engineering, process design, process control and laboratories where principles learned in the lecture courses are reinforced, and include elements of both written and oral communications of experimental results and analysis. Finally there are several electives to choose from, in chemical engineering as well as in other science and engineering discipline. The core graduate curriculum has essentially mirrored curriculum at the undergraduate level, with the former always being more fundamental and mathematical in content. Thus, courses in thermodynamics, kinetics and reaction engineering, transport processes and mathematical analysis based on the engineering science approach are currently required in most graduate programs. In research, chemical engineering graduate programs have moved forward to embrace all area of new technologies. There is a growing trend towards interdisciplinary research. This trend has its origin in the fact that cutting-edge problems are often in the interface between disciplines (Varma 2003).

It is obvious that chemical engineering has evolved over the five decades from being an engineering discipline rooted in the concept of unit operations to one based on engineering science and mathematics.

Today chemical engineering has to answer to the changing needs of the chemical and related process industries and to meet the market demands. Being a key to survival in globalization of trade and competition, the evolution of chemical engineering is thus necessary. To satisfy both the market requirements for specific end-use properties of products and the social and environmental constraints of the industrial-scale processes the introduction of the concept of the “chemical supply chain” seems to be useful (Grossmann and Westenberg 2000). A necessary progress is concerned with the understanding and development of systematic procedure for the design and optimal operation of process systems, ranging from nano- and microsystems to industrial scale processes (Villermaux 1996). Organizing scales and complexity levels it is possible to understand and to describe the relationships between events at nano- and microscales to better convert molecules into useful products at the process scale (Figure 3).

In order to move towards the molecular level, traditional process design will be expanded to include product design. In addition to a molecular level description of chemical transformations, there is growing feasibility to conduct molecular scale simulations to compute thermodynamic, transport and other properties of fluids and materials. Another major challenge that will remain is the design of sustainable and environmentally benign processes. The considerable developments that has taken place in process control will be aimed towards a tighter integration between design and control. The area of process operations will expand upstream to research and development and downstream to logistics and product distribution activities. The integration of several parts of the chemical supply chain will give rise to a number of challenges, especially in the area of process system engineering. In summary, the concept of the chemical supply chain will reduce the gap between science-based and system-based research due to breakthroughs in molecular modelling, scientific instrumentation and powerful computational tools.

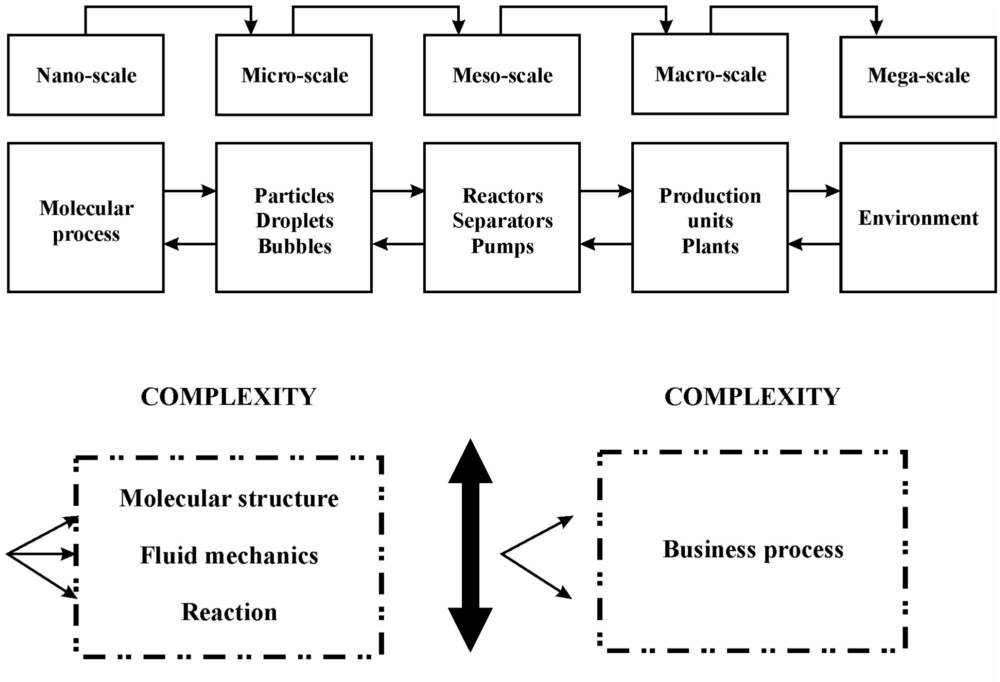

Fig. 3. Scales and complexity levels in chemical engineering

So, the future of chemical engineering requires the integrated approach presented at the triplet "molecular process-product-process" engineering. This approach which allows to understand the multidisciplinary interactions at different time and lengths scale necessary for a successful product development will be the key technology serving mankind regardless of the industries where chemical engineers work.

The future directions of chemical engineering education should remain unaltered, both under graduate and graduate, having foundation in chemistry, physics, mathematics and in biology along with a quantitative engineering science but with orientation not only to process but also to product design. The core subjects in the curriculum involving mass and energy balances, thermodynamics, reaction engineering, separations, laboratories and design should continue in the future, but with structural modifications. As it is apparent that chemical engineering methodology is available to the other engineering disciplines and covers areas involving wide variety of technologies, it is important to broaden the scope by including examples from areas such as materials processing, pharmaceuticals, and environment. The challenge of product engineering science demands modern tools of physics and physical chemistry of highly nonideal systems to be integrated, but the overall methodology remains unchanged (Cussller and Moggridge, 2001). Finally, it is important "to recognize that the professional four year BS degree is a myth" (Bowen, 1997).

Conclusion

These trends in education will help to realize the future objectives of chemical engineering: (a) to increase productivity and selectivity through intelligent operations via intensification and multiscale control of processes; (b) to design novel equipment based on scientific principles and new methods of production: process intensification; (c) to extend chemical engineering methodology to product focussed engineering, i.e. manufacturing and synthesizing end-use properties required by the customer, which needs a triplet "molecular processes–product–process" engineering; (d) to implement multiscale application of computational chemical engineering modelling and simulation to real-life situations, from the molecular scale to the overall complex production scale (Charpentier 2002).

It is important to mention that it is generally accepted that (a) Holistic approach (lateral thinking, experiential learning, synthesis, problem formulation, idea implementation, team work, societal context) and (b) Life-long learning as well as the need for internationally recognised standards are essential for chemical engineering education.

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Experimentation in Modern Education of Chemical Engineers

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Abstract

This article present idea and implementation of an intelligent tutoring system, Laboratory Tutor Expert System, LabTEx-Sys, designed to be a tool for transfer of theoretical knowledge and skills to chemical engineers students, supported by experiment. System was developed as extension of intelligent tutoring system TEx-Sys and enables communication of students and real process trough world wide web. For experimental validation of gained knowledge serves laboratory apparatus that support heat exchange process. Using LabTEx-Sys system, students gain knowledge of process, measurement and process control.

Key words: *e-learning, education, training, intelligent tutoring system, chemical engineering, measurement, process control, experimentation*

Introduction

Advancing technology sets new demands on high education. New knowledge must be incorporated within existing learning materials, and at the same time old knowledge cannot be excluded. This represents a serious problem, because the lecturing time remains the same, or in some cases even decreases, which is the case when new collegiums are introduced in learning process. Educational communities all around the world are finding new ways to deal with these problems. They utilize advanced learning technologies, such as computer-assisted instruction, computer-based training etc., what can be summed with a coupling term: e-learning.

Considering new trends in learning and teaching processes in the field of technical sciences, where skills are needed as much as theoretical knowledge, we extended principles of e-learning to education supported by experiment by developing intelli-

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gent tutoring system that specially addresses the field of measurements and process control, and we called it LabTEx-Sys, Laboratory Tutor Expert System [1].

System architecture

LabTEx-Sys is designed as extension of intelligent tutoring system TEx-Sys, Tutor-Expert System [2, 3], which proved his value in transfer of theoretical knowledge of many different knowledge domains. We extended this system with knowledge bases that include measurement and process control theory, process modelling and identification theory, and with a knowledge base of process that is to be experimented on. Third, and most significant extension is laboratory interface, which connects system with laboratory experiment, fig. 1.

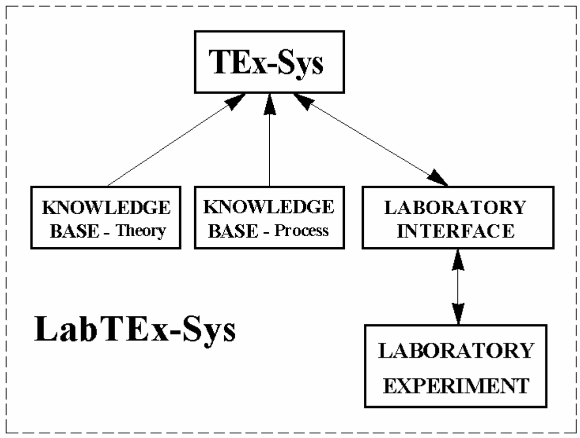

Fig. 1. LabTEx-Sys general architecture

Knowledge Bases

The TEx-Sys system is modularly structured and consists of a login model, a tutor shell T-Expert, a communication module in quasi-natural language, a questioning module and an evaluation module. It presents knowledge by semantic networks with frames and production rules. Semantic networks apply different semantic entities and relations: nodes, links, properties, and frames, property inheritance with inference engine, as well as multimedia and hypertext. The hypermedia with a rich attribute structure made by integration of multimedia and hypertext is associated with the objects in the knowledge base; hypermedia consists of textual description, icon, picture, slide, animation, sound, or even executable file.

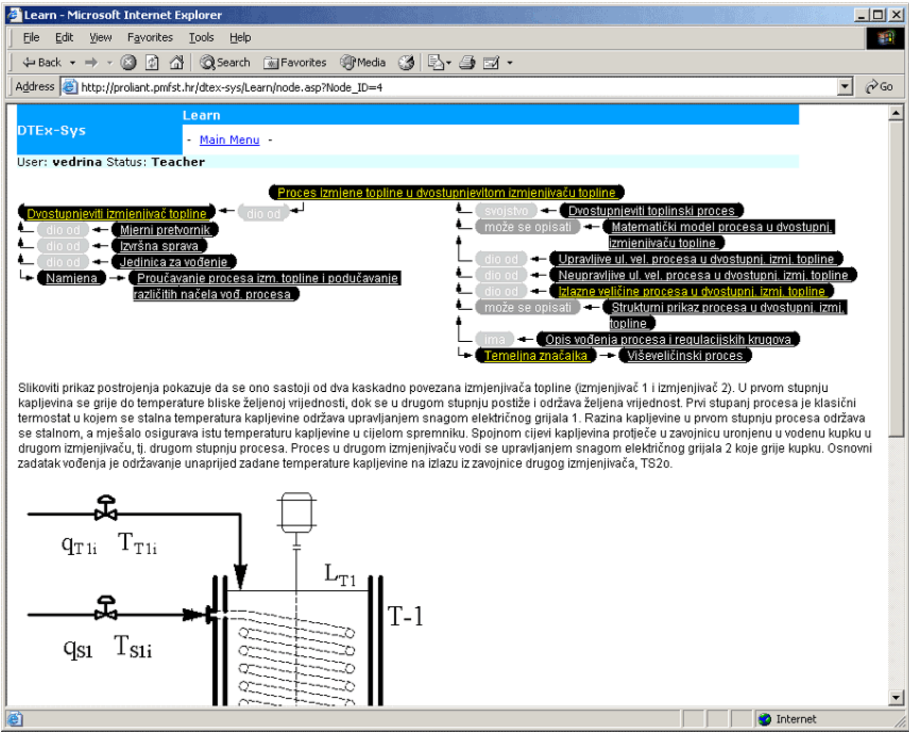

Fig. 2 Representation of knowledge within TEx-Sys

Laboratory set-up

Experimental apparatus was imagined and build to support process of heat exchange, typical for chemical process industry. Process fluid must be heated to a specific temperature, which must be maintained within strict limits regardlessly of flow changes. Process evolves in two stages, as shown on fig. 3. This increases system complexity, but at the same time allows us to implement and compare different process control principles and strategies, such as feedback control, feedforward control and adaptive control.

Apparatus is equipped with numerous sensors and control devices, such as RTD, flowmeters, heaters and control valves, which are connected to control device, Honeywell's UMC800. Relevant process data is acquired from this device by a LabTEx-Sys Server application, and stored in server's cache memory, from where can be transferred to the LabTEx-Sys Client application, i.e. student-laboratory interface. Communication scheme is shown on fig. 4.

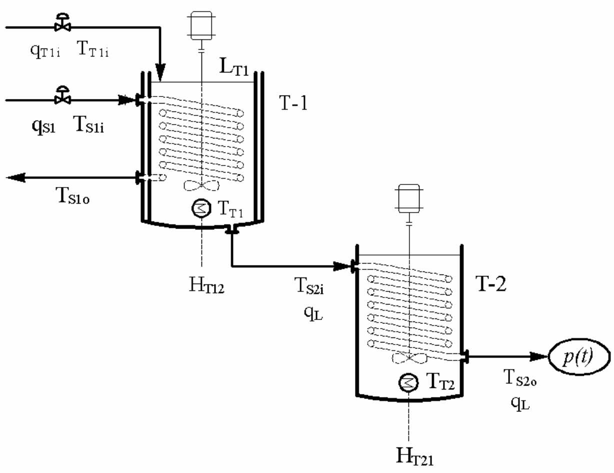

Fig. 3. Scheme of the controlled process

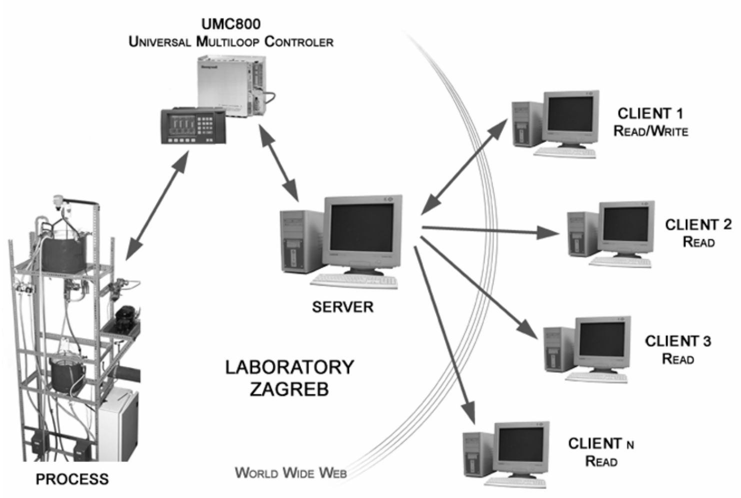

Fig. 4. Data-flow diagram

Laboratory interface

Laboratory interface (LabTEx-Sys Client application) connects students with remote processes. It consists of graphical representation of apparatus (P&I diagram) and software components (user controls) that represents process elements, measurement and control equipment. Number of these components as well as their properties can be set within client application, allowing us to adapt system to any given process. There are four types of components: sensor, control loop, control device and passive element, as shown on fig. 5.

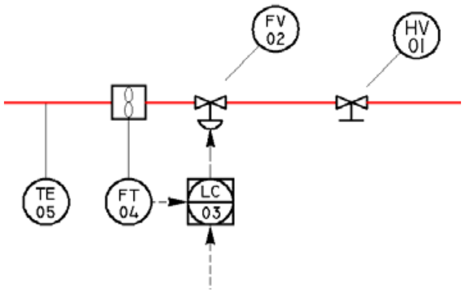

Fig. 5. Process components

Sensors (temperature element TE-05, flow transmitter FT-04), loop (level control LC-03), control device (flow valve FV-02) and passive element (hand valve HV-01)

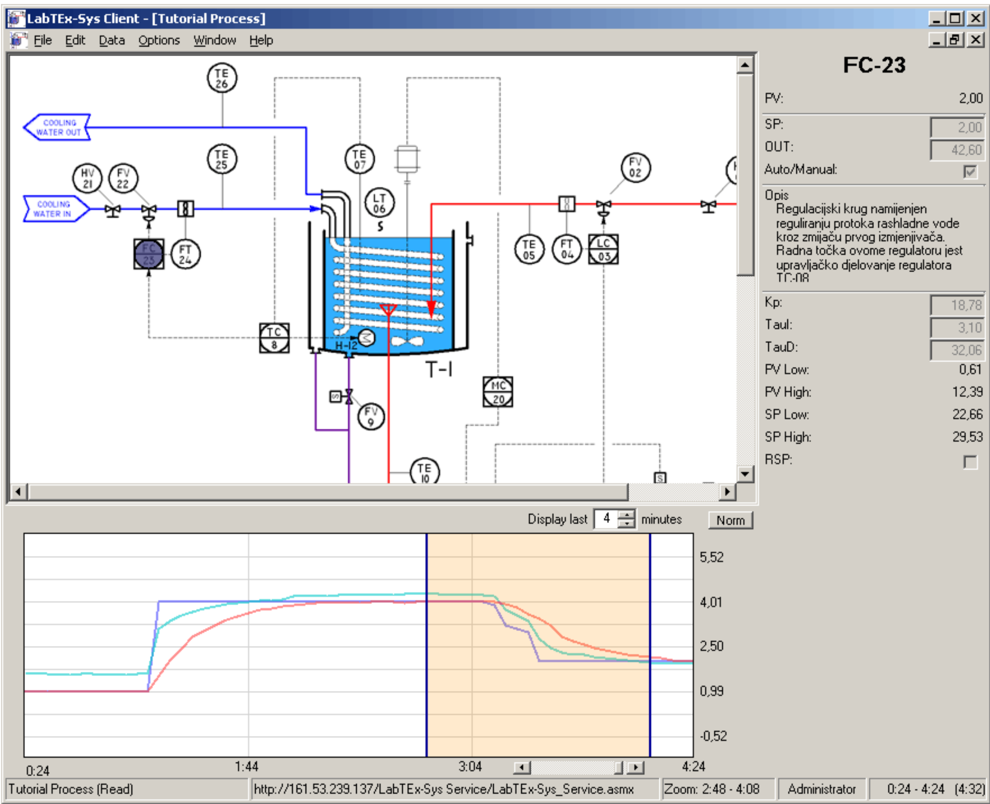

Fig. 5. Laboratory interface

Learning supported by experiment

Learning units define amount of knowledge that must be adopted by students before they can gain permission to certain stage of remote experimentation. After registration, students are pointed to learning modules of Tex-Sys, and then to questioning and evaluation modules, where they can creatively solve specific tasks, answer to questions and see achieved results. After knowledge evaluation students can experiment on remote laboratory experiment using laboratory interface, within client application of LabTEx-Sys software.

In first stage of learning, students are instructed to knowledge base of process, which consists of process and process equipment description, and a simulation of the process. Upon successfully finished knowledge evaluation, students can manually control process within LabTEx-Sys Client application. Second stage starts with learning about control loops and feedback control, in knowledge base of automatic process control, after which follows implementation of feedback control through experiment, i.e. finding optimal flow, level and temperature control loops parameters. Next learning stages involve even more complex control principles implementations, such as feedforward and adaptive control, and process identification and parameter estimation. At the end of each stage students are obligated to write reports in which they explain their actions during experimentation (which can be compared with LabTEx-Sys Server log file), and conclusions, that are subject of a later discussion with a teacher.

Conclusion

Idea and implementation of an intelligent tutoring system was presented without many technical details. Together with a described laboratory apparatus LabTEx-Sys makes unique system for teaching about process, measurements and process control. LabTEx-Sys can be easily adapted for different processes, and implements standards from automatic process control field, as well as data security principles, which makes him adequate for industrial applications, as well as academic.

Acknowledgment

Authors would like to thank all associates who made this project possible, especially to Prof. Juraj Božičević, Ph. D., Nenad Bolf, Ph. D. and Assist. Prof. Slavomir Stankov, Ph. D.

Development of LabTEx-Sys was supported by technological project of Ministry of science, education and sport of Republic Croatia, No. TP 01/12507, "Distributed laboratory for process control and tutoring".

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Education of Modern Engineers of Metallurgy in the Context of the World Development of Metallurgical Industry

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Abstract

In the developed countries metallurgy comes third or fourth in importance as a branch of the economy. Its most important product is steel, with the output of 930 million tons in 2003. The other ferrous alloys, along with aluminium, copper, zinc and lead, are also manufactured in large quantities. The average per capita world steel production amounts to approximately 150 kg. In industrialized countries this figure is several times higher, whereas in Croatia the production rate is far lower. Strong international competition poses big challenges to the metalworking industries. Those call for fast and extensive transformation of the Croatian metallurgical industry. The speed with which innovations are introduced into industrial practice is a key to its very existence and development. The basic prerequisite for keeping pace with the world in this area is to ensure first-rate education of the metallurgical engineer. This can be accomplished by bringing the university curricula up to date, and by advancing the quality of scientific research. For this substantial financial resources are needed, so is support of individuals and the society. Only through the lifelong process of education will the engineer become capable of keeping abreast of an ever faster development of the engineering science.

Key words: *education, engineers, metallurgy, development*

Introduction

Metallurgy is a science which deals with metals - their production, properties, processing and use. It is a very ancient branch of knowledge whose beginnings go to the earliest days of human civilization. The fact that the periods in the history of human culture are named after copper, bronze and iron, the metals characteristic of the time, testifies to its historical importance.

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Metallurgy worldwide and in Croatia

In the developed countries metallurgy comes third or fourth in importance as a branch of the economy. Steel, with other iron alloys, is its most valuable product. There are more than 2500 types of steel with a wide range of properties which make it the material not only of today, but as trends show, of future as well (RWTH Aachen, 2004). Major branches of the economy like metal industry, transportation, power industry, construction industry, and others, make large use of steel. Steel is therefore considered to be a strategic product. In 2003 the world steel production and consumption exceeded 900 million tons, with a tendency to grow (Figures 1 and 2); (IISI, 2003; Ekeroth et al., 2003).

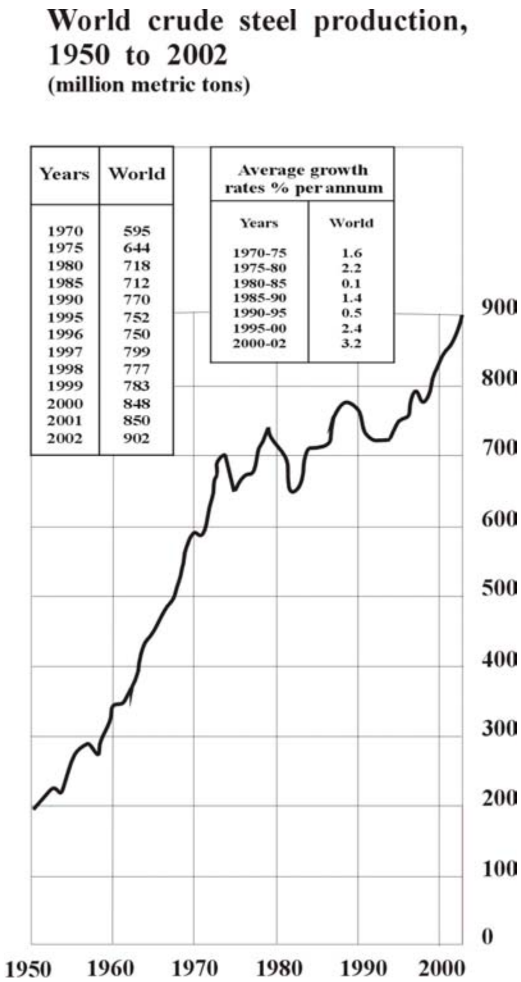

Fig. 1. World steel production 1950- 2002

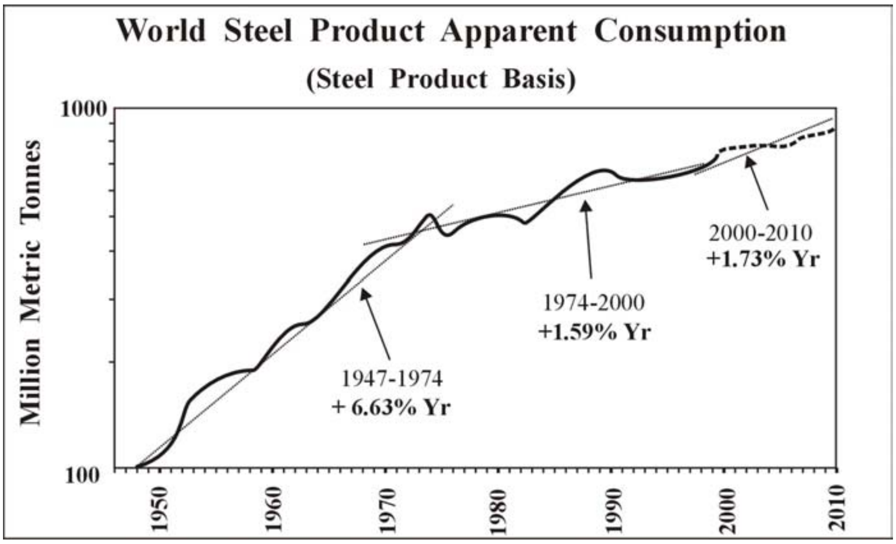

Fig. 2. World steel product apparent consumption (from P. E. Markus et al.)

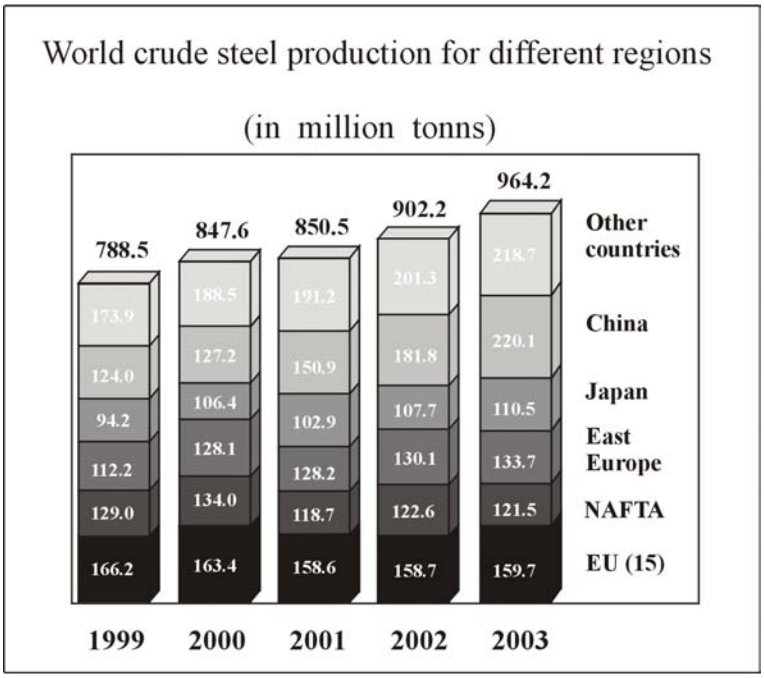

Fig. 3. World steel production in selected geopolitical areas (1999–2003)

Figure 3 shows world steel production by major geographical and geopolitical areas (Stahl Zentrum, 2004).

Major steel industries are found in China, Japan, U.S.A, Russia, Republic of Korea, and Germany (Figure 4).

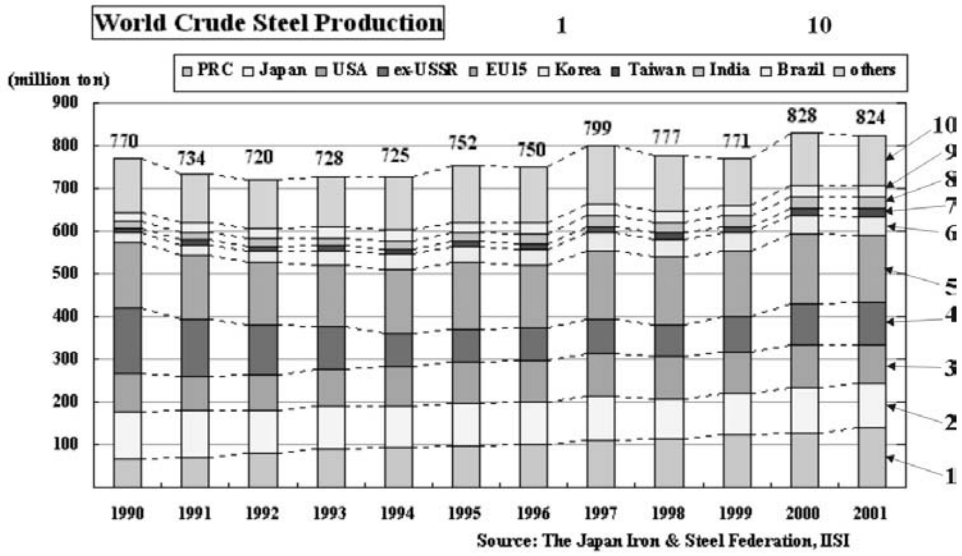

Fig. 4. World crude steel production

Ferrous alloys and metals essential to steel production, such as ferrochromium, ferrovanadium, nickel, molybdenum, and wolfram, are also manufactured at a large scale. Among the metals that occupy a vital place in certain areas of human activity are aluminium with an annual production of 25 million tons, copper with 16, zinc with 9.5 and lead with 6.5 million tons. Their individual shares are best illustrated by means of a pyramid, with steel at its bottom, and other metals with diminishing shares going upwards. At the very top of the pyramid are metals (metalloids) like silicium, germanium, gallium, arsenium, etc. The order of the metals, however, must not be taken to reflect their values in the world economy. The semiconducting and other superior features of those metals find massive application in the electronics industry, so that their output is greatly surpassed by their economic impact (Figure 5).

Strong metalworking industry is a prerequisite for a country's successful development (Ameling, 2003). Even the countries poor in ores and power products, like Japan, or small like Belgium, Austria and Luxembourg, can develop big metal industries, especially steel industry. With a world's population of about six billion people the average per capita steel production today is 150 kg. That average is greatly exceeded in the developed countries, for instance in Belgium, where it amounts to over 1000 kg per inhabitant (about nine million tons of steel per about eight million inhabitants), whereas other, mainly poorly developed or underdeveloped countries are falling far behind.

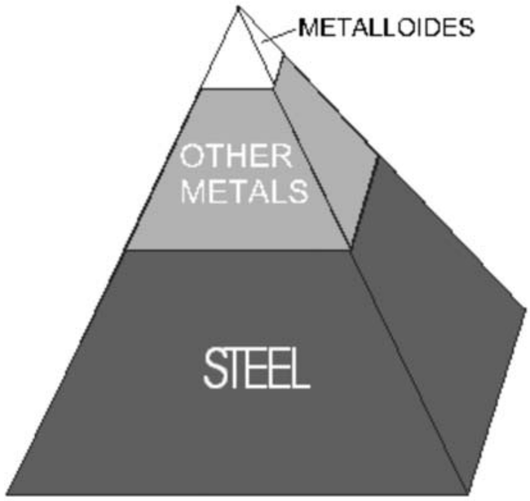

Fig. 5. Schematic view of world production of some groups of metals

The Republic of Croatia is a small country, with rather modest mining resources and a poorly developed metallurgical industry. This assertion, for certain, is not meant as a justification, but to draw attention to the state of affairs that needs to be changed by all available means and as soon as possible. Good examples from the neighbouring countries are abundant, as pointed out above. With the current annual production of about 100 thousand tons of steel per four million inhabitants Croatian per capita production comes to 25 kg, which is far below the world average (Gojić et al., 2002).

Croatia has two ironworks, one in the town of Sisak, and another in Split. Both works have been going through a period of privatization and are burdened with serious problems. The recovery process at the aluminium industry in Šibenik is not yet over. Its current production rate is about 25–30 thousand tons per year. Situation is only slightly better with some larger- or small-scale casting plants in the country, of a total of forty or so, having an annual production of about 50 thousand tons of cast products most of which is exported (Table 1). Other metallurgical plants (small rolling mills, zinc workshops, etc.) are hardly worth mentioning (Mamuzić, 2004).

Table 1. World Casting Production - 2002

World Casting Production - 2002 (Metric Tons)

Country	Gray Iron	Ductile Iron	Malleable Iron	Steel	Copper Base	Aluminium	Mag.	Zinc	Other Nonferous	Total
Austria	52,524	117,539 [A]	-	14,630	4,121	102,912	3,917	10,661	-	306,304
Belgium	77,954	18,593	36,979	11,461	534	25,050	-	1,137	50	171,758
Brazil	1,219,207	493,652	23,189	87,156	13,735	122,048	4,074	7,570	-	1,970,631
Canada*	684,000[A,D]	-	-	152,000	-	76,000[E]	-	-	-	912,000
China	9,840,108	2,994,986	451,788	1,692,109	156,966	979,290[C]	-	146,316	-	16,261,563
Croatia	27,583	11,799	90	1,171	603	9,907	-	580	1,343[F]	53,076
Czech Republic	247,009	42,783	9,851	81,911	1,766	55,839	2	1,935	56	441,152
Denmark[L]	52,853	34,444	-	-	1,322	-	-		-	88,619
Finland	55,568	43,283[G]	-	16,678	3,898	5,287[C]	-	474	8	125,196
France	2,513,000[A,D]	-	-	114,939	-	390,241[E]	-	-	-	3,018,180
Germany	2,253,278	1,276,751	38,277	181,358	89,993	660,548	24,506	66,624	4,107	4,595,442
Great Britain[I]	545,000	326,000	15,300	-	-	-	-	-	-	886,300
Hungary	50,435	12,375	53	5,576[K]	2,312[K]	63,401	-	2,491	116	136,759
India	2,370,000	300,000[J]	30,000	325,000	-	242,000[E]	-	-	-	3,267,000
Iran*	280,000	95,000[J,H]	1,500	28,000	25,000	30,000	-	5,000	-	464,500
Italy	932,855	443,840	9,650	74,521	110,000	777,000	13,100	79,600	-	2,440,566
Japan	2,351,141	1,742,123	81,064	232,388	86,763	1,217,129	166	34,463	6,523	5,751,760
Korea	925,100	523,400[J]	47,900	144,500	21,600	45,500	-	-	5,500[B,C]	1,713,500
Mexico	800,000[A]	175,000	-	300,000	175,000	480,000	-	100,000	-	2,030,000
Netherlands*[I]	66,100	60,300	5,200	700	-	-	-	-	-	132,300
Norway	19,606	44,247	-	3,483	3,458	23,278	-	-	-	94,072
Poland	389,494	101,907	14,642	44,005	5.127	97,922	72	6,605	312	660,086
Portugal*	33,700	51,500	100	14,400	5,950	17,450	350	1,550	115	125,115
Romania*	255,473	20,736	5,840	53,798	9,984	18,100	-	1,560	-	365,491
Russia**	4,400,000[A,D]	-	-	1,200,000	-	600,000[E]	-	-	-	6,200,000
Slovenia	57,606	25,616	4,200	22,420	3,488	21,882	5,519	2,925	200	143,856
Spain	592,170	642,600[J]	22,750	80,180	8,720	265,800	-	16,400	-	1,628,620
South Africa**	221,200	88,400	1,400	144,496	5,000	45,600	-	3,500	2,020	511,616
Sweden	156,800	57,000	-	20,800	10,000	37,100	1,600	4,200	-	287,500
Switzerland	29,020	51,373	-	-	2,319	17,083[C]	-	1,736	-	101,531
Taiwan	722,600	275,000	8,000	62,700	49,000	267,000	5,000	50,000	1,840	1,441,140
Thailand	67,080	100,800	1,350	1,300	-	3,200	-	-	2,600	176,330
Turkey	620,000	139,000	7,600	110,000	2,120	41,350	-	1,530	-	921,600
United States	4,463,424	3,703,190	115,214	840,067	266,716	1,876,997	78,019	297,562	170,553[K]	11,811,742
Ukraine	626,610	40,000	10,000	266,060	11,000	20,500	-	-	-	974,170
TOTALS	**37,998,498**	**14,053,237**	**941,937**	**6,327,807**	**1,076,495**	**8,635,414**	**136,325**	**844,419**	**195,343**	**70,209,475**

* 2001 tonnage ** 2000 tonnage

A) includes malleable iron
B) includes zinc
C) includes magnesium
D) includes ductile iron
E) includes all nonferrous
F) lead castings
G) includes white iron
H) includes 15,000 high alloy cast iron (mostly High Cr ball mills)
I) ferrous reported only
J) includes pipe
K) includes investment castings
L) only copper reported for nonferrous

In terms of strong international competition steel and metalworking industries are faced with ample challenges. To stand up to those challenges an overall transformation of the industry is required. Those who do not take part in the process in time will not be able to keep in the marketing stream. Joining the process as observer is not enough; action and creative changes are called for. So far the Croatian metallurgy has not responded in time or satisfactorily. The changes required are complex. Manufacturers all over the world are daily confronted with a rising competitiveness. This is the time of global economy. Within the framework of fast technical progress, demanding customers and pressing requirements of financial market, the industry must prove again and again its ability to compete. For the metallurgical industry computerization and introduction of information and communication technologies are yeast to its fast development. Generally speaking, the industrial society has been undergoing rapid transformation into a society of communication and science. The speed with which innovations are introduced into metallurgical production is a key to its very existence and further development. It may come as a surprise that the material steel, with a lifetime of over a hundred years (from today's standpoint), still has an enormous evolutional potential. More than half of the steel classes currently on offer on the market are under five years of age! On the other hand, metallurgical aggregates (e.g. the blast furnace) have been expanding capacity, while small unprofitable works have been facing closure. Fully automated, computer-controlled, and expert-system-guided facilities are being introduced into all branches of industry, metallurgy as well. As a result, the number of employees in the metallurgical industry has dropped significantly but at the same time, a rise in productivity has been noted (Figures 6 and 7).

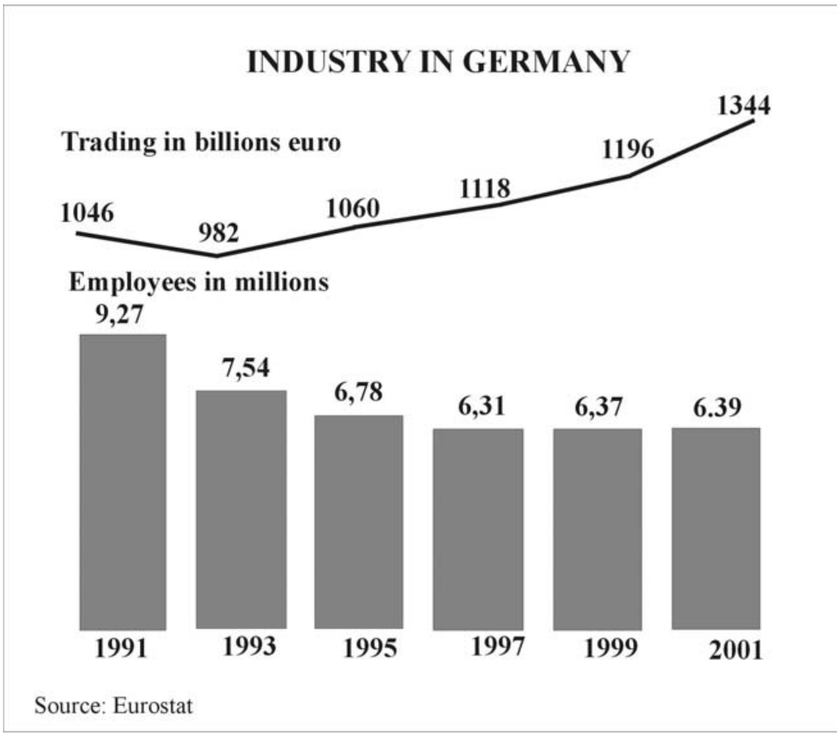

Fig. 6. Comparison between trading and workforce in Germany

In steel industry the percentage of highly qualified engineers has been steadily increasing in relation to the total number of workforce. A similar trend can be noted in Germany (Figure 8).

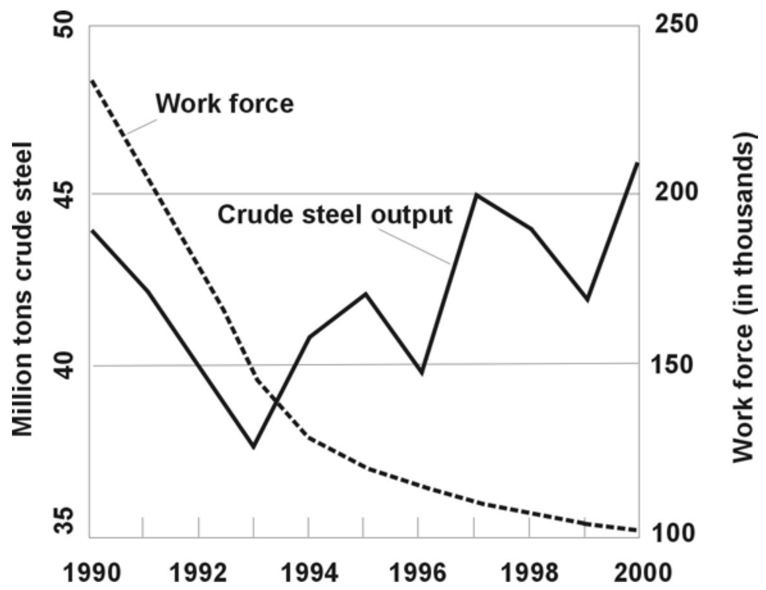

Fig. 7. Relation between workforce and crude steel output in Germany
(Source: German Steel Federation, 2000)

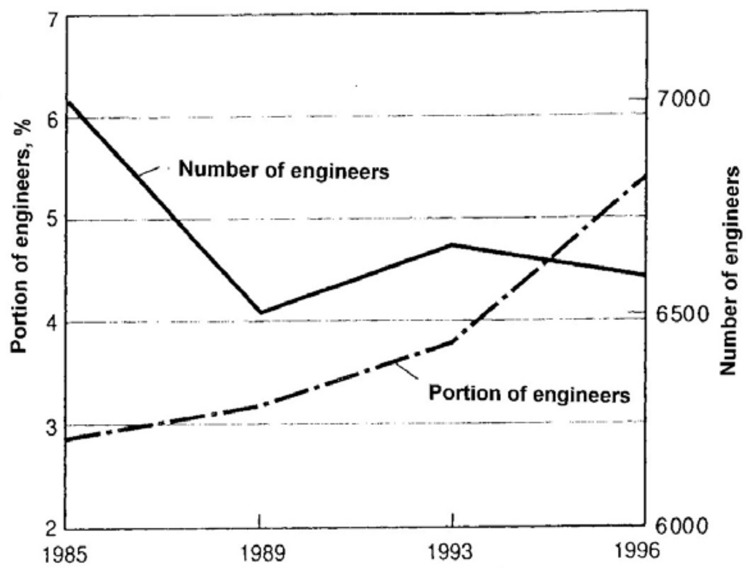

Fig. 8. Number and percentage of engineers in relation to overall number
of workers (Source: German Iron and Steel Institute, 2000)

Quickly, and in growing numbers, producers have been turning into service providers. This means that metallurgy has been undergoing transformation into a service industry, with the production based on orders from known purchasers. Quality education of the metallurgical engineer has become a basic prerequisite of his keeping pace with fast advancement of the profession. Yet knowledge alone has long been only one piece of the puzzle. Only when accompanied by creativity, team spirit and responsibility-based self-motivation can knowledge be effectively applied. It is the speed with which the process of knowledge implementation occurs that is so decisive in the race for competitive advantage at the world level.

In Croatia, like in other countries, development of metallurgy is not feasible without interdisciplinary cooperation with a number of economic and academic institutions, in the first place with the Faculty of Metallurgy. Today, more than ever before, a saying holds true: for those aspiring to success first-rate and permanent education is a must. Well aware of those successful metallurgical companies worldwide have been investing more and more into the education of their current and future employees, through close collaboration with educational institutions (Figure 9).

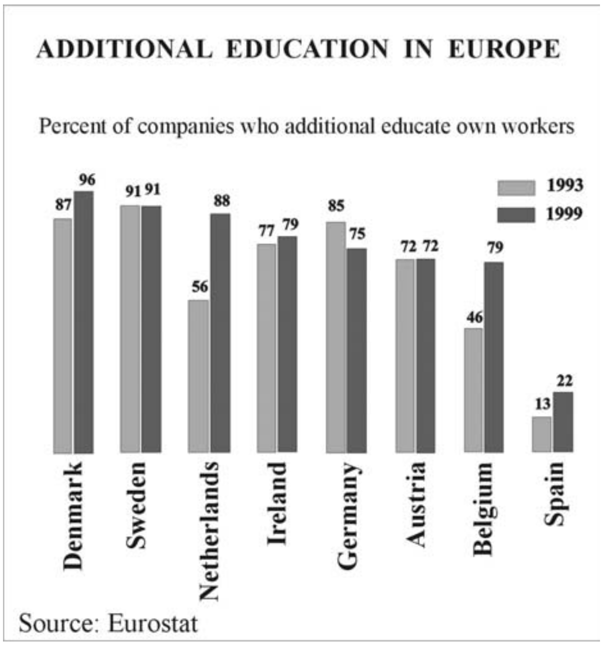

Fig. 9. Additional education in Europe 1993–1999 (IG metal, 2004)

Educating the Metallurgical Engineer for the Future in Sisak (Croatia)

Proposing a scenario of the prospective development of metallurgy in the 21st century is hardly possible, and even an attempt to do so would appear slightly pretentious. We are therefore going to confine our considerations to what the near future has in store for us.

It goes without saying that the beginning of this century continues to be strongly marked by natural sciences and engineering, among which molecular biology, global information technologies, and new and smart materials are expected to predominate. In the coming years new technical, technological, social and geopolitical issues will have to be tackled. What is our reaction to the challenges of the new century going to be? Answer to that question can only be based on knowledge, will, high level of organization, competence, and individual responsibility. Inevitably, geopolitical areas of "protected standard" are bound to become restrained. Those who fail to recognize the forthcoming need for change, or to enter the process as creators and not merely as participants, will have to bear the consequences. Croatia is a small country whose natural resources are modest. The only way to take part in the distribution of the world's economic cake is through advancement of engineering education and development of science (Figure 10).

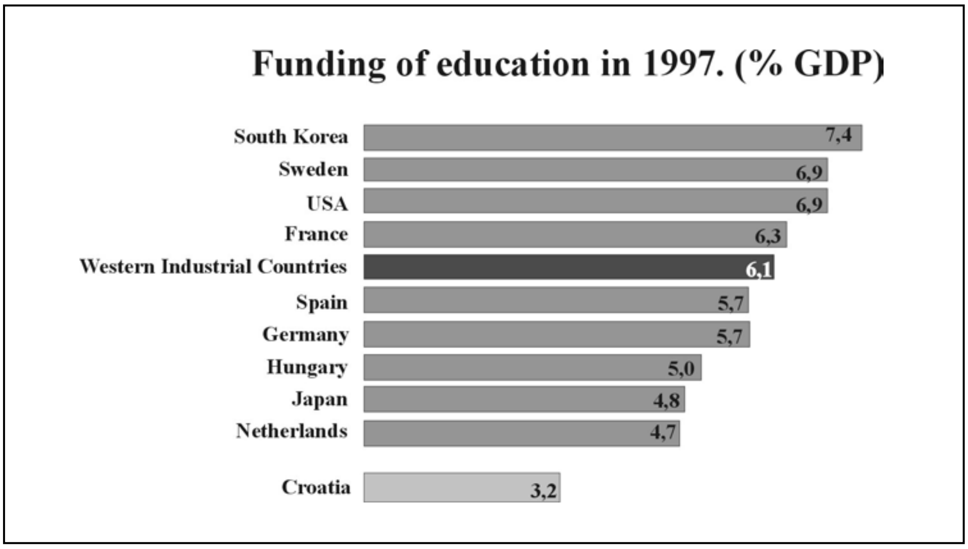

Fig. 10. Funding of education in Croatia and in some other countries

By reaching that aim we could lay firm foundations for a small but advanced and competitive industry. From comparison with the developed western countries in Figure 10 it becomes apparent that the government funding of education (and also science) in Croatia expressed as GDP percentages is far lesser than in those countries. Comparison becomes even less favourable if the Croatian funds are considered in relation to those of South Korea, Sweden, or the U.S.A. The planned increase on 2.5% GDP (in year 2004) for science in Croatia is not going to make the difference any lesser because the same countries also plan to increase investments for this purpose.

According to Kondratieff the evolution and progress of mankind over the past two centuries have been carried on the "long waves" of major inventions made in those centuries (W. A. Herrmann, 2001). The change from the agrarian society to the industrial one has taken place in cycles. The period from 1800 up until 1850 can be named the steam engine era, that from 1850 to 1900 the steel and railway era, from 1900 to 1950 the electrotechnical science and chemistry era, the one from 1950 to 1975 the era of petrochemical and automobile industries, and from 1975 to 2004 and on as the information technology era. In the new century three candidates seem to have emerged as promoters of future development. This does not necessarily mean that only one will be predominant. Development might be headed, and it seems very likely that it would be, by a remarkable, closely connected trio: information science (knowledge network), smart materials and biotechnology (encompassing environmental protection and public health).

A special place among the smart materials will be held by those of metallic origin, which will certainly serve as catalysts for the new innovation cycle. These are, in the first place, optoelectronic materials many of which have already found application in CD players, photocopying machines, laser scanners, LEDs, etc. Then there are nanomaterials with promising application in medicine, in the electronics industry, in the power industry, etc. Investigations of whiskers, metallic glasses, superconductors, semiconductors, SMA materials, new composites with special characteristics, etc., should also be noted. From non-metallic materials here is a new generation of glass fibres capable of transmitting, in the space of one second, over a distance equalling the Earth's circumference, huge amounts of data, which could match the contents of a row of books 50 km in length.

Naturally, new technologies cannot be expected to act for themselves or to be sufficient. For the most part they are going to rely on present achievements, and on the most advantageous processes and best products of classical technology. To those belong some current products of the metallurgical industry, steel in the first place.

The Faculty of Metallurgy, future metallurgical engineers and metallurgical industry face big challenges. Fast development of information and communication technologies, and a rising competitiveness worldwide demand to be responded to quickly and competently. In that respect the University of Zagreb and its technical faculties occupy a vitally important role.

The Faculty of Metallurgy in Sisak, as a part of University of Zagreb, has been in existence for over 40 years. It provides education at the graduate and postgraduate levels, to graduate engineers, and masters and doctors of science in metallurgy. Presently, there is a total of about a hundred students and twenty postgraduate students. The number of students could increase provided another course of studies opens or a present one is expanded. Scientific research is at the core of further development of the profession, and goes hand in hand with educational and teaching programmes. Five science research projects are currently going on at the Faculty, as are a number of technological projects, which receive a financial support from the Croatian Ministry of Science and Education.

Survey of historical development of the metallurgy departments in other countries allows to draw a general conclusion. Most departments have completed the process of transformation and, having changed their names to contain materials in the title, have become known as "Faculties of Metallurgy and Materials Science". According to M. C. Flemings, in the United States the process, which was by no means simple, involved successive introduction of new subjects and contents from the field of metal materials (Fleming, Suresh, 2001). Until 1970 50 per cent of metallurgy departments had changed their names as well as fields of interest, more than 80 per cent of the departments did so by the year 1990. Today, percentages are certainly higher. Similar changes, although slightly later than in the United States, are taking place at universities in the adjoining countries, in Ljubljana (Slovenia), Leoben (Austria), practically all over Europe.

A great part of teaching as well as of research at the Faculty of Metallurgy is concerned with the production, structure, properties and use of metal materials, as well as with technological advancement. On the whole, we can say to have followed the world-wide trend, at least in the field of metallic and fire-resistant materials, although we have kept the Faculty's title.

Bearing all this in mind we have a question to answer: how are we to devise a modern teaching curriculum at the Faculty of Metallurgy which will generate, as a result, an engineer capable of meeting the demands of the 21st century, and how are we to ensure a high teaching level for a relatively small number of students? Current legislation does not make it possible for a limited number of students to be taught by a sufficiently large number of teachers of different specialities, or to have at disposal research equipment by means of which the desired level of education can be reached. Which are the prerequisites and can we meet them? Bound by international agreements Croatia is committed to carrying out the obligations she has accepted in the sphere of higher learning. Let the "Bologna Declaration" serve as an example. Still, our approach to transformations ought to take into account our historical, cultural and social heritage, the more so as we too wish to become part of the united Europe. If the commitments undertaken are accepted only formally and real changes in university education are not implemented, the desired results will fail to materialize.

All over the world the sum of knowledge is considered to grow much faster than human population. Some authors claim that knowledge is increased twofold every ten years, others are of the opinion that the speed is much faster. The process of implementation of educational changes must be continuous if it is to take account of technical innovations. To accomplish that the concerned partners, which have been very few, should be sought in the metallurgical industry. Without joint action of the Faculty and industry there is no real chance of actual progress for either. The following rule should apply in industry: research and production must go hand in hand, and research must be directed to feasible prospective production.

Current revision of undergraduate, graduate and doctoral programmes at the Faculty of Metallurgy aims at bringing them up to date, and making them more productive and in line with the international programmes. To amend the compatibility between the Faculty and European universities and thus to enhance student mobility the ECTS scoring system has been introduced. It is well established that the interest in engineering studies of the young in Croatia, particularly in metallurgy, is gradually declining, as is the case all over Europe. In view of such circumstances it is imperative to make technical studies more attractive to the young candidates by ensuring high research and teaching levels, and by providing well-equipped laboratories and modern information technology. This, of course, is not enough. It is essential to change the society's attitude to education, engineering science and science in general, in other words, to alter its perception of the engineer's status. Change of attitude will take place only when industry achieves a high level of organization and development. The goal can be realized only with the help from engineers themselves.

In the field of education competition is already at the door and market relations are waiting to be introduced shortly, as indeed they have been in the greater part of Europe.

Conclusion

Future is going to need engineers who not only know how but are capable of and willing to engage themselves as business-oriented engineering experts with excellent communication skills and a sense of social competence. To an engineer, lifelong learning will become a natural necessity. Meeting and following the changes that come with fast technical and scientific development is not an easy task. It calls for top-quality education and knowledge in the first place but at the same time it also demands financial means, the time in which to achieve the goal, and a sense of responsibility. Here in Croatia, we seem to possess a good deal of knowledge, we do not have too much time on our hands, and our financial resources are rather scarce, as is the sense of responsibility. The technical proficiency of the modern engineer supported by environmental awareness and comprehensive general education will enable him to understand different cultures and their social and religious distinctions, and to respect their geopolitical views. Modernization of education is a process which cannot be avoided, and the sooner we start on its path the better the results of our actions are going to be.

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Course of Study of Materials Engineering at the Faculty of Mechanical Engineering

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Abstract

The Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, has developed the curriculum for the new course of study "Materials Engineering" which the students could take for the first time starting from the academic year 2004/2005. The study is designed according to the Bologna Declaration and divided into two parts: 7 semesters until acquiring the title of Baccalaureus and additional 3 semesters to acquire the title of the graduate engineer (or the Master's degree). The total number of ECTS credits is 300 (210+90). The first year is common for all the courses of study of mechanical engineering, whereas in the second year the students take a certain course of study.

The weekly obligation does not exceed 25 lessons, and the maximum number of exams during one year is nine. Every course is accompanied by exercises.

The structure of the study consists of the compulsory basic and technical subjects of the study of mechanical engineering, specific subjects in the course of study and the optional technical and non-technical subjects. The share of the fundamental subjects is about 40 per cent; professional technical subjects about 50 per cent and non-technical subjects about 10 per cent. From the fifth semester the students elect a total of nine technical and non-technical subjects. Two independent projects and industrial practice in the duration of one month twice during the study are compulsory.

The central paradigm of study is the strong structure-processing-properties-performance interrelations and connections. This approach will provide students with the foundations for a productive career in the changing environment.

Key words: *course of study, materials engineering, mechanical engineering*

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Introduction

The development of individual engineering professions is increasingly conditioned by and related to the knowledge of materials and the respective technologies. In the past the discovery, production, shaping and treatment required only the skills of individuals, and today these require an entire scientific approach. The research, development and application of engineering materials involve the work of interdisciplinary teams of scientists and experts. The advanced materials have been developed owing to the application of the knowledge in physics, chemistry, biology, mathematics, computers and various engineering professions (Figure 1).

The synthesis, combining of data and knowledge and the synergy are the basis of producing new materials and the respective technologies as well as innovative products.

The number and diversity of materials is growing, different properties are searched for, and the development of production technologies not known previously is becoming necessary. The research is focusing on new alloys, engineering ceramics, different types of polymeric, metal and ceramic composites, intelligent and functional materials, as well as computer modelling, simulations and design of composition and structure of materials with the desired properties.

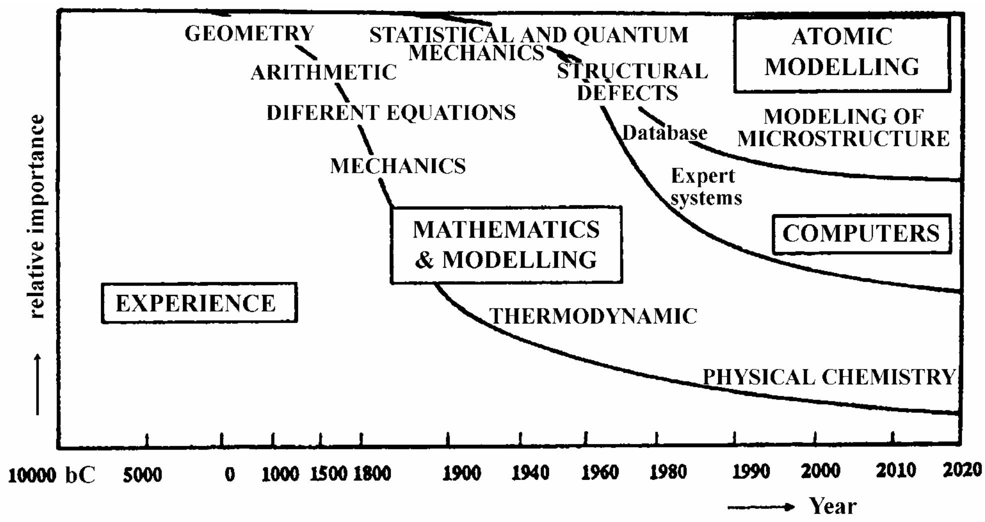

Fig. 1. Necessary knowledge and methods in the development of materials through history /Krempasky, 1994/

One of the basic characteristics of current research of materials are also the attempts at *mathematical modelling* of phenomena at the atomic and molecular level and establishing relations between the structure composition and the desired properties /Dalton, 2002/. The first products have been realised already by the integration of the modelling based on the "end-to-end" theory (from quantum mechanics to the simulation of assemblies and entire products). Based on such integrated approach the flows of experiments would be directed: from the synthesis of molecules to the processing into materials of nano- and mezzo-size unit cells or to the production of assemblies and devices (Figure 2).

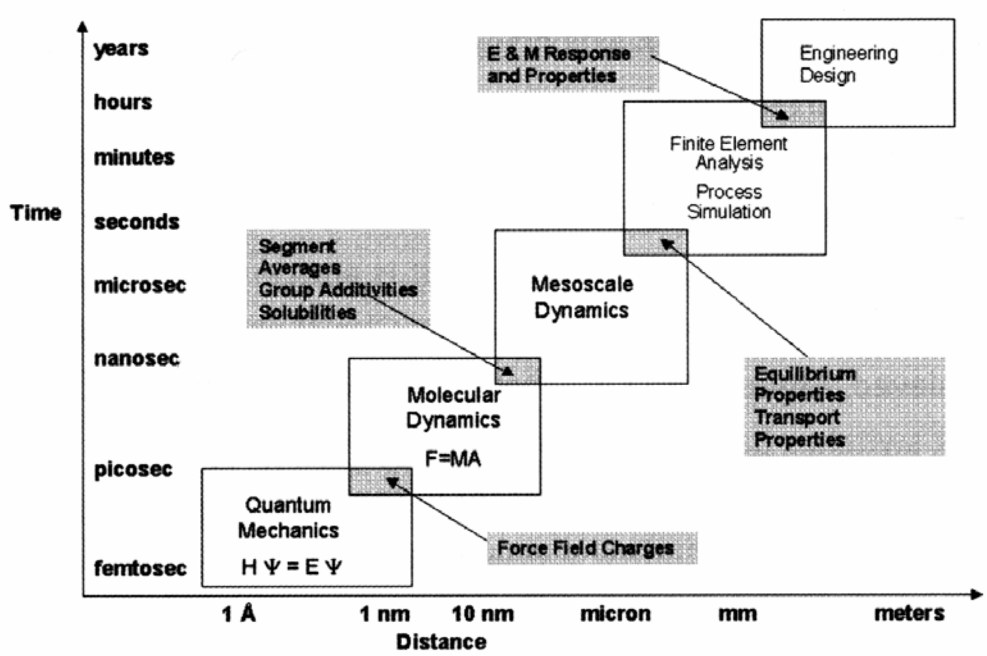

Fig. 2. The organisation of the end-to-end theory effort /Dalton, 2002/

Materials Science & Engineering - MSE, (German: Werkstoffwissenschaften und Werkstofftechnik) is considered as one of the generic branches – along with biotechnology, information technology and communications. New knowledge and innovations in the field of materials have started the development of new products and processes in a number of other branches of science and technology – mechanical engineering, naval architecture, aviation, electronics, optical engineering, civil engineering, medicine, etc. Many of the manufactured artefacts which had so influenced peoples' lives in the 20th century and whose development had depended critically on MSE were already in common use /Nicholson, 1997/: high performance cars, aircrafts, gas turbines, nuclear reactors, consumer durables, modern bridges, computers, sports appliances etc.

According to Sir R. Nicholson /Nicholson, 1997/ there are two key characteristics of modern MSE: "*utility* and *hugeness (wideness)"* of discipline. MSE is an applied subject, the purpose of which is to provide materials that people need in a form in which they want them. That is not to say that the science (or engineering) is any less "fundamental" or intellectually demanding than in other subjects, but it is directed towards an understanding of materials and materials processing with a clear end point of utility rather than curiosity. The intellectual demands on a materials science and engineering lie as much in the need to master the breadth of the subject as in the depth of knowledge in any part of it". The above two characteristics point out that MSE could bridge the fundamental science and applied discipline more effectively than any other one.

Study of Materials Engineering

In the last thirty years, the undergraduate and postgraduate studies in the world include independent departments, courses and faculties for materials – a number of studies in the U.S.A., ETH Zürich, Montanuniversität Leoben, TU Dresden, TU Bochum, University of Trento, Cambridge, Košice, etc.). At the beginning these studies were established as a result of restructuring of the classical studies of metallurgy, mining, physics or chemical engineering. At the beginning of the 1970s, less than 50% of the metallurgy and mining departments in the US had changed their names to contain materials in the title /Flemings, Suresh, 2001/. Two decades later, 80% of the departments had done so. In Europe, the evolution of materials departments is difficult to assess. In some countries, universities are organised as a group of institutes or faculties rather than departments. The last ten years could see the establishment of the courses of study in materials science and engineering at the engineering studies, especially at those of mechanical engineering.

The basic characteristics of the academic teaching of materials in Croatia are the following: the study related to the materials science and engineering does not exist at any of the Universities or Faculties. At some technical faculties (Faculty of Chemical Engineering and Technology, Faculty of Mechanical Engineering and Naval Architecture, Faculty of Civil Engineering) there are courses of study and optional modules at the undergraduate and postgraduate studies, and they offer some more detailed study of the engineering materials. At the Faculty of Metallurgy in Sisak, the production and forming technologies of metallic materials are studied, and at the Faculty of Chemical Engineering and Technology the focus is on polymeric and ceramic materials. Several years ago, the University of Zagreb started to organise a postgraduate interdisciplinary study of Materials Engineering but until today that has not been carried out.

The Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, has developed the curriculum for the new course of study "Materials Engineering" at the study of Mechanical Engineering which the students could take for the first time starting from the academic year 2004/2005. This course of study is the result of the 30-year experience of teaching at the course of study Materials of the current study of mechanical engineering (course: production engineering) that the students can take in the 7th semester. Ten to twenty students selected this course of study every year, which was the average number of those who signed up for other courses of study.

The study of Mechanical Engineering and the course of study Materials Engineering are designed according to the Bologna Declaration and divided into two parts: 7 semesters until acquiring the title of Baccalaureus and additional 3 semesters to acquire the title of the graduate engineer (or the Master's degree). The total number of ECTS credits is 300 (210+90). The first year is common for all the courses of study of mechanical engineering, whereas in the second year the students take a certain course of study.

The weekly obligation does not exceed 25 lessons, and the maximum number of exams during one year is nine. Every course is accompanied by exercises. The share of the fundamental (basic) subjects is about 40 per cent; professional (technical) subjects about 50 per cent and non-technical subjects about 10 per cent. From the fifth semester the students elect a total of nine technical and non-technical subjects. Two independent projects and industrial practice in the duration of one month twice during the study are compulsory.

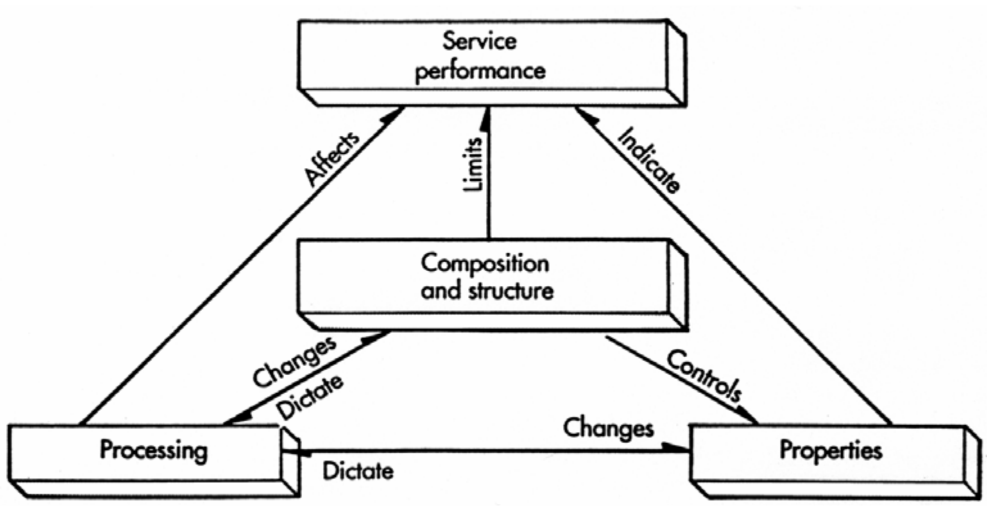

Fig. 3 - Relationships between the concepts of materials engineering /Stammers, 1990/

The curricula of the study of materials engineering at the Faculty of Mechanical Engineering and Naval Architecture have been deduced from the analyses of the curricula of the studies of materials at the ETH Zürich, Montanuniversität Leoben, TU Dresden, University of Trento, and the University of Cambridge.

The central paradigm of the MSE discipline is the strong structure-processing-properties-performance interrelations and connections (Figure 3). This approach will provide students with the foundations for a productive career in the changing environment.

After having adopted the theoretical bases, following this paradigm, the concept of the study follows the combination of acquiring knowledge from these three interconnected units:

- product development (methodology, computer application in the design and analysis of structures);
- technologies - production, forming, bonding, heat treatment and surface modification of materials and products;
- structure, properties, selection, application and behaviour of materials.

Materials engineers develop their understanding of materials properties and performance by relating to their composition and structure. The widely known examples are the changes in composition, microstructure and properties induced by heat treatment or by welding processes. On the other hand, designing the structure and form of the products, adapted to loading characteristics in use, is modern concept for the development of composite materials.

The education in materials engineering should not produce a specialist such as a corrosion or a welding engineer, but rather prepare the student to be able to solve the problems in designing and manufacturing or in the use of the products.

The structure of the study consists of the compulsory fundamental and professional subjects of the study of mechanical engineering, specific subjects in the course of study and the optional technical and non-technical subjects.

Compulsory subjects cover the following areas: Materials, Mathematics, Statistical Methods and Planing of Experiments, Computer Application, Applied Mechanics, Strength of Materials, Machine Elements and Design, Electro-engineering and Electronics, Automation, Methods for Structural Analysis and Design of Product, Technologies – Casting, Polymer Processing, Deformation, Machining, Welding and Joining, Materials Protection, Tools and Devices, Quality Control and Assurance, Organisation and Production Management.

Specific subjects of materials course are: Introduction in Materials Science and Engineering, Thermodynamic of Materials, Characterisation of Materials, Heat Treatment of Metals, Chemical Resistance of Materials, Metallic Materials, Polymeric Materials, Ceramics, Wood and Concrete, Composites, Mechanical Properties of Materials, Service Behaviour of Materials, Tribology and Surface Engineering, Modelling and Simulations, Advanced Materials Technologies, Selection of Materials, Recycling of Materials.

The share of the number of lessons in the specific subjects in the total number of lessons is about one third.

Optional subjects offered by the course of study of “Materials Engineering” to other courses of study at Mechanical Engineering, Naval Architecture and Aeronautical Engineering are all the specific subjects at the course, and additionally, the following subjects are offered:

Materials for Shipbuilding
Materials for Aviation
Surface Modification
Powder Metallurgy
Special Structural Materials
Heat Treatment
Tool Materials
Chemistry of Polymers
Composite Materials
Polymeric Materials
Non-metals and Composites
Advanced Materials
Technological Properties of Materials.

During the studies, the students acquire the following skills:

- understanding of nano- and microstructure of materials as well as the relation between the material structure and material properties;
- knowledge and ability to use the techniques and methods of researching and studying materials;
- knowledge of the methodology and computer support for the development and design of products;
- knowledge about producing, forming, heat treatment and surface modification materials technologies;
- understanding of the causes of characteristic behaviour of materials in real conditions of application;
- knowledge of the properties and possibilities of application of individual groups of engineering materials;
- application of the systematic approach to materials selection which takes into account all the relevant requirements and factors, including total life costs;
- monitoring and adopting new information and knowledge in the field of materials development;
- collaboration and communication with experts of different scientific or technical background (interdisciplinary thinking and team work ability).

Laboratory exercises, industrial experience and undergraduate research opportunities as well as the diploma thesis provide the possibility to develop practical skills.

Most of the final part of the study at the course will be taught by the lecturers from the Department of Materials at the Faculty of Mechanical Engineering and Naval Architecture, from two Chairs (Chair of Materials and Tribology and the Chair of Heat Treatment and Surface Engineering) where about 20 lecturers, assistants and junior researchers, as well as about 10 members of technical staff are employed. The students will carry out their practical and independent work within the technical subjects at the five laboratories of the Department of Materials: Laboratory for the Analysis of Metals, Laboratory for Materialography, Laboratory for Testing Mechanical Properties of Materials, Laboratory for Tribology, Laboratory for Non-metals, and the Laboratory for Heat Treatment.

Part of the practical work will be carried out at the laboratories of other faculties or institutes (e.g. at the Faculty of Chemical Engineering and Technology, Faculty of Civil Engineering, Institute for Physics and at the Ruđer Bošković Institute). Additionally, on-site education is planned in the production and processing plants for various types of materials.

Potential places of employment for the graduate engineers include:

- departments of testing materials and quality control in industry and government institutions;
- as entrepreneurs in founding and managing a company based on the acquired knowledge – e.g. ceramics, composites, modification processes, coating technologies, etc.;
- in shops dealing with materials and technical products – e.g. representing foreign companies;
- in research laboratories for materials;
- in institutes and centres for the development of products and technologies in industry;
- at faculties and secondary schools as teachers.

Conclusion

In the realisation of the study a number of teaching assessments require attention, like /Blicblau, 1990)/:

- emphasis on modern materials teaching with the basis in traditional materials;
- integrated teaching approach encompassing the structure-properties-behaviour concepts with applications in design and manufacturing;
- utilisation of audio-visual presentations;
- development of computer-based laboratory sessions;
- implementation of case study approach to materials design and manufacture.

Some expected problems in the course of the study include:

- a lack of awareness of freshmen students about the importance and relevance of materials in engineering and in everyday life is noted;
- insufficient basic knowledge of the students in physics, chemistry and biology;
- relatively poor level of equipment at the laboratories regarding advanced research equipment.

Based on the experiences in carrying out this study, the plans in the future include organising of interdisciplinary university undergraduate and doctoral studies that would provide stronger connections of science and engineering of materials. Such study could be the core of the university department for materials. In this form the use of the existing knowledge (human potential) and laboratory equipment would be more rational.

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Mechatronics and Robotics

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Abstract

According to the proposed new curriculum, the study of mechanical engineering at the Faculty of Mechanical Engineering and Naval Architecture would be substantially changed in its organizational structure. Instead of the current course of study-specialization structure, the new curriculum puts the stress on the proposed courses of study, while the specializations become less important, and in some cases even disappear. That is why the number of courses of study has increased to nine different courses. «Mechatronics and Robotics» is one of the new courses of study proposed in the new curriculum.

Keywords: *mechatronics, robotics, education*

The Faculty of Mechanical Engineering and Naval Architecture (FAMENA), University of Zagreb, is traditionally involved in the education of specialists in the field of engineering disciplines to satisfy the needs of this region. This study is to some extent different from the studies commonly adopted world-wide as it covers a wide range of the specialist field. In addition to traditional mechanical engineering, the study encompasses some disciplines that are offered as independent studies at a number of universities in the world. Thus, FAMENA educates specialists for working on the development, design, construction, application and maintenance of plants, machines, tools, devices and other equipment. It has taken quite a lot of time to change the perception of mechanical engineering both in public and in the specialist field as well. Mechanical engineering has come a long way from being perceived simply as the field dealing with the conversion of some energy form into mechanical work to being perceived as a wider field of specialization in which mechatronics has rightfully found its place. Therefore, the conception of the new curriculum is of vital importance in this respect, and the course Mechatronics and Robotics is probably the best illustration for that.

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Mechatronics is an interdisciplinary engineering and scientific field in which the disciplines of engineering, electronics, automation and information science meet and are integrated into a common discipline. Mechatronics is also a natural evolutionary step in and a philosophical approach to the design, manufacture and application of modern engineering systems. It is also due to the concept of mechatronics that the dividing lines between some fields have become blurred and even negligible. In addition, mechatronics promotes another important conception – the need for team work. That is why the study of mechatronics enjoys the benefit of support on the part of economy, and engineers who are specialists in mechatronics can easily find employment.

The need for a course in mechatronics has already been recognized by lower levels in our educational system. Thus, there are at least two secondary schools in Zagreb which offer a program with an emphasis on mechatronics («Ruđer Bošković» and «Faust Vrančić»). The Polytechnic in Zagreb also offers mechatronics as a course of study which is very popular among students and the number of students enrolled in the course increases constantly.

Mechatronics was first offered as a course of study in Europe more than a decade ago. It is often offered as a field of specialization within a course of study, and sometimes as an individual course of study. The following four courses of study have been taken as models for establishing the field of specialization Mechatronics and Robotics at the Faculty of Mechanical Engineering and Naval Architecture:

- *Mechatronics* - Johannes Kepler University of Linz, Austria
- *Mechatronics & Micro System Engineering* - University of Applied Science, Heilbronn, Germany
- *Automation & Mechatronics* - Chalmers University of Technology, Göteborg, Sweden
- *Mechatronic Engineering* - Faculty of Engineering and Design, Dublin, Ireland

All these courses of study have the idea of mechatronics as a common feature. At the same time they differ depending on their tradition and on the part of mechatronics on which they focus special attention. Duration of the study is 4 or 5 years, and it is divided into semesters. An exception is The Chalmers University of Technology, where the academic year is divided into quarters. The University of Applied Science, Heilbronn, follows the German tradition so the 3rd and the 6th semesters are dedicated to practical work. The Johannes Kepler University of Linz is one of few institutions which include Precision Engineering into its curriculum, and a lot of attention is paid to measurements. The University of Applied Science, Heilbronn, includes into its curriculum specific fields, such as optics, nuclear engineering, micro systems, laser technique together with chemistry and physics. The Chalmers University of Technology, Göteborg, pays special attention to communications, medical systems and neural networks, and in the 4th and 5th year of the study it offers only elective courses.

For the purpose of performing a quantitative analysis of these different courses of study, the number of hours per course in different fields available from the Internet has been compared. If there are two numbers in a box, the former refers to the number of hours of obligatory lectures, and the latter to the total number of hours of elective lectures.

Table 1. Number of hours per course at five universities

	Linz	Heilbronn	Göteborg	Dublin	Zagreb
Mathematics	24	14+2	23+102	25	21
Mechanics	17+11	12+12	9+5	20	21
Electronics	25+42	20+12	11+17	25	11
Informatics	17+34	2+0	24+41	15	16
Automatic controls	9+38	4+8	7+12	10	9
Robotics	0+14	0+4	0+4	10	5
Microcomputers	0+6	3+0	0	0	5

Students' main objection to the former curriculum was that specializations were not clearly defined and determined. The new curriculum offers specializations as early as the 2nd year of study, which enables a more distinctive definition of a specialization. At the same time special attention is paid to the content which is supposed to cover a wide range of specialist fields, thus ensuring the breadth of professional training of future engineers. This is made possible by the regulation which states that the elective technical courses cannot be from the chosen field of specialization. In addition, the number of hours of obligatory lectures per week has been reduced to 25 hours, thus relieving the students of excessive workload.

Table 2. Courses related to mechanics

Course	*Hours per week*	*Semester*
Mechanics I	3+3=6	1st
Mechanics II	3+2=5	2nd
Kinematics and dynamics of mechanisms	2+1=3	4th
Theory of elasticity	2+1=2	5th
Finite elements method	2+2=4	7th

After introductory courses in general and mechanical engineering, the specialization Mechatronics and Robotics offers specialist knowledge in the fields of mechanics, electronics, automatic controls informatics, sensorics and robotics.

Courses from the field of mechanics (Table 2) cover the theory and design of a part of mechatronic system. The design is carried out on computers using modern tools and methods. Mathematical modeling enables a deeper insight into the physics of various system types.

The field of electronics (Table 3) covers the electronic part of the mechatronic system, from the theory of design to the practical realization. The focus is on microprocessor systems, the omnipresent element in modern engineering environment. Practical work, carried out through the work on models and commercial devices, is given a special value.

Table 3. Courses related to electronics

Course	*Hours per week*	*Semester*
Electrical engineering	3+2=5	3rd
Electronic	2+1=3	4th
Electrical servo drives	2+1=3	5th

The field of automation (Table 4) defines the basic principles of automatic and autonomous operation of mechatronic systems. In addition to standard methods of automatic control, students are presented with the latest developments in the field, such as fuzzy logic, and in particular neural networks and artificial intelligence.

Table 4. Courses related to automatic control

Course	*Hours per week*	*Semester*
Feed forward and feedback control	3+2=5	4th
Control of technical systems	2+2=4	8th

The automatic functioning of a mechatronic system depends upon computer software support (Table 5). Microcontrollers are programmed on a local level together with the widely used network applications. Good hardware enables practical applications of vision systems which can be connected to a robot.

It is important to point out that a mechatronic system is approached from an integral point of view, and that the specialization in mechatronics integrates all aspects of this complex system. The wide, interdisciplinary knowledge and training acquired during the study ensures flexibility in finding employment in different sectors. Furthermore, the application of mechatronic knowledge can be extended to non-engineering systems (biomechatronics), thus enabling employment in the sectors that are not directly related to engineering.

Table 5. Courses related to informatics

Course	*Hours per week*	*Semester*
Computer and engineering graphics	2+3=5	1st
Computer modeling	2+2=4	2nd
Object programming	2+1=3	3rd
Computer simulations	2+2=4	4th
Microprocessor control	3+2=5	5th
WEB programming	2+1=3	elective

As mechatronics and robotics are interrelated disciplines expanding rapidly, the specialization in mechatronics also encompasses robotics (Table 6). Students of mechatronics acquire a sound theoretical knowledge and have at their disposal first-class laboratories equipped with 5 robots that enable the acquiring of practical knowledge and skills. Robotics is a course that has been traditionally taught for many years at the Faculty of Mechanical Engineering and Naval Architecture and has become an integral part of traditional formation of graduated engineers in mechanical engineering.

Table 6. Courses related to robotics

Course	*Hours per week*	*Semester*
Industrial and mobile robots	3+2=5	7th
Measurement robot	2+1=3	10th

In addition to the courses related to specific fields, the new curriculum includes other courses related to traditional disciplines of mechanical engineering, as well as new disciplines seeking their way to be incorporated into the family of traditional ones. Students show a great interest in these new disciplines.

Since mechatronics and robotics are relatively new disciplines, this course of study has no specializations. But, in time, as the range of the discipline grows, the course of study will be adapted to the new trends and specializations will be formed. For the time being, «mini» specializations can be realized through the choice of elective courses. Elective courses cover a wide range of disciplines that can satisfy students' interests, both in the field of engineering and in the non-engineering one. In the course of study, students can choose 6 courses from the field of engineering (but not from the ones offered at their specific course of study) and 3 courses from the non-engineering field.

Table 7. Other courses

Course	*Hours per week*	*Semester*
Introduction in thermodynamics	2+2=4	3rd
Fluid mechanics	2+2=4	5th
Pneumatics and hydraulics	3+2=5	5th
Virtual design of mechatronic systems	2+3=5	6th
Sensors	2+2=4	6th
Artificial intelligence	2+1=3	6th
Neural networks	2+2=4	7th
Biomechatronics	2+2=4	8th
Fuzzy and digital control	3+2=5	9th
General system theory	3+2=5	9th
Vision systems	2+1=3	10th

The following department and chairs will be in charge of the realization of the new curriculum:

- Chair of Mechanical Engineering Automation
- Department of Applied Mechanics
- Chair of Manufacturing and Assembly System Planning

Practical work will take place in the following laboratories:

- Laboratory of Automatics and Robotics
- Laboratory of Intelligent Manufacturing Systems
- Laboratory of Experimental Mechanics
- Laboratory of Numerical Mathematics
- Laboratory of electrical engineering

In the course of time, a laboratory for mechatronics may be established.

The aim of the study of mechatronics and robotics is to produce engineers to satisfy the current and future needs of economy. Once Croatia becomes the member of the European Community, a part of Croatian economy will certainly require some changes in its structure. New owners and the foreign capital will introduce new standards that will have to be followed if companies want to be competitive on the world market. A part of the required expert knowledge will be from the expert field of mechatronics and robotics. Graduated engineers of mechanical engineering, with a specialization in mechatronics and robotics will have the same level of expert knowledge as engineers specialized in mechatronics and robotics who have graduated from other European universities or from those worldwide.

Mechatronics is a discipline in the process of formation. Its boundaries cannot be envisaged, let alone explored. For a proper understanding of the future world, a good knowledge of mechatronics will be a vital necessity. If the 19th century was marked by classic engineering disciplines, the 20th century was marked by electronics; the 21st century will be marked by mechatronics.

Conclusion

The new curriculum at the Faculty of Mechanical Engineering and Naval Architecture offers a wider and more attractive choice of studies intended to satisfy students' wishes and needs of the society.

Mechatronics and robotics as a course of study offers the basic knowledge required for the anticipated development in the 21st century. The field of robotics is fully supported by the relevant theory and laboratory equipment. Disciplines in mechanical engineering, electronic engineering, automation and computer science have a comprehensive theoretical background, but the required laboratory equipment should be completed and up-dated in order to enable the laboratory practical work. The field covered by the course of study Mechatronics and robotics attracts wide attention both of the public and of students. Among the interviewed first year students of mechanical engineering, 31 expressed their wish to choose Mechatronics and robotics as their preferable choice of the course of study. This is approximately 10% of the first year student population. Considering that Mechatronics and robotics is a new course of study that is offered at the graduate level of study for the first time, such interest causes optimism and requires full commitment on the part of all participants and organizers.

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Application of Engineering in the Study of Human Locomotion*

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Abstract

Engineering methods for measuring kinetic and myoelectric quantities used in the study of human locomotion are briefly described and illustrated. These methods, combined with those to capture movement kinematics, serve to provide objective quantitative diagnostics of particular locomotor patterns. The approach is used in various medical subfields, as well as in sports science, kinesiology, and ergonomics. In the process of diagnostics, quantitative measurement data, appropriately processed, combine with traditional expert knowledge. Contributions, during the last decade, to teaching curricula at the University of Zagreb are noted, by introducing new elective under- and post-graduate courses for electrical and computer engineers and for medical doctors. Comprehensive education programs for biomedical and clinical engineers have yet to be developed.

Key words: *locomotion, biomechanics, kinesiology, biomedical engineering, signal processing*

Introduction

The subject of human locomotion is relevant for various medical subdisciplines, kinesiology, ergonomics, and also - given its inter-discipilinary nature – for robotics. Although existing from ancient times (reviewed in Cappozzo 1997, Medved 2001a, Medved 2002), actual practical impetus for its development has come from engineering. Modern engineering methods of modelling, measurement and comput-

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* The subject was presented at the meeting «Suvremeni pristupi u obrazovanju inženjera» (Contemporary Approaches to the Education of Engineers) organized by HATZ, on February 27, 2004, in Zagreb. The present paper is successive to «Human locomotion study: the biomechanical methodology and kinematics measurement aspects» published in the Annual of The Croatian Academy of Engineering, 2002, pp. 69-80 (Reference Medved 2002)

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erized data processing enable widespread implementation of the inverse dynamic approach in the study of movement (Medved 2002).

Among measurement methods, three distinct subsets of physical variables are included: kinematic data, which describe movement geometry, forces and moments that are exerted when the body and its surroundings interact, the so-called kinetic or dynamic data, and bioelectric changes associated with skeletal muscles' activity, so-called myoelectric, i.e., electromyographic (EMG) signals. Taken together, all these data provide a comprehensive picture of the locomotion phenomenon.

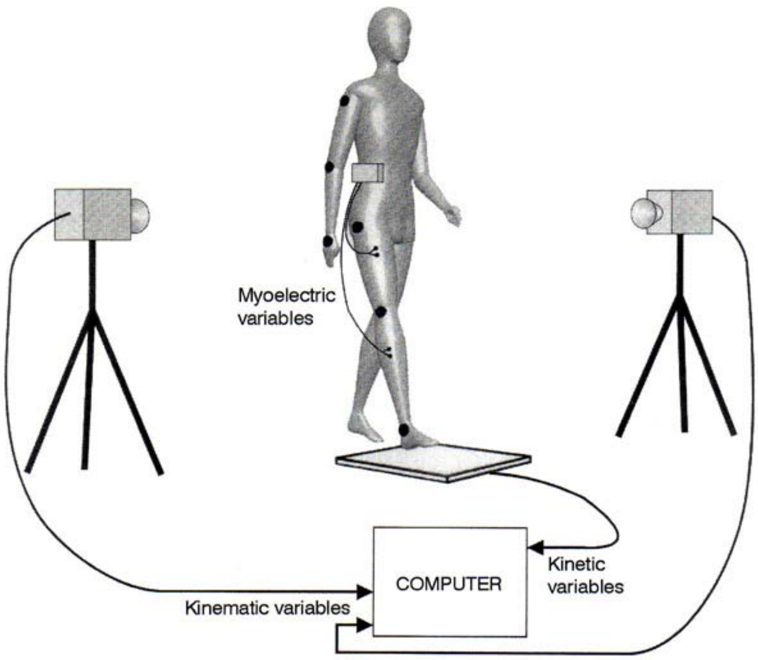

Fig. 1. Human subject and three groups of measurement variables which monitor his locomotion comprehensively (Medved 2001a).

The most prominent areas of application of the study of human locomotion are probably those concerned with medical rehabilitation, such as are for instance orthotic and prosthetic devices for extremities which are applied in pathologies and traumas of the locomotor system. Further, sportive movements may also be studied by essentially identical methodology. Ergonomics (man-machine interaction) also may benefit from measuring certain movements.

There is a multitude of working situations where it is of interest to estimate quantitatively the loading pattern induced by certain dynamic actions or static body positions, and, in connection with this, the organism's energy expenditure. Procedures of this kind might provide a basis for the improvement of the working process and, simultaneously, decreasing chronic, potentially traumatic actions on the body. Finally, in view of bionics, human movement might represent a model for the design of engineering locomotion automata and robots.

Figure 1 shows, symbolically, a subject whose locomotion is being measured by using three groups of measurement variables.

In a previous publication a short historical overview, methodological basis for the field, as well as summary of kinematics measurement methods were given (Medved 2002). In the present article we describe and illustrate methods to measure kinetic and myoelectric variables in particular. Measurement data are combined with relevant expert knowledge in the process of locomotion diagnostics. Education of engineers and other professionals in this inter-disciplinary field is discussed at the end, presenting some of our recent contributions. Future prospects for the University of Zagreb in providing comprehensive education for biomedical engineers are also outlined.

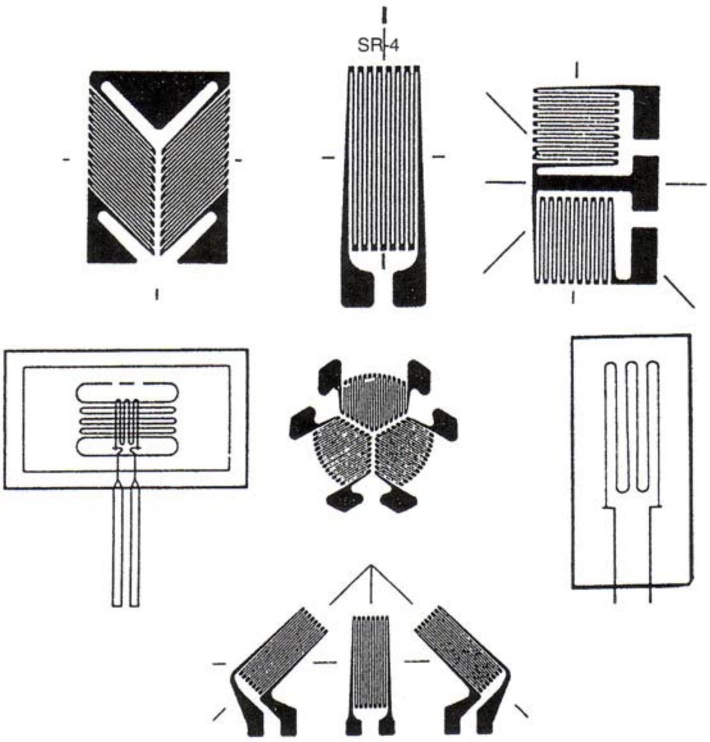

Fig. 2. Various strain gauge-based transducers (Medved 2001a).

Measurement and presentation of kinetic variables

Kinetic (dynamic) movement quantities encompass forces and moments of force developed during movement: these are forces and moments between a body and its surrounding, and internal forces and moments. While internal forces may be calculated (estimated) using the inverse dynamic approach, the most important kinetic quantity to be measured is the force developed between the body and the ground. Ground reaction force measuring platforms are devices which enable the measurement of the total force vector manifested in various locomotor activities during the contact between the subject's body (typically foot) and the surface, into which the device is embedded. Also, the device usually produces the moment of force vector, as well as planar coordinate values of the point of centre of pressure. It is, therefore, generally applicable in locomotion study, healthy or pathological.

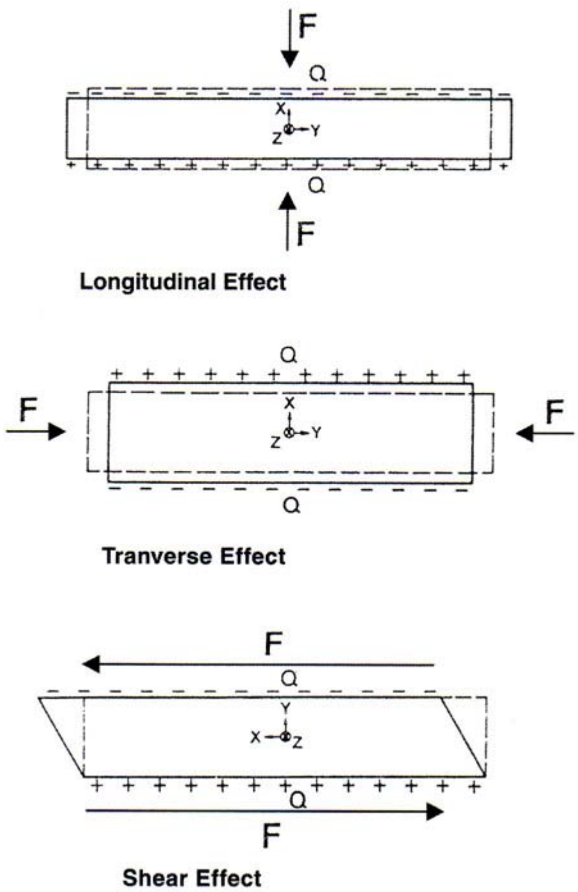

Fig. 3. Piezoelectric transducer of a quartz crystal (Medved 2001a).

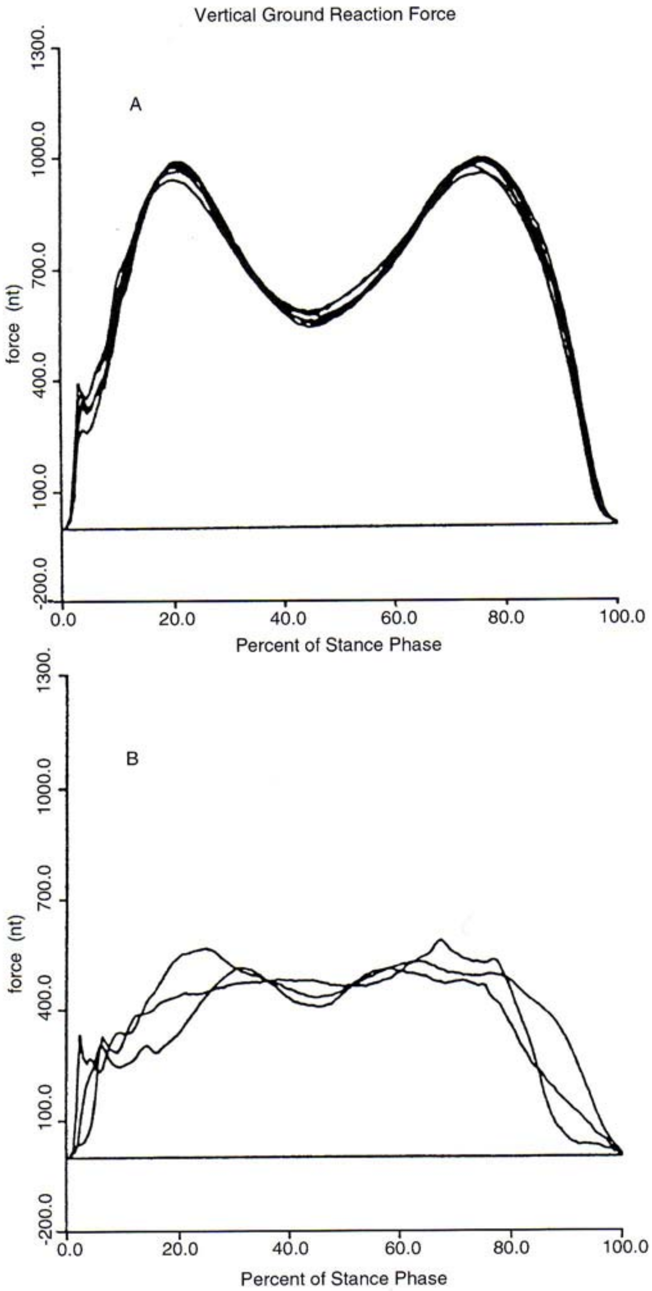

Fig. 4. Ground reaction force in walking in a healthy person (A) vs. An individual with cereberal ataxia (B) (Medved 2001a).

Besides being used to detect dynamic phenomena such as gait and running, force platforms (force plates) may also be used in measurements of approximatelly static body postures. In this case, with body support via the feet being nearly fixed, measurement signals are a consequence of the movement of the body's centre of mass. This may be exploited, for instance, when testing the vestibular apparatus from the neurological and othorinolaringological standpoint, and, in general, when examining postural stability and balance.

The instrument's contact area is a rectangular plate usually 60 x 40 cm in size - various other special designs of larger platforms are, however, also possible - which is then embedded in a firm, massive base. The platform's surface must be at ground level; possibly, it should be covered by a "carpet", so as to enable truly non-invasive measurements (where the subject is not aware of having stepped onto the platform). A track about 10 m in length for gait measurements is needed, and an even larger corresponding space for measurement of running, take-offs, etc.

During construction, force transducers are adequately positioned and incorporated within the device. Depending upon the kind of transducers and the device's construction, transducers must be positioned so as to attain selective sensitivity of the instrument-when forces and moments of forces are applied by the interacting human body-in all three spatial directions. An appropriate frequency response is required of the system, with the resonant frequency of the subject-platform system reaching above 200 Hz, and sufficiently low cross-talk between channels. The construction must secure that force, i.e. moment values measured be independent of the site of application at the plate's surface. The two most widely applied technical realizations of this measurement instrument are the strain gauge based-platform and those using piezoelectric transducers.

The principle of strain gauge transduction is based on the phenomenon of mechanical strain. Strain gauges are made in the form of wires or foil. Foil strain gauges are manufactured by engraving, they are usually 0.02 to 0.05 mm thick, and are designed in complex geometrical shapes, like those depicted in Figure 2. Design and layout of strain gauges are the result of a compromise between the requirement for flexibility, with the aim of attaining as high a degree of sensitivity as possible, and the requirement for rigidity, with the aim of realizing as high a characteristic frequency as possible. Strain gauges, appropriately positioned, are connected in bridge circuits (Wheatstone bridge) so that changes in resistance are converted into voltage changes.

Besides strain gauges, another kind of physical principle is also used for measuring forces and moments: the piezoelectric effect. It concerns a kind of active transducer, since the transduction of mechanical into electrical energy occurs without an external energy source. A feature of some materials of crystalline atomic structure which, when influenced by mechanical strain generate electrical potential, is of concern here; an electrical potential is created by the movement of charges along certain christallographic axes. Electrical charge values are minute, of the order of magnitude of a pC, imposing high requirements on the layout of electronic amplifier circuits (charge amplifiers). Apart from this, stringent requirements are also placed on necessary isolation materials. The quartz crystal is the most suitable piezoelectric material available. It is characterized by high isolation resistance, high mechanical strength, a high Young modulus (the modulus of elasticity in the longitudinal direction), the absence of the pyroelectric effect and hystheresis, it has extremely high linearity and excellent stability. Taking quartz as an example, various piezoelectric effects, like the longitudinal, transversal and shear effect can be identified and used, shown schematically in Figure 3. Coordinate axes correspond to the crystallographic axes of quartz. The z axis is called the optical, and the x axis is called the electrical axis.

There is one common problem encountered in both kinds of platforms. This is cross-talk between channels caused by nonidealities in device layout. Therefore, each particular manufactured instrument has to be appropriately calibrated and correction of the identified cross-talk has to be provided. This task can be achieved in practice by using software solutions.

There are specific comparative differences between measuring platforms based on the piezoelectric effect and those using strain gauge-type transducers. Namely, since frequency response of piezoelectric systems to mechanical excitation is very high, these kinds of transducers are indispensable for certain special applications. However, the piezoelectric system, as an active system, does not enable strictly static measurements like those by means of strain gauge transducers, but quartz as a piezoelectric material in connection with a charge amplifier nevertheless offers the possibility of measuring approximately static phenomena that may last for a number of minutes, even hours. For the needs of biomechanical studies of human locomotion, this is completely satisfactory.

Being the most natural among human locomotions, walking and running have often been the subject for ground reaction force measurements. Figure 4. shows the example of comparison of healthy individual and an individual with cerebelar ataxia. Significant differences are evident in vertical component of ground reaction force signal in terms of its shape and repeatability in multiple trials.

One additional way of representation applicable in medical clinical practice and sports testings is put forward. A vector diagram is a graphical representation of a spatio-temporal sequence of the two component vectors of ground reaction force in the sagital, i.e., frontal plane. This kind of representation might be provided after the signals are measured and analog-to-digital (A/D) converted, preferably in real time, and is mostly realized in commercial systems of PC-supported measurement platform devices as a standard option.

Pedotti (1982) and Crenna and Frigo (1985) applied this kind of "synthetic" way to represent kinetic locomotion data in a clinical environment, which resulted in a large number of gait measurement records. The features of signals so presented can be illustrated by taking the example of normal gait performed at three different velocities (Figure 5). The following characteristics of measurement records may be observed:

- symmetry of records of left and right leg at certain gait velocity,
- harmonious and monotonous waveform of courves' envelopes,
- sensitivity of records to changes in speed of gait, in the sense of enlarging the difference between values of maximum and (local) minimum of the curve with increasing speed; shortage of duration of envelope and enlargement of the slope of vector in the beginning with respect to the end of the support phase and
- monotonous advancing of the point of the centre of pressure in the direction of movement with a pronounced plateau during the last part of the support phase.

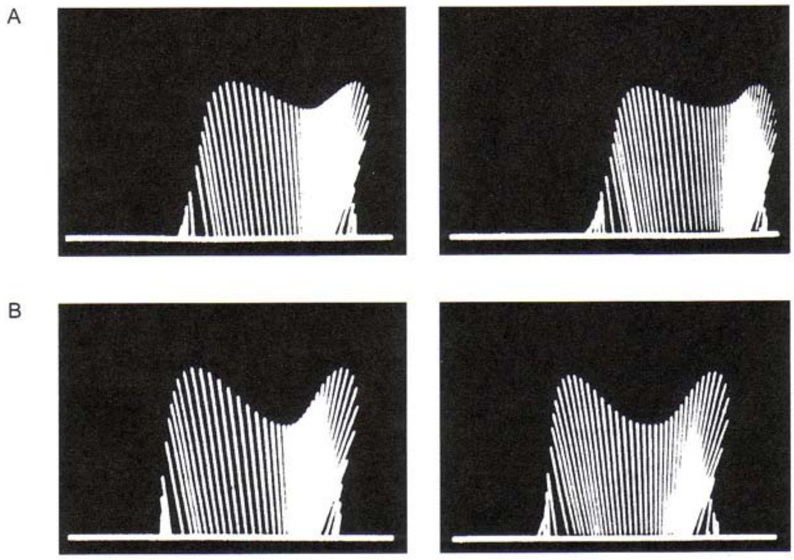

Fig. 5. Vector diagrams of a normal subject at two different stride frequencies: 48 strides/min (A) and 56 strides/min (Medved 2001a).

At a certain speed, the records of a certain individual are repeatable.

On the contrary, Figure 6. shows several vector diagrams of gait by patients suffering from hereditary spastic paraparesy. In general, individual deviations from the normal vector diagram model are present. Inferior signal repeatability is present than what is observed in normal subjects, but among the signals shown, each one is, nevertheless, typical for the respective individual (steady state), and they are shown in the order of incidence of morphological changes of the envelope and, accordingly, to the degree of pathology. In this group of pathologies, the most frequent findings are as follows:

- an increased vector amplitude in heel strike and a considerable disorganization of the body weight acceptance phase,
- presence of a higher number of local maxima, resulting in a nonharmonious shape of the envelope and lacking smoothness,
- general verticalization of vectors and
- inversion of the forward displacement of the point of application.

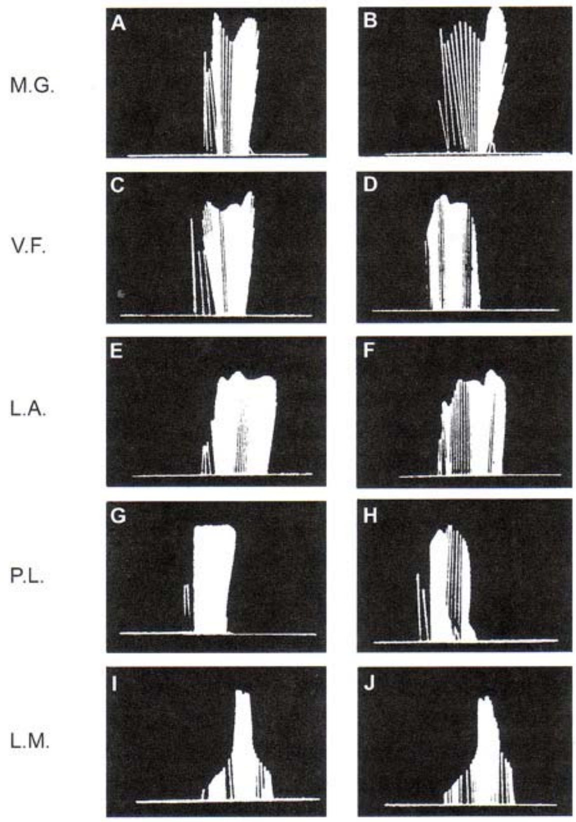

Fig. 6. Vector diagrams from five individuals with hereditary spastic paraparesis with different levels of disability (Medved 2001a).

This kind of signal representation makes it possible to document and objectively follow patient's recovery during treatment, i.e., rehabilitation.

The kinetic measurement devices considered so far enable the registration of instantaneous values of applied force and, possibly, the moment of force, as resultant quantities which, hypothetically, act in only one point whose planar coordinates change in time. This is an idealized view, and the point of centre of pressure may even be totally fictitious (i.e. fall outside the contact area), as, for example, when an individual assumes a symmetrical two-legged upward standing posture. However, this reflects a view where the biomechanical model of the human body consists of interlinked rigid segments (Medved 2002).

In reality, body support always occurs through a certain contact area between the foot, or, alternatively, the sole, and the ground, so that the total force of action is distributed. Therefore, distribution of pressure (defined as force over the unit area) over the ground must be considered. The existing technological solutions for measuring and registering pressure distribution between two (quasi)rigid bodies offer new quantification possibilities for human biomechanics. By means of systems of this kind - named pedobarographs - mechanical interaction between the body, via the foot, and the ground may be followed in greater detail.

There are a number of instruments today for measuring pressure distribution between the foot and the ground, on the market and in laboratories, which can be applied in the study of posture and locomotion. Besides problems occuring in sports medicine, physiatry and orthopedics, syndromes (pathologies) traditionally belonging to other medical fields can also be evaluated indirectly by means of these devices. In diabetes, for instance, anomalies in circulation develop, and this is reflected particularly in the foot. Pressure distribution data may, therefore, offer new and original information important for treatment. Such measurements may provide a basis for manufacturing insoles, aimed at correcting irregular pressure distribution and preventing pathological effects.
As an example, a commercial product by an American firm Tekscan, Inc., Boston, Massachusetts is based on a very thin flexible resistive tactile sensor, developed originally for measurements of dental occlusion, whose manufacturing methodology was originally developed for flexible printed circuits. It houses 960 sensor sited at the surface, each capable for 8-bit pressure resolution. The sensor is shown in Figure 7. It is based on a combination of conductive, dielectric and resistive inks. The sensor is characterized by a grid of rows and columns formed of a silver based conductive ink deposition. Each sensitive trace is coated with pressure sensitive resistive ink, so that one sensor cell is created on each grid crossing point. The resistance of each sensor cell is inversely proportional to the applied surface pressure. By scanning the grid and measuring the resistance at each crossing point, pressure distribution at the sensor surface can be determined. A unique feature of the manufacturing process of the sensor is that the layouts may be adjusted to the broad spectrum of shoe sizes: the multilayer printing technology enables connection to traces forming the sensor grid at locations intermediate to their endpoints. A flexible equivalent of a multilayer circuit board is created by printing isolation dielectric coating across traces which connect the sensor with scanning electronic circuits. The small approach holes enable connection to the sensing area traces. Before depositing the grid traces, holes are filled by conductive ink to form a flexible equivalent of a plated-through hole. In this manner, the grid trace endpoints may be trimmed to contour sensor outline, whilst total functionality of the remaining sensor surface is kept.

Electronic circuits for sensor signal measurement are connected to computer so that measurement data may be presented in real time or, else, stored and presented later in a number of detailed graphical modes.

While there is no doubt as to the relevance of clinical and other diagnostic applications of the described pressure distribution measurement systems, its standards are still developing. Suitable clinical protocols, to be applied in the fields of orthopedics, physical medicine and rehabilitation and sports medicine, which would qualitatively suit and supplement the group of other indices obtained by examination, are still being developed.

The advantages of systems measuring pressure distribution are:

- they offer spatially precise information, new and original. Redundancy inherent in this information is still to be determined,
- insole layouts enable the measurement of more strides, which gives them an important advantage over imbedded platforms, because insight into statistical features of more successive strides is enabled, important in population studies or during a sports game.

The systems' disadvantages are:

- precision and accuracy of measurements is inferior to ground reaction force platforms with piezoelectric sensors or strain gages, and they wear quickly with use,
- platform layouts measure only one step (which is a disadvantage of classical platforms as well).

Measurement and processing of myoelectric variables

Electromyography means detection, amplification, and registration of bioelectrical activity changes in the skeletal musculature. This method may be applied on the surface (metal disk electrodes) and under the surface, either subcutaneously (wire electrodes), or intramuscularly (needle or wire electrodes). In the realms of clinical neurology and physical medicine, different variants of electromyographic measurement techniques are routinely applied in the diagnostics of particular neuromuscular pathologies. In this presentation we shall only cover surface electromyography, i.e., the detection and measurement of muscular action potential changes manifested at the surface of the skin, above the measured muscle. This subgroup of electromyographic measurement techniques is one which is most often applied in locomotion measurements.

Measuring EMG signals during movement is called dynamic electromyography by some authors, this being the only method in practice which is capable of determining which muscles are active and when during a certain movement. Electrodes are the sensor elements in the measurement chain, making contact with the subject's body in order to detect bioelectric changes; in this way they act as a kind of electrochemical transducer for reactions occuring within the living organism. Due to this contact, by definition, the requirement for the measurement method to be non-invasive is disturbed to a certain degree. However, the complete procedure, beginning with the contact between electrode and skin should, however, not significantly disturb the subject's perfomance or measurement, and contact itself does not really set limitiations in this case but possibly other factors (for instance, cables).

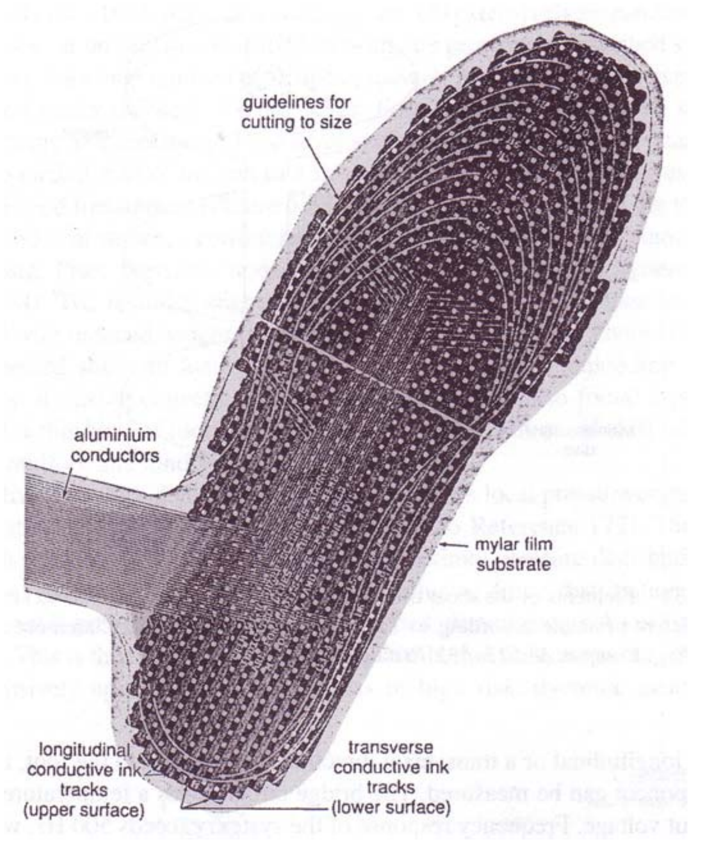

Fig. 7. Matrix type pedobarographic sensor in the form of an insole (Medved 2001a).

Multiple sources of noise are present when measuring EMG signals. The most important are: a) surrounding sources of electromagnetic radiation, of which the most prominent is power line voltage of a 50 Hz (or 60 Hz) frequency and its harmonics which are, electrostatically or magnetically coupled to the body. This is the dominant source of noise with an amplitude of one to three orders of magnitude larger than the EMG signal. b) unwanted biopotentials generated in other bodily sources. c) movement artifacts, which are a consequence of the electrode-skin interface on the one hand, and of moving cables, on the other. These sources cover a region from 0 to about 20 Hz; d) a broadband noise, characteristic of electronic components for signal amplification and processing.

The whole procedure, therefore, must be such that successful detection and amplification of myoelectric signals are achieved in the environment described. EMG signals are of small amplitudes, while source impedance is high. Detection electrodes are connected to the preamplifier input. To amplify myoelectric signals, differential amplifiers are used, suitable for signal amplification in the presence of noise, since they amplify the difference between two signals, detected at two detection sites (bipolar detection). In this way, useful information - a signal relatively close to the detection electrodes - is selectively amplified, while noise - made by the total signal from sources relatively distant from the detection site (all previously mentioned influences), which is approximately equal at both detection sites - is canceled. In this way, differential amplifiers realize good separation of signal from noise. The frequency spectrum should be from 20 to 500 Hz, according to the spectral characteristics of surface EMG signals.

Advancements in electronic technology have made it possible to construct miniaturized and compact, ergonomically designed EMG devices of a Holter type. So, for instance, the ME3000 Professional, manufactured by the Finnish firm Mega Electronics Ltd., weighs only 600 g including batteries, is 166 × 77 × 30 mm in size, enables measurement and storage of up to 4 surface EMG channels, with a sampling frequency of 2 kHz per channel, and long record duration. Its small mass and size make the device very practical, so that it can be used in measuring various movement structures, as long as they are not too fast, like sprint-like locomotions. For instance, the EMG activity during long jump in track and field sport cannot be measured successfully, because during the approaching run the device fixed to the athlete's body trembles forcefully, thereby certainly hindering concentration, and so becoming invasive.

In multichannel measurements the problem of cross-talk always occurs and, therefore, it is necessary to take the actual functional-anatomical characteristics of the skeletal musculature monitored into account during measurement procedure, to minimize cross talk.

In analogy to the trend encountered in human kinematics measurements (the problem of body markers (Medved 2001a, Medved 2002)), it is also desirable for EMG measurements to be as non-invasive as possible. Within this context, and so as to enable subjects to move freely both indoors and out, there is a need to eliminate wires, i.e., cables in electromyography.

Surface EMG signals are quasi-stochastic, their amplitudes ranging approximately from 0 to 6 mV, with a frequency spectrum between 10 - 500 Hz. EMG signals may be analyzed in their raw form, but mostly only qualitatively. In order to represent measurement information in the most appropriate way and to ease its interpretation, various EMG signal processing methods have been developed.

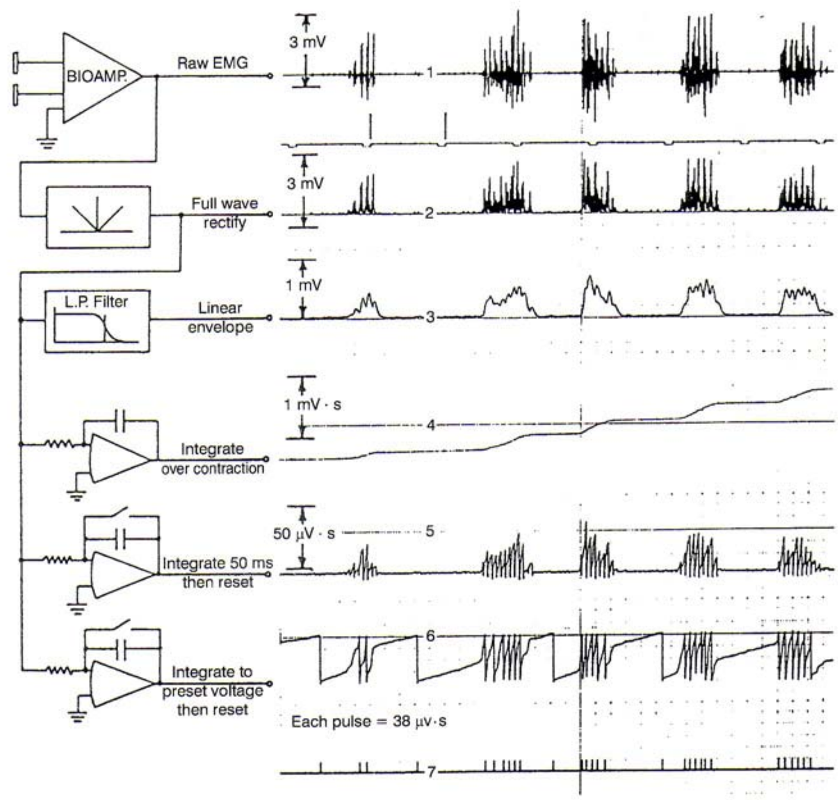

Fig. 8. Common surface EMG signal processing methods in time domain (Medved 2001a).

Figure 8. shows the standard methods for processing EMG signal in a time domain. These are:

- Full-wave rectification

In this procedure the entire energy of the signal is retained and the mean value is other than zero, which enables the application of various averaging procedures.

- Averaging (smoothing) of the full-wave rectified signal

The procedure may be realized by analog or by digital means, and consists of suppressing higher frequency components, i.e. low-pass filtering of a full-wave rectified EMG signal. The filter spectrum width determines the degree of smoothing. Equivalent to smoothing, in the digital sense, is averaging of the full-wave rectified signal (averages, means rectified signal).

$$\overline{|m(t)|}_{tj-ti} = \frac{1}{t_j - t_i} \int_{t_i}^{t_j} |m(t)| \, dt \qquad /1/$$

$T = t_j - t_i$ represents a time window. When the window is moved along a whole record operation is called "moving average". There are various possibilities for positioning the window. Typically, the T value is between 100 and 200 ms.

The most common type of EMG signal processing in a time domain is full-wave rectification followed by some form of smoothing, i.e. low pass filtering, and we also call it averaging. Such an approach is compatible with the following EMG signal description:

$$e(t) = I(t) \cdot n(t) \qquad /2/$$

with n(t) denoting a stationary stochastic process with a zero arithmetic mean and a unity variance. I(t) denotes the time-variable intensity of EMG, and e(t) is the recorded EMG signal. Such an approach is in correlation with the signal model, but is a crude simplification.

In practice, averaging is, by far, the method most often used. In spite of the simplicity and practicality of the analog method, it is clear that, in principle, a superior processing procedure is where the raw signal has been digitized previously and then smoothed by digital means, since - if smoothing is provided twice consecutively in both directions of the time axis - this enables the elimination of phase lag (as introduced by analog filtering). The smoothed EMG signal is very often primarily used because - in a way - it represents a certain correlate of muscle force (although the influence of elasticity of muscles and tendons "is not seen", only active generated force (Medved 2001a)).

- Integration

Integration means the calculation of the area below a curve, and it is also applied to the full-wave rectified signal. The operation, therefore, results in a value expressed in Vs (mVs). In professional reference books the term has often been used incorrectly; it is, in fact, a "linear envelope detector".

$$I\{|m(t)|\} = \int_{o}^{t} |m(t)| \, dt \qquad /3/$$

It concerns a subgroup of operations for obtaining "average rectified value". Only, there is no T.

- Root Mean Squared (RMS) value

$$RMS \{ m(t) \} = \left(\frac{1}{T} \int_{t}^{t+T} m^2(t)\, dt \right)^{1/2} \qquad /4/$$

- Number of zero crossings

This time-domain operation consists of counting the crossings of the EMG curve through the zero line. In this way, the calculation of the medium of the signal spectrum is approximated, which should otherwise be calculated by means of fast Fourier transform (FFT).

Spectral representation of the EMG signal is estimated by digital means, by means of FFT algorithms. The dominant field of application of such a representation is in the evaluation of local muscle fatigue due to isometric contraction, and not so much in studies of locomotor activities. The most significant spectrum parameters for the evaluation of muscle fatigue, as mentioned, are considered to be its median f_{med} and mean value f_{sr}:

$$\int_{0}^{\omega_{med}} S_m(\omega)\, d\omega = \int_{\omega_{med}}^{\infty} S_m(\omega)\, d\omega$$

$$\omega_{sr} = \frac{\int_{0}^{\infty} \omega\, S_m(\omega)\, d\omega}{\int_{0}^{\infty} S_m(\omega)\, d\omega} \qquad /5/$$

($\omega = 2\pi f$)

Absolute EMG signal amplitude values (expressed in mV) are influenced by factors such as skin filtering influence, etc., so, in repeated measurements on the same subject (electrode repositioning), it is not possible to realize reliable comparisons (inter-trial or inter-muscular). Further, comparisons of values of a certain muscle in different subjects are also not possible on an absolute scale. Therefore, in kinesiological measurements it is customary to normalize the signal amplitude in some way. The amplitude of the signal measured during maximal voluntary isometric contraction of the corresponding muscle is chosen (MVC) as the value to which the normalization is made (100%). However, what the biomechanical conditions should be when determining this value (i.e. the value of the angle in a corresponding joint) is a question which remains to be answered. However, this is not the only amplitude normalization method, but individual researchers use their own modifications. Normalized EMG signals enable valid inter-subject and inter-muscular comparisons and analyses. (Of course, in certain experimental conditions direct comparisons of signals expressed in absolute units, Volts are also possible.)

When cyclical locomotor activities are being measured, typically gait, an EMG record may also be normalized along the time coordinate to the duration of one cycle (period) (also valid for the remaining locomotion measurement variables).

Myoelectric changes are related to muscle force, but this connection is not simple, nor is it of a linear character. It is influenced by various physiological factors, like conditions (eccentric, concentric, isometric) and speed of contraction, instantaneous muscle length, the state of local muscle fatigue, specificities in muscle and body structure of the respective subject, specificities in the muscle measured with respect to others, etc

It can be concluded (Perry and Bakey 1981, citation after Medved 2001a):

- there is no universally accepted method of measurement, processing and quantification of EMG signals,
- during isometric contractions, a linear proportionality exists among corresponding quantified EMG measure and the registered force, at least in the vicinity of the midrange of operating force, and for some electrode configurations,
- the proportionality constant between the quantified EMG and force depends on joint position (i.e. on muscle length)
- during movement, the relationship EMG/force cannot be described by linear algebraic equations,
- the choice and location of electrodes and the applied processing methods have a significant role in the evaluation of the EMG/force relationship.

Apart from their illustrative "descriptive" role, multichannel EMG signals may serve as a kind of "window" into the function of the neuro-muscular system, since they represent correlates of its functioning. Multichannel EMG signal processing may be carried out on raw signals, but it is more suitable to do this on previously processed EMG signals. Namely, as mentioned, in the first approximation the average EMG may be considered to be a muscle force correlate. Such waveforms are amenable to processing by correlation analysis.

Gandy et al. (1980, citation after Medved 2001a) have proposed a method of processing averaged EMG signals by means of which the degree of mutual connection of bioelectric activity of the two muscles measured is estimated. The degree of connection of bioelectric activity is estimated by calculating the coefficient of correlation between the two signals according to the expression:

$$c.c. = \lim_{T \to \infty} 1/T \int_{-T/2}^{T/2} x(t)\, y(t)\, dt \qquad /6/$$

where x(t) denotes average EMG signal of the first, and y(t) of the second muscle. The range of possible resulting values is between 1 and -1, where 1 denotes an extreme case of maximal positive correlation, 0 the lack of correlation, and -1 a case of maximum negative (inverse) correlation (for example in antagonist muscles).

Surface electromyography as a technique, therefore, enables detailed insight into muscular activity during gait and thereby also corresponding insight into the function of the neuro-muscular system. (One has to be aware, however, of limitations due to the small number of measured channels and because of accessibility of surface muscles only). The EMG signal as a "window" into the action of the central nervous system is an illustrative analogy. By recognizing patterns of multichannel EMG signals, it may be possible to identify basic neurophysiological mechanisms in the realm of the peripheral neuromuscular system - reciprocal inhibition, for instance, is a typical example

Diagnostic process in the biomechanics laboratory

The process of diagnostics applied in the biomechanics laboratory is depicted in Figure 9. It combines the acquisition methods of all three types of measurement data, implementation of the inverse dynamic approach, EMG-force relation determination for particular muscles, and observational analysis by experts (Medved 2002). The trend today is toward standardizing measurement and testing protocols for various specific medical and kinesiological applications.

Innovations in higher education at the University of Zagreb

Besides teaching biomechanics ate the undergraduate and postgraduate levels of the Faculty of kinesiology, we have, during the last decade, developed:

- A new elective subject aimed for students of electrical engineering and computing: «Multisensor systems and locomotion» (Medved 2000, 2001b). The subject is aimed at teaching principles and techniques of biomechanical measurement systems, and preparing the student for more advanced study of muscle biophysics and cybernetic modelling.
- As new equipment for laboratory measurements was acquired, with the finnancial aid from The Ministry of Science, Education and Sport of the Republic Croatia, we were able to offer another new elective course aimed for students in Medical School (to be thaught in English) entitled: «Measurement and analysis of human locomotion» (Medved and Pećina 2003). The course is to be launched in the spring semester in the year 2004/2005 and will be given by interdisciplinary team of engineers, medical doctors and kinesiologists. The course

is aimed to explain principles of biomechanical analysis of human locomotion with specific references to clinical applications in neurology, orthopaedics, rehabilitation and sports medicine.

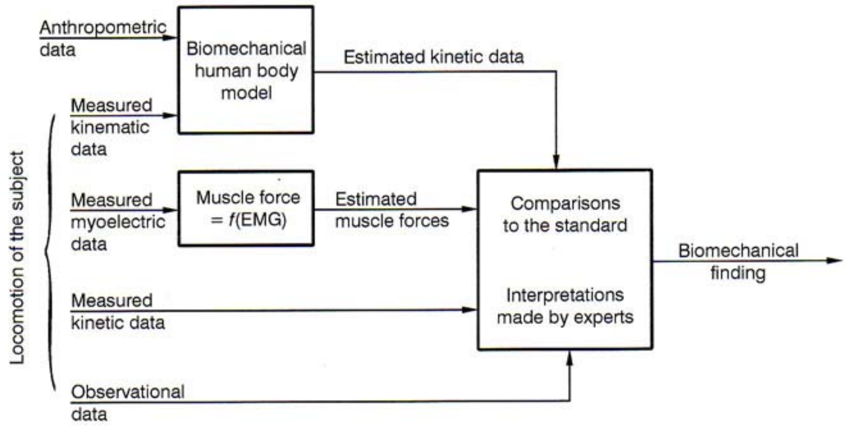

Fig. 9. Information flow in a clinical locomotion measurement system (Medved 2001a).

Recent initiative for international compatibility in the fiels of medical engineering in Croatia has underlined the need for a comprehensive curriculum for biomedical and clinical engineers at the University of Zagreb (Tonković et al. 2003).

Conclusion

Measurement and processing methods for kinetic and myoelectric variables of human locomotion were shortly described and illustrated. These methods add to previously presented methods for movement kinematics (Medved 2002). Combined with relevant expert knowledge, all these methods serve to provide objectivized quantitative diagnostics of human movement, both healthy and pathological. Modern locomotion laboratory facility has recently been equipped at the Faculty of Kinesiology. Paralelling advancements in research in this field, corresponding teching efforts have also been made at the University of Zagreb. Besides classical biomechanics curriculum traditionally given for physical education (kinesiology) undergraduates, undergraduate elective courses for electrical and computer engineers and medical doctors have been introduced as well. Postgraduate teaching is also provided for kinesiologists and electrical and computer engineers.

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Health Care in New Technologies Environment

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Abstract

The essential characteristic of considerable and rapid development of medical sciences and improvement of quality of provided medical services and health care is an increase and introduction of a large number of the most varied, frequently extraordinary complex and sophisticated, electromedical devices and equipment in everyday medical practice, and later on, introduction of ICT, firstly in administrative - financial area, and soon after, in medical practice as well, with an extremely high-speed and propulsive growth. However, the reorganisation of public health care and health protection assumes the existence and introduction into medical institutions of qualified persons, experts of new profiles (which is in the world known and acknowledged practice) – biomedical and clinical engineers, medical physicists, medical informaticians, etc., who in close co-operation with physicians, render adequate services (e.g. purchase of equipment, education on optimum use of equipment, care about safety of patients, users and environment, maintenance of equipment, care for computer programs, protocols and networking etc.), by application of "specific technical" knowledge acquired by special education. As it is a question of extremely interdisciplinary knowledge, it is logical that the question arises how to educate such a personnel? At the present (this issue must be harmonised on the level of the EU as well) as an optimum appears integral postgraduate specialist's studies, and life-long specialisation, depending on specific requirements of particular work posts. In other words, life-long learning is suggested itself as "must be" with reference to extraordinary propulsiveness of the area.

Key words: *health care, high technologies, electromedical equipment, ICT, interdisciplinary knowledge, medical education*

The important and significant technological & technical development at the end of the last century, was also reflected in considerable and rapid development of medical sciences and improvement of quality of provided medical services and health care. It is closely and inseparable connected with the development of electronics, computer science and engineering, and information and communication technolo-

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gies (ICT). The essential characteristic is an increase and introduction of a large number of the most varied, frequently extraordinary complex and sophisticated, electromedical devices and equipment in everyday medical practice, and later on, introduction of ICT, firstly in administrative - financial area, and soon after, in medical practice as well, with an extremely high-speed and propulsive growth.

Electromedical equipment has today irreplaceable, unavoidable and inevitable assessment in medical diagnostics and therapy. It is estimated that (estimation from the year 1998!) even in about 86% of diagnostic and/or therapeutic procedures, the application of electromedical equipment and biochemical analyses has the essential, if not crucial importance for successfulness of diagnostics and therapy, respectively. At the same time, medical technologies represent an important and fast-changing industry, requiring a complex framework of relationships between private sector, national and international regulators and civil society stakeholders in developed, and in developing countries, as well.

Electromedical and biochemical equipment, by the development of electronics, computers and ICT, become more and more powerful and influential, but on the other hand *more expensive and more complex* for reliable and safe use, taking advantage of all equipment's possibilities and functions, management and maintenance. The use of computers and ICT of public health care, health systems and medical procedures in all sectors of their activities has been reality in all more developed countries, and lately in Croatia also (Bronzino et al, 1998, van Bemmel, Mussen, 1998). State allocations for health care become higher and higher and become commensurable only with allocations for military purposes.

The advancement and diffusion of technology are among the most controversial developments in the provision of health care. Technological innovations have given health services providers the means to diagnose and treat an increasing number of problems and illnesses. The same advances have been criticized, however, for their effect on the practice of medicine and on national health care expenditures, which rapidly increasing.

The dramatic rise in health care costs since 1950 is partly related to the proliferation of new technologies, the increased use of existing tests and procedures, including attendant specialised staff, and financing of the innovations. Here, the purchase price of technology has a minimal effect on health care costs. In 1993, for example, expenditures for technology, defined as ranging from advanced diagnostic products and implantable devices to major capital equipment and routine medical supplies, totalled only 5.1% of health care spending.

That part of the rise in health care costs that is attributable to the use of technology is uncertain. Estimates have been as high as 70%. There seems to be a consensus that approximately 50% of the rise in total health care expenditures results from the use of new technologies and the overuse of existing ones.

Health economists conceptualize the issues in various ways. One theory examines the impact of technology on acute care hospital costs as measured by discrete units such as the labour and non-labour inputs of using technology. A second theory analyzes the costs that are associated with specific acute care hospital-based technologies. A third theory examines the impact of technology on treating specific conditions and types of illnesses through time. A fourth theory measures the impact of technology on total health care expenditures. It is generally agreed that technology has increased the intensity of resources that are used to treat individual cases and that this has increased costs. Increased intensity also has resulted from the introduction of new technologies used on new categories of patients, in addition to the use of existing technologies in new ways.

Although, it is proven that *quality* of medical services and *successfulness* of therapeutic interventions depend directly on *investments* in health care, in all more developed countries it comes to serious *reconsideration of efficiency and profitability* of work of public health services and their re-organisation. The words like Quality Management Systems or Health Technology Assessment became familiar in health care organisation and systems (INAHTA, 2004, Longest et al, 2000) (*Healthcare technology is defined as prevention and rehabilitation, vaccines, pharmaceuticals, and devices, medical and surgical procedures, and the systems within which health is protected and maintained. Technology assessment in health care is a multidisciplinary field of policy analysis. It studies the medical, social, ethical, and economic implications of development, diffusion, and use of health technology*).

At this point, we shall state only a few basic guidelines for that:

- allocations for public health care and health protection are extraordinary large, and significant economies are possible
- biomedicine and biotechnologies have been among most propulsive branches, regarding technological development and innovations
- information and communication technologies face radical changes in possibilities of approaching the organisation of public health care and health protection, however the education of physicians and other medical workers as well
- physicians can not (and *do not have to*) use any more profitably and rationally *all* possibilities of new technologies, electromedical devices and equipment and ICT *("do not have to": because their primary obligation is medical knowledge and health care for patients)*
- considerable changes and newness may be expected in "home" care, way of a care for larger and larger number of older persons, as well as health care of an individual for himself
- integrated interdisciplinary approach, multidisciplinary team work, knowledge transactions, life-long learning and additional education (scientific and specialist's post-graduate studies etc.) are necessities of our future.

"Almost digital hospital" (George Pompidou European Hospital/2000 Paris) is today's reality (Weiss, 2002). The changes are *not only* in administrative-financial-business sectors or new ways of communications, but also in introduction of a new approach to and manner of thinking about the health care for patients.

Most computer applications in health services are and have been business related, such as finance and administration. Clinical applications became and will become more common with the growth of computing power and ICT. Today, medical education makes demands on balance between science and pragmatics. As with other technical areas, executives, i.e. physicians, need not be expert in information technology, but will need help from someone who is. Information technology assists in four areas:

1. Process management – redesigning processes to make them seamless and more efficient
2. Care management – expert systems and other ways to assist clinicians, some of which are described below
3. Demand management – especially useful in integrated systems to attract physicians, employers, health plans, and enrolees, as well to direct patients to the least-intensive setting able to meet their needs
4. Health management – essential to store and retrieve risk assessment information, genetic profiles, family health histories, and similar data that predict and prevent disease, a use that is especially important in a captivated payment system

Telemedicine and e-health are powerful tools increasingly used by health practitioners around the world. Irrespective of distance and availability of medical specialist on site, these technologies facilitate medical care, particularly in developing countries.

The prototype of telemedicine was the telephone consultation between physicians; more recently, facsimile machines are being used for electrocardiograms and medical records. Never technologies include interactive contact, e.g. physicians vs. physicians, physicians vs. patients, etc.

Five issues, however, are unresolved in telemedicine:

1. Clinical expectations and medical effectiveness (much of the information about the clinical effectiveness of telemedicine is anecdotal.)
2. Matching technology to medical needs (inconvenience of interactive technology is a major obstacle to widespread use. Rural practitioners may lack support technologies.)
3. Economics of telemedicine (Telemedicine equipment costs hundreds of thousands of dollars, plus thousands in maintenance. Health plans may not pay for telemedicine, and health care financing is reluctant to increase consultations.)

4. Legal and social issues (Remote licensure and liability must be addressed, as must the social and political issues relating to access to telemedicine. [Chapter 14 discusses the legal aspects of telemedicine.])
5. Organizational factors (Organizations must address issues surrounding telemedicine prospectively and specifically.)

But, telemedicine continues to be an essential element in health services delivery in the 21st century, and significant growth is certain (Klapan, Čikeš, 2001).

Introduction of "electronic patient records", even for electronic-computer experts extremely complex electomedical equipment/devices, minimum invasive technologies, new possibilities rendering telemedical/e-health services, new ways of home care, new ways of care and heath care for older persons are only some of possibilities, but on the other hand problems as well, that are opened by introduction of new technologies.

Such a reorganisation of way of providing health care should be targeted primarily to prevention of decreasing illness of those about whom it cares, as well as proper diagnostics, treatment and rehabilitation of the sick. So far, it should be emphasised that it provides a large number of advantages and benefits to medical institutions and thus to the organisation of public health and health care.

Let us mention only some of them:

- increase of business operations profitability of public health care as well as medical institutions
- decrease of "running in place" of medical workers
- increase of flow and comfort of patients
- increase of safety and availability and decrease of possibility of defect on a device and equipment
- increase of correctness of diagnostics and successfulness of therapy, which is also a kind of promotion of a medical institution
- possibility of monitoring quality and costs of maintenance of devices and equipment of producers

However, there are some prerequisites.

The first prerequisite of successful computerisation of health care and introduction of new technologies is the investment in and purchase of new computer equipment and networking.

The second prerequisite is standardisation of computer and communication protocols, on which it is intensively worked in the world. Unfortunately, in application of standardisation in the sphere of computerisation and communication not only in Croatia, but also world-wide, we encounter three basic problems:

- data on patients are extremely complex and in various forms (written descriptions, biomedical signals, results of biochemical analyses, medical imaging, etc.)
- different wards and clinics within an medical centre are mostly completely differently organised and use fully different data and information, not only by kind, but by structure also!
- a majority of hospital wards and clinics, even primary health care units, is today “computerised!?". Yes, if the concept of computerisation we consider as a software which, may be works good for a certain medical unit, but which is *incompatible with anything***,** mostly in the own institution, not to mention compatibility with other medical institutions in the same city or country, let alone internationally.

The third prerequisite refers to better informatics education of doctors (physicians) and medical personnel.

The fourth prerequisite for implementing the reorganisation of public health care and health protection assumes the existence and introduction into medical institutions of qualified persons, *experts of new profiles* (which is in the world known and acknowledged practice) – *biomedical and clinical engineers, medical physicists, medical informaticians, etc.,* who in close co-operation with physicians, render adequate services (e.g. purchase of equipment, education on optimum use of equipment, care about safety of *patients*, users and environment, maintenance of equipment, care for computer programs, protocols and networking etc.), by application of “specific technical” knowledge acquired by special education (EMBS, 2004, IEEE 21-compl. issue, 2002).

These developments suggest that attitudes will change

- from performing maintenance because it is required to performing maintenance because it saves money
- from purchasing based on price to purchasing based on life cycle cost
- from biomedical service as a part of maintenance to managing technology as part of managing health care
- from a focus on technology to a focus on information

As it is a question of extremely interdisciplinary knowledge (e.g. biomedical instrumentation, medical imaging, biological signal analysis, medical informatics, clinical engineering, biomechanics, rehabilitation engineering, prosthetic devices and artificial organs, biomaterials, biosensors, cellular and tissue engineering, transport phenomena, physiologic modelling, biologic effects of electromagnetic fields, etc.), it is logical that the question arises how to educate such a personnel? One among the problems is that there is not great need for a large number of biomedical engineers, especially in medical facilities. Hence, the question arises if there is a need for undergraduate study devoted completely to the “biomedical engineering”, or it is better to give the students basic knowledge in some of above mentioned fields, and after on postgraduate or specialisation study’s level give specific “biomedical” knowledge?

Programs may be complete, partial or interdisciplinary, on expert, undergraduate or postgraduate level.

Let’s mention here that, at this time, in Croatia partial education in biomedical sciences can be obtained only at the Faculty of Electrical Engineering and Computing, University of Zagreb (undergraduate courses: Biomedical electronics, Biomedical informatics, Bio-monitoring systems, Multi-sensor systems and locomotion, Selected topics on biomedical engineering; postgraduate courses: Use of computers in medicine, 2D electromedical equipment, Multi-sensor biomonitoring systems, Biomechanical and neuro-physiological mechanisms).

In addition to partial (a certain number of “specialist’s” subjects), at the present (this issue will be harmonised on the level of the EU as well) as the optimum appears integral postgraduate specialist’s studies and of course, life-long specialisation, depending on specific requirements of particular work posts. In other words, life-long learning is suggested itself as “must be” with reference to extraordinary propulsiveness of the area (IEEE 22-compl. issue, 2003).

Conclusion

Astounding progress has been made in medical science over the last half-century. Nowadays, medical practice in developed countries is often completely dependent on engineering. Remarkable advances in quality and use of modern elecromedical equipment and ICT have taken place into everyday medical practice. Biomedical engineering appeared as the new field of science, exceptionally complex and highly multidisciplinary. Modern hospitals are full of devices, instruments and machines that have been designed and produced by engineers, usually working in close collaboration with other healthcare professionals. Reliable, successful and rationale use of these advances depends not only on physicians, but also on biomedical engineers. Although biomedical engineers are primarily engineers, they need to have a firm grasp of the biology and medicine that is relevant to their work. Education, specialisation and life-long learning become the "must be" not only for engineers, but also for health care professionals including doctors, nurses, biochemists, etc.

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Opening the Discussion on the Introduction of eLearning Principles in the Life-long Education in Printing

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Abstract

Graphic engineering is entering the interdisciplinary space. Catalog of professions was recently describing hundreds of different subspecialities within within each of units known today as Prepress, Press and Postpress. Those groups are also being integrated into one single - Printing. It found itself in the multimedia surrounding, where each participant should overcome many different skills in print production. The problem is not in requalification from one profession to another, but in additional qualifying in what can be described only as "printing worker". In such a vocational integration, many skills are not actual any more; some will be needed never again, but the need for many new skills will appear. Ahead of us is a brilliant connection of informatics, robotics and printing. Existing workers can survive in such an environment only if they accept comprehensive learning of new technologies that are entering printing works.

At this point, we are proposing a central topic that should be established in studying of the new printing technologies, around which the structure of new professional skills. All workflows of conventional print production include the phase of printing plate production, which is a material image carrier. Several new and dominant methods in this section of prepress have something in common - printing form (plate), which in different methods of screening enables reproduction of graphics. Therefore, we are of the opinion that special attention in eLearning should be given to plate production, because it can actually comprise learning of the entire field of printing technology. If we assert that the learning in the area of printing forms can be extended to some 50% of all knowledge needed for the contemporary printing technology, it can be supported by the fact that it includes the following: Design and layout of pages; Reprographic and screening techniques; Typesetting and integration of text and images; Planning of printing; Choice and usage of printing presses; Planning of bookbinding and postpress actions; Plan of orders and selection of materials; Plan of profit. We can expect that in the area of platemaking permanent enhancement will appear, because all automatization issues in print production are related to it.

Printing works differ very much one from another. Printers with dominant book production are completely different from those, which - for instance - print newspapers. Printing house producing printed packaging is different from the one where principal products are valuables and protected documents. Shifting of workers from one kind of printing job to another was sore. If discussion on rapid technological changes with integrated digital techniques is added to this, then the situation seems to be vague. So many diversities can be resolved on by applying some "new method". The concept of eLearning requires additional learning, after regular education and in full working period. In the field of printing, there are no similar solutions by now, even on the expert level. There are no expert teams that could offer eLearning in printing. Volumes of professional literature are extremely expensive, while books by themselves are not organized for eLearning.

Key words: *e-Archives, e-Learning, Computer-to-Plate, Print production, XML technology*

1. Bringing professions together

Prepress was the first - ten years ago - to collect many professions into one. The same worker is taking care of:

- the text;
- scanning of images, archiving prepress material, retouching;
- transforming recording formats, compressing electronic graphics;
- using the computer, digital camera, video devices;
- organizing the sheet layout of sheet for the plate;
- planning behaviour of printed sheet in the press and in postpress;
- planning of spoiled prints, planning of later folding procedures;
- planning of diecutting and cutting;
- relations between process and spot colors;
- planning methods of color separations, depending on print run, type of printing and determination of the printed product;
- design of the interior and exterior appearance of the printed product, and many other operations.

Printing (press phase) requires workers who, with full understanding, reached skills and knowledge of prepress, being able to serve all printing techniques in the pressroom:

- conventional and digital printing;
- web printing and sheet printing;
- printing for special purposes - packaging, labels, foil printing;
- printing on different materials for extraordinary occasions.

Postpress appears to be the most complicated part of the entire graphic process. Each printing house has specific postpress operations, depending on the market requirements. Normatives of machine usages in postpress are a network of different addresses, which cannot be integrated into one single system. Description of working operations in postpress is several times more extensive than in previous two phases. Only some of them can be mentioned: folding, covering, cutting and diecutting, glueing, laminating, sowing, perforating, rounding, counting, many different ways of bookbinding etc. A special group is related to manual postpress operations. For all this operations descriptions of working processes are existing, together with norms and qualifying certificates. Simulators are used for education in this extremely big number of skills: physical models, videos, program and interactive training machines. However, this is unique, present in printing industry on demonstration level only. Simulators appeared more as a part of technical or scientific projects, less as a rule in a real printing procedure.

2. Requalification and new knowledges

In recent twenty years printing experienced several unsuccessful attempts of requalification of workers related to introduction of computers in prepress and digital presses. In such a vocational integration, many skills are not needed any more, while need for new knowledges appears, as well as for new workflows and integration of printing and information technology. In this paper, establishing of knowledge bases is suggested for the fields of prepress and press and incubation of software and hardware simulators in the area of graphic engineering. A discussion on motivation centres in learning for the new age of printing is proposed.

Surveys on the future of printing are very poor; they are more or less dealing with variables not showing real changes as: paper market, advertising in daily newspapers, of journals and magazines, quantity of new titles and printed books, connections to the new media, increase in print runs of newspapers, magazines, brochures, journals etc.

(http://www.smartfactory.org/smart/presentations/PBeyer_DSFactory.pdf).

Internal changes in printing are related to flow of information, application of computer technology, inclusion of new printing technologies. This is what actually changes working habits, working places, communication publisher-printer and reduces time for publishing of new information by means of printing technology. Studies on development of printing are not only poor, but are showing that experts did not anticipate at all certain developments in computing and printing. Therefore, studies performed 5 years ago did not even mention XML and contemporary printing language JDF (Job Definition Format), which became central point of graphic engineering.

3. New topics in studying printing technology

DTP (Desktop Publishing) has improved workflows, but only in the prepress segment, and now it has a steady increasing influence to print production. On the contrary, network flows are changing workflows much more, leading towards total integration of the job and business process. E-production - anywhere and any time. What can be expected in the future of printing?

Linear following of printing processes is being introduced - Prepress, Press, Postpress. This will happen only when interfaces will be performed between presses and information systems. Each press should be described in details through normatives for different print runs, materials and type of printing activities.

Survival and development of printing is related to improvements in business by means of sofisticated printing services, i.e. development of XML based technology in printing, communications and management. Printing co-exists with electronic, so-called ePrinting, and that is determining the future of printing industry.

ePrinting means reproduction from computer directly to paper (or any other material), known from twenty years ago as an idea of DeskTop Publishing. Digital presses do not require specially trained operators. ePrinting includes participants ready to accept up-to-date state of the art - eAuthors, eUsers, ePublishers, eDesigners, ePlanning, eOrdering, ePrinters, eServices, ePostpress, eSales, eArchives, as well as many others within the ePrinting community. All of them are communicating and exchanging information by Internet technology, thus acting as a business electronic society. In this was production terms in conventional printing will be reduced and expenses decreased, giving at the same time electronic e-publication. New relations are opened among users, printers and suppliers. New sources are discovered, from authors, to materials, expert workers and services; new market relations are being introduced. Network and knowledge are linking customers and producers. All the participants are “on-line”.

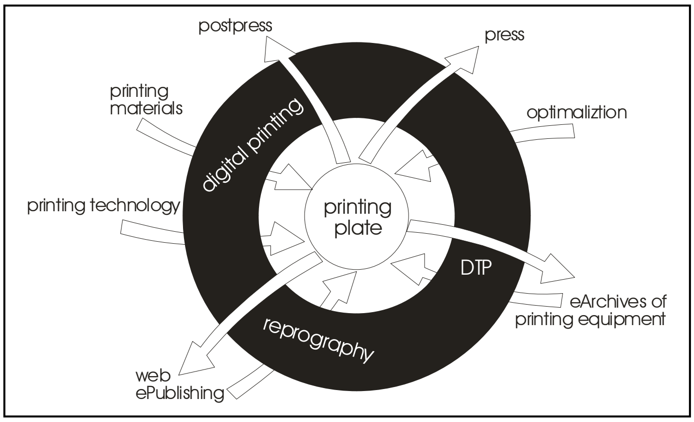
4. Bases of knowledge in printing technology as the beginning of an organized eLearning

The foundation of learning in printing by eMethods should be established on organizing knowledge bases and databases on exploitation parameters of presses. For certain printing systems it is necessary to organize relation bases on workflows and bases of printing materials. What replaces a classic teacher-instructor should bring closer to the student all processes and procedures in the way similar to conventional learning. eTeacher has the advantage that it can be upgraded, standardized, improved in different ways; it can be copied, reviewed, changed. This basic attitude should be supplemented with the fact that we still do not have eInstructors for printing, which could in our own language assist in widespreading and dissemination of knowledge on print production technologies.

A group of our lecturers introduced - within approved research projects and along with changes in big printing works - a base of normatives for print production. Experimental simulators are developed with data for over 160 presses and print processes. They are implemented upon exact measurements in local printing houses and under local working conditions; System is performed in XML technology (eXtensible Markup Language). This enables simple access to databases by Internet technology, without regard is it related to inhouse points or some other place. Reviewing, editing and using of those bases are possible from any location and at any time. Such a base is established as a milestone on the way of organized learning in printing processes.

5. Printing plate as the key point of printing technology studies

When the overall reproduction process is considered, it is clear that the plate production is that point in print production that separates - but also links - prepress from printing. Prior to it, activities are focused to those participants in the process, who are giving meaning to the final shape of the printed product: author, publisher, designer, reprographer, typesetter. After it, those participants are following, who are preparing the product in the material form - book, folder, poster, newspaper, boxes and many thousands of other different printed products.



Printing forme can exist in the non-material outline, as it is in digital printing, or as material one in conventional printing. A great deal of material printing formes is related to the term "Computer to-Plated" - CtP. Therefore, this abbreviation will be exceptionally used in this text for all platemaking processes. CtP itself, as a technological process, is known and present in the printing industry for more than 20 years. Until mid-nineties development of this technology was somewhat slowed down, because of insufficient computer capacities and still competitive prices prepress with films and classic (manual) stripping. Because of this slow acting progress, but also because of sometimes-conservative approach towards new technologies, there were not enough workers able to operate CtP units, since this is a process where no mistakes are allowed. At the same time, strong progress happened in the field of digital printing, which proved dissemination of knowledge in electronic imposition, without big expenses of misprinting involved. Therefore, such digital printing was a kind of a simulator for massive learning and quality control in what is CtP today.

Working out a printed product is a complex and multiphase process. Everything done prior to the point marked with CtP is immaterial, subdue to changes and improvements - from design to corrections. In this pre-phases all further steps and press and post-press operations are determined - not only printing, but register of inks, plan of cutting, folding, wire stitching, machine sewing, binding - practically all multiple procedures, by which a product is not only printed, but completely finished. Paperweight should be calculated, as well as number of folds, method of binding etc. Sequence of printing is planned and spot and process inks are determined, dependence on the press and number of units. Paper supply is planned, its preparation for printing, B/W test prints, printing on alternative presses, alternative printing sheets, alternative foldings, diecutting. In phases prior to plate production, a complete production plan should be established, terms, human and material resources. CtP, as an output unit, only materializes information by means of a recording on the printing plate.

Because of the reasons mentioned, it can be emphasized that CtP is the key point of not only printing processes, but also of learning in printing workflows. At them moment of the plate output, all details of the further process and the printed product must be known, planned and determined. Organizing of knowledge bases in printing has the central point in the phase of CtP. Through this sensitive hub, normatives in pressroom are linked with prepress works. Such an establishment determines necessity of integration of the entire print production. This implies interactive relation of CtP with presses and finishing machines. Automatization in printing works starts with platemaking, because here are recorded all parameters of a printed product. This applies if only one or two machines are in the JDF system, or if all parts of the operations are networked. Data, saved in bases, can be always recalled, updated or controlled. However, most of all, they should be used for eLearning and permanent updating of knowledge.

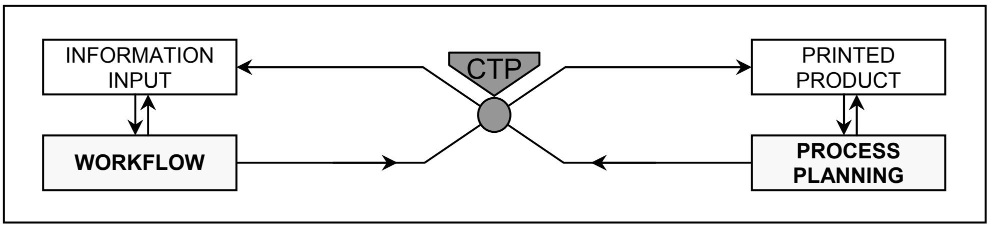
Integration of print production more than anything else implies need for knowledge on printing among all participants in the process. Such “software integration” for studying printing as a discipline, its reason and sense. Wide general knowledge and technical culture is needed for that. Therefore, CtP is an integrator of eLearning in printing. However, as far as integration as a concept is concerned, it can be reached among all on the level of cognition and complete comprehension of graphic processes. This is in a certain way troublesome, since CtP cannot be considered as unambiguous. In hardware and software sense, different processes have been developed (i.e. thermal or visible emission, diffusion of silver halides or polymers, ablative and non-ablative methods etc.). Although their basic role is always the same, methods of CtP plate production and their characteristics are very often different.

Those who have certain experience in electronic prepress (recordings to film) or digital printing will easily accept integrative role attributed to CtP within the process. Here the question of verification of the digital recording arises. Proof prints - regardless of the method - lost the sense, but importance of “preflight” proofs is increasing. Different is the situation on the other branch of this key point - printers should be acquainted not only with the role of CtP, but should also understand the way image is generated and recorded on the plate. Such printing plates, which are carrying the entire information about the printed product, are quite different from conventional ones, screening structures are different, as well as geometry of printing and nonprinting elements; different dot gains and reproduction curves, with no side effects typical for photomechanical processes. Operational characteristics of presses should be adjusted to these new circumstances; knowledge bases on CtP characteristics should be therefore permanently extended and upgraded.

Entire production plan, conducted by electronic methods, will become a reality only when presses and other machines will be upgraded to the level that enables reading, registering, correcting and reporting on processes in real time. Brilliant solutions already exist in part of print processes, folding and cutting. Slow implementation of “hardware intelligence” has the reason in the fact that it cannot be applied to old machines within reasonable level of costs. New generations of machines, however, have the ability to “recognize each other”, so their operational characteristics can be modified according to the stored data. High level of automatization should not be considered only as application of several commands; on the contrary, it implies wide and active knowledge and full understanding of all processes.

Regardless of printing technique, prepress methods or printing substrate, plate (forme) is the point in the reproduction chain in which image is completely and irreversibely determined. Image elements, obtained by analog or digital recording, are defined by shape, size and structure. They will be - as they are - transferred to prints.

All previous prepress phases are therefore in functional dependence on printing plates. Although image is transferred to paper in presses, it would be wrong to claim that plates are only in function of printing; on the contrary, printing plates are information carriers of the complete printed product. Consequently, the concept of graphic reproduction (which is sometimes limited to transfer of image by printing) should be extended to producing the integral graphic product. It is known that that more and more products are of complex structures, and that printed image is only one of these elements. These product require numerous postpress (finishing) operations, which are nowadays very sofisticated and highly automated. All of them should be clearly understood in order to include their elements into the process, which should be functioning as an integral unit. This claim - although can be also applied to conventional methods - has special significance in considering new technologies and integrated printing processes. With the development of new reproduction technologies, advanced computing methods and new software solutions, the key point of the reproduction chain is shifted closer to the completed printed product. It should be stressed, however, that the process of planning and workflow itself should be conducted in opposite directions; CtP is located just in their intersection.



The meaning of CtP is not - what is often wrong perception of its role - only output unit for producing printing plates, which can be operated by a couple of simple commands. They are open, but completely determined prepress systems, with the highest possible level of automatization, where all information about the final product are worked out. That also means that in the area of CtP the product already has to be completely determined.

6. Printing plate archives

Already now - and so it will be in the future - the printing forme exists in digital form only. It will be considered as an electronic recording, ready for activating the entire reproduction process: backwards to prepress and onwards to press and post-press operations. Digital form enables various transformations: plates for different printing techniques, for digital printing, for proof prints, web forms, forms for electronic publishing. The other group of transformations enables reworking for different types of products - books, brochures, newspapers catalogs etc.

Electronic base of the printing forme remains as a permanent value with extension possibilities. Organization of eLearning in printing leans on the archive of such formes. Through such bases, answers and solutions can be fount to any question or problem related to the printing process. Accessability to knowledge through this printing forme base enables elaboration of different tools for eLearning and advanced education of printing processes. Application of eArchives of printing formes gives a possibility of a critical approach to certain solutions, thus opening the path to permanent improvements of printing technology.

7. Conclusion

A big task is ahead of us, to give meaning and to perform training for all participants in the field of printing and graphic reproduction, and to be prepared for the upcoming global society. Methods of motivation should be developed, consciousness that life-long education is not a "must", but a way of thinking, as a precondition for survival on the global market. Only people with "digital business culture" will succeed with the ePrinting technology. Advances in print production are possible by following changes and developments in computing technologies. Digital printing forme should be adopted not only as a key point of automated print production, but also as central issue of studying print processes. eArchives of printing formes will be sources research of printing technologies based on real production circumstances. eArchives of printing processes (supported by Web and Internet technologies) will be the point of motivation in the task of life-long professional education.

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The Future of Geodetic Engineers

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Abstract

Since the immediate future of Croatian geodetic engineers is closely connected with the state of geodetic survey in Croatia, basic data about that survey are given in the paper. Changes in geodesy which ocurred in the last 30 years considerably affect the employment structure, which is evident from data from Denmark and Germany. There is also data about maximum number of ECTS points which students can acquire at eight European geodetic faculties, including the Faculty of Geodesy in Zagreb, from three most important areas of work of contemporary geodetic engineers: classical geodesy, geoinformation management and land management. From this data, it can be concluded that the Faculty of Geodesy from Zagreb has to, via the upcoming reform, enable its students the acquisition of advanced knowledge, not only of classical geodesy, but also of other two areas.

Key words: *geodesy, surveying, Croatia, geoinformation, land management*

1. Introduction

In Croatian geodetic terminology the term geodesy (*geodezija*) contains the subjects of geodetic reference systems, physical and satellite geodesy, photogrammetry and remote sensing, geographic information systems, and cartography as well as traditional surveying as the core discipline. The term geodesy and the adjective geodetic have that meaning in this article.

With the development of information, spatial and computer sciences, classical geodesy transforms from analogous into digital, from static into dynamic and kinematic, it changes from subsequent data processing to real-time data processing, from local approach to global approach. A geodetic engineer becomes a geoinformation specialist. Such development forces us to adapt the curricula and programs of geodetic schools to the development of science and technology more often than in previous periods. In this paper we are going to try to give our view of the future of geodetic engineers. Since the immediate future of Croatian geodetic engineers is

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strongly connected with the state of geodetic survey in Croatia, we are also going to give basic data about that survey.

According to the new *Law about Scientific Activities and High-Level Education*, the university study encompasses three levels of education: undergraduate, graduate, and postgraduate studies. According to the Bologna declaration, undergraduate studies typically last three to four years, graduate studies one to two years, and postgraduate studies lasts three years. The organization of undergraduate studies has to begin not later than school year 2005/2006, according to the aforementioned law. That is also the reason for the reform of the curriculum and the program of the Faculty of Geodesy, University of Zagreb.

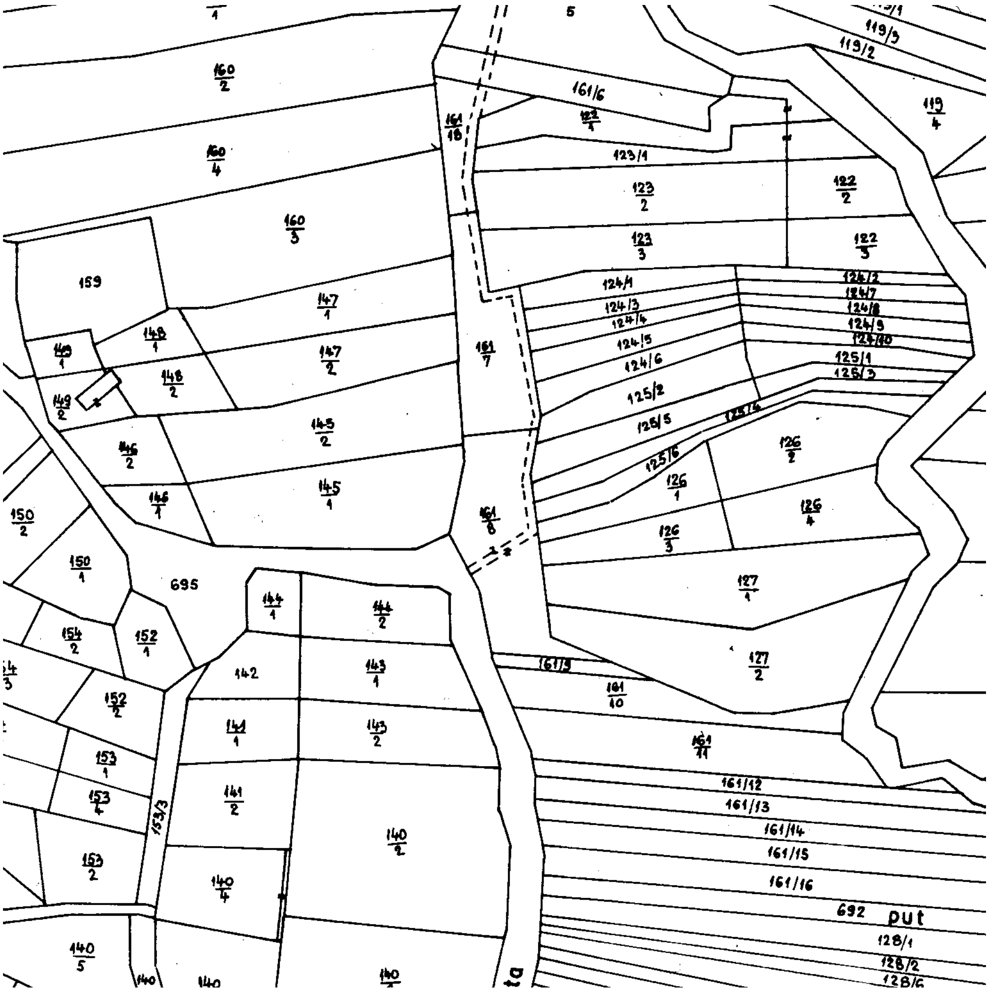

Fig. 1. Part of a cadastral plan

2. Geodetic Survey of Croatia

Geodetic survey is defined as collecting, processing and representing data via geodetic methods. The most important types of geodetic surveys are cadastral survey, topographic survey and hydrographic-geodetic survey. A retrospection of the state of cadastral and topographic survey of Croatia follows.

Cadastral Survey

Cadastral survey was, and still is, used as an original for establishing and maintaining land cadastre or real estate cadastre and land books. Cadastral records are produced on the basis of data acquired and processed in cadastral surveys for each cadastral county district and cadastral area at sea. Cadastral records consist of cadastral plans, general cadastral maps and other graphical document, as well as of written parts.

Land cadastre consists of records which contain data about the land – its position, shape, area, type of exploiting, production capability and the owner, and it has been maintained in Croatia since 1817.

Real estate cadastre, which has been produced in Croatia since 2000, consists of files about land particles, buildings and parts of buildings, as well as all other buildings which are permanently above or below the land surface.

Land books are public and credible registers about real estate and its rights. They are established and maintained on the basis of cadastral survey. The rights are acquired, transferred, limited and cancelled via registration.

Cadastral plan (Fig. 1) is a map of the largest scale with a ground-plan of built objects, ownership boundaries which stretch to boundaries of land particles, their numbers, settlement and lawn names and vegetation marks. Such maps rarely contain a representation of Earth's relief. When necessary, such a map may contain other information.

According to data of the State Geodetic Administration, the age of surveys and their number by periods is given in Table 1.

Table 1. Number of surveys

Period	Number of Surveys
1817-1918	2753
1918-1945	155
1946-1980	85
1981-2000	237
Total	3230

Numbers of sheets and the area in hectares and percentage of the survey type are given in Table 2. From the given data, it can be concluded that only 21.6% of Croatia has a contemporary numerical survey, and the rest has the graphic survey from the 19th and the beginning of the 20th century. 12 679 sheets out of the total number of cadastral plan sheets are in bad condition, and 6647 sheets are in very bad condition (UDK, 2003).

Table 2. State of cadastral survey in Croatia

Type of survey	Number of sheets	Hectares	%
Graphic Survey	24 783	4 449 543	78.4
Orthogonal and Tacheometry	4 705	152 278	2.7
Photogrammetry	6219	275 352	4.9
Land Consolidation	10 116	797 001	14.0
Total	55 823	5 674 174	100.0

Cadastral survey data don't present the full cadastre and land book state in Croatia. The largest problem is their lack of coordination. The degree of the lack of coordination of those two records is so high that it practically makes their economic usage impossible, and is not comparable to any other country in transition, not to mention Western European countries (Gojčeta, 1997). Besides, 232 out of total 3307 county districts don't have a land book. 635 cadastral county districts renewed their land books, while 1952 did not (UDK, 2003).

At the beginning of 2002, the State Geodetic Administration set itself a goal of vectorizing all 55 823 sheets of cadastral plans within the scope of the state survey and real estate cadastre program, to 2010 at the latest. Within the scope of realizing the CRONO GIP I project (Croatian-Norwegian geoinformation project), with Norwegian help of 9.5 million HRK, the State Geodetic Administration line for scanning and vectorization of cadastral plans was established. Norwegian company proCaptura delivered a special large format flat scanner KartoScan IV and five special workstations to the State Geodetic Administration, and developed special software for the vectorization of Croatian cadastral plans. Ever since the line was established 14 months ago, 4000 sheets of cadastral plans and 3500 sheets of Croatian Base Map 1:5000 have been scanned. The basic goal of the project – to make cadastral data available to users in a simple and modern way, and to facilitate its maintenance – is slowly coming to an end (Bosiljevac, 2003).

At the end of 2002, the State Geodetic Administration also started a project of harmonizing and settling land books and the cadastre. In order to do so, Croatia and the World Bank made a treaty about loans. The goal of the recommended project is the creation of an efficient land management system for contributing to the development of an efficient real estate market. The total area of the area recommended for restoration, corrections and coordination of land book and cadastral data within the scope of the project is about 250 000 hectares (about 5% of the total territory of Croatia), it encompasses about 1.05 million land parcels, and the project would be useful to 360 000 people in that area, including about 110 000 real estate owners. After the project establishes improved mechanisms, including required human resources, the continuation of the systematic registration of real estate in the rest of the country is going to be much cheaper and will be realized with the help of resources granted by the government, the European Union and other donors. The period for realization of the project is 2003-2008 (Marjanović, 2003). It should be mentioned that the cadastre and the land book united in a unique information system form one of the largest such systems in many countries. Such a system in Croatia is going to contain data about approximately 22.8 million land parcels (UDK, 2003).

Topographic Survey

The second topographic survey of the former Yugoslavia has been performed from 1947 to 1976. It was the first integral survey of the Yugoslavia area. A base topographic map of Yugoslavia at the scale of 1:25 000 was produced on the basis of that survey. The map was produced in three Gauss-Krüger projection systems on the basis of Bessel's ellipsoid parameters. The longitudes were calculated from Greenwich. Topographic maps of smaller scales, i.e. 1:50 000, 1:100 000 and 1:200 000 and general-topographic maps at the scales of 1:300 000 and 1:500 000 were produced after that (Frančula, 2000).

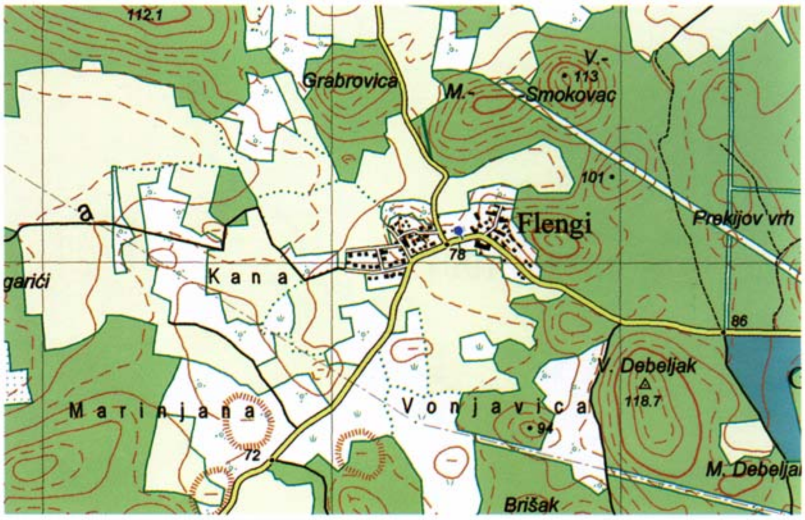

Fig. 2. A part of the new topographic map at the scale of 1:25 000

Military institutions in former Yugoslavia made it possible only to acquire multicolour printed copies on paper, while the usage of originals or copying reproduction originals was prohibited. This situation was the cause of the independent Republic of Croatia's lack of basic equipment, as well as reproduction originals and printed maps, in which it previously invested considerable funds. Therefore, a decision was made to produce reproduction originals out of existing topographic maps at the scale of 1:25 000. Although the content of existing topographic maps at the scale of 1:25 000 was outdated, the printing of renewed sheets with a new designed margins without the revision of the content was a necessary, but only temporary solution. The production of reproduction originals was carried out by contemporary digital procedures of scanning multicolour prints and separation into layers according to colours applied in printing.

In order to produce new topographic maps, a method of aerial photography was applied in mid 1990s. The data is processed by contemporary digital methods not only to produce the map itself (Fig. 2), but also to create a quality basis of topographic data for the production of an information system and a digital relief model. The Official Topographic Cartographic Information System (Službeni topografsko-kartografski sustav – STOKIS) is being produced in Croatia based on the German ATKIS. The basis of the system is the Croatian Topographic Information System (CROTIS). The Cartographic Data Model (Kartografski model podataka – KMP) was designed in conformity with CROTIS, which will enable the production of a cartographic base from the topographic one (Biljecki *et al*, 2003).

3. The Future of Geodetic Engineers

Changes which occurred in geodesy in the last forty years, and especially in the last decade, can be called revolutionary with no exaggeration. They are connected with the development of electronic, satellite and computer technologies. These changes are so important and huge that they are the cause of changes in names of geodetic associations, journals, geodetic schools and even the whole profession. At first in Canada, then in Australia, after that in Europe, the term geomatics is introduced here and there instead of geodesy and surveying. More often, the term geoinformatics is added to geodesy. Geoinformatics is a contemporary scientific term for an integrated approach to the acquisition, analysis, management and representation of spatial data. The appearance of geoinformatics means an integration of mathematical-physical geodesy with photogrammetry, remote sensing, cartography, geographic and land information systems and multimedia communication. With the development of information, spatial and computer sciences, classical geodesy transforms from analogous into digital, from static into dynamic and kinematic, it changes from subsequent data processing to real-time data processing, from local approach to global approach. A geodetic engineer becomes a geoinformation specialist. A more detailed description of these changes can be found in a paper (Frančula and Lapaine, 2000), see also (Medak and Car, 2002; Bašić *et al*, 2003). Here we are going to expound several additional information, at the same time listing some foreign data we believe will help the consideration of the future of Croatian geodesy.

A network of permanent GPS stations in Germany (Satellitenpositionierungsdienst – SAPOS) is almost completely finished. In spring of 2003, it contained 261 stations (Becker and Weber, 2003). SAPOS services include four precision classes: 1-3 m, 1-5 cm, 1 cm, and more precise than 1 cm. The precision in the first two classes is obtained in real time, while that of the two more precise ones is obtained via subsequent processing. In a detailed survey, SAPOS will never completely replace terrestric survey methods, but it will be widely applied because of its economic and technical advantages (SAPOS, 2003).

The first terrestric scanners appeared a few years ago in order to help a wide range of users with computers sufficiently powerful to process a large amount of 3D data, and with the help of the evolution of length measurements without reflectors, but of high precision. In structural surveillance, laser scanning can be considered more advanced than those geodetic methods which can follow the deformations only on a limited number of points, while the scanner is able to measure the deformation surface. Laser scanners are more than adequate for monitoring deformations on capital constructed objects such as dams, bridges etc. Automatic 3D survey of various objects without contact has become one of important tasks of engineering geodesy. The last, but not the least is the model creation from measured data (x, y, z), which results in a possibility of a realistic representation, and that procedure is called *as built* (Matijević and Roić, 2002).

The transition from analogous and analytic to digital photogrammetry during the 1990s has had a strong influence on education. Stereo capable high-resolution satellite sensors are the cause of convergence of photogrammetry and remote sensing. The basis of education are these themes: digital processing and image analysis, digital aerial photogrammetry, laser scanning, digital close-range photogrammetry, remote sensing with stress on high-resolution sensors and multispectral classification. Main products of contemporary photogrammetry and applications are: orthophoto, terrain models, 3D city models, 3D visualization, land use, environment and culture objects protection, industrial measurement technique (Nebiker and Grün, 2003).

The objects of newest research in cartography are location based services and telecartography. Location based services are all those information a user can obtain via a cell phone or a portable computer which are related to the position where he or she currently is. For example, a user is in a certain city and wants to know where the nearest hotel or hospital is. A great deal of such information can be transferred to the user very efficiently in the form of cartographic representations on cell phone or portable computer displays. The goal of telecartography is to create such cartographic representations suitable for small displays of those devices. Multimedia elements have to be integrated into the cartographic communication process because of the very small size of those displays (Kelnhofer *et al*, 2002).

Describing the need for reconstructing the geodesy (geomatics) studies, Konecny (2003) determined that it has to happen in coordination with the job market. He illustrated the changes which occurred in the last 30 years on the example of Denmark (Table 3).

Table 3. Fields of employing geodesists in Denmark

Employment Sector	1967	1997
Cadastre	70%	20%
Planning	5%	25%
Mapping	15%	30%
Other	10%	25%

The number of geodesists hired in cadastre in Germany, as well as in Denmark, has decreased in the last few years. For Germany, Konecny (2003) lists the percentages of employing geodesists in various fields of geodesy at the moment (Table 4).

Considering the importance of this data for the future of geodesy in Croatia, it should be pointed out that, considering the state of the cadastre and the land book in Croatia (see §2.1), such changes in the structure of geodesists' employment will not occur in Croatia for some time. However, changes in the curriculum of the Faculty of Geodesy in Zagreb are necessary. Some data from tables 3 and 4 also point to that necessity. The immediate cause for the changes is the new Law about Scientific Activities and High-Level Education, which has, in coordination with the Bologna declaration, prescribed the study by the 3+2+3 or 4+1+3 year model. After the first three or four years, one acquires the professional title bacalaureus (B.S.), and then after one or two more years, the title graduated engineer (M.S.). The last three years are for the doctoral study.

Table 4. Fields of employing geodesists in Germany

Employment Sector	
Terrestrial Surveying	40%
Higher Geodesy	5%
Photogrammetry and Remote Sensing	5%
GIS	30%
Land Management	20%

In the decision about the type of changes in the curriculum, an analysis of curricula of geodetic high schools from 16 European countries can help. The analysis was made by Prof. Hans Mattsson from Sweden (Mattsson, 2000). Here are some data for seven faculties from seven European countries from the analysis. The faculties are from Athens, Madrid, Bonn, Delft, Aalborg, Stockholm and Dublin. In table 4, there is a maximum number of ECTS points (European Credit Transfer System) which can be acquired at a particular faculty from three fields which Mattsson considers important for the activities of a contemporary geodesist: technical geodesy (we are going to refer to it as classical geodesy), geoinformation management (GIM) and land management (LM). Mattsson mentioned another field – real estate economics, which we left out, because in most European countries, the study of geodesy does not include it. GIM includes subjects which teach students how to analyse spatial data with the help of geoinformation systems. LM contains expanded knowledge from the science of law, planning and development, including certain knowledge from land evaluation. Mattsson claims that advanced knowledge from the field of classical geodesy and land management is acquired with the minimum of 90 ECTS points, while advanced knowledge from geoinformation management, as a new field, is acquired with the minimum of 40 ECTS points. Table 5 also includes data for the Faculty of Geodesy from Zagreb.

Table 5. Maximum number of ECTS points

Faculty	Classical Geodesy	GIM	LM
Athens	131	14	18
Madrid	144	15	10
Bonn	153	27	57
Delft	99	45	34
Aalborg	111	49	110
Stockholm	104	23	104
Dublin	93	40	35
Zagreb	166	23	41

From table 5, we can see that all seven faculties enable the acquisition of advanced knowledge from classical geodesy, three of them enable the acquisition of advanced knowledge from GIM (Delft, Aalborg and Dublin) and two of them the LM (Aalborg and Stockholm). Only one faculty enables the acquisition of advanced knowledge from all three fields (Aalborg from Denmark), and two faculties enable the acquisition of advance knowledge from two fields: Delft (classical geodesy and GIM) and Stockholm (classical geodesy and LM). It is essential that, in the upcoming reform, the Faculty of Geodesy from Zagreb becomes able to enable the students the acquisition of advanced knowledge, not only from classical geodesy, but also from the other two fields.

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High Education Mission in the Field of Wood Processing Technology

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Abstract

This paper is an attempt to present the mission of high education in the field of wood processing technology. It starts with the presentation of the historical development of high education for wood technological engineers, followed by a vision of the development of wood processing and furniture production. On this basis the hypotheses of the mission of high education in these fields are made.

The basic dilemma is to which of the scientific fields – biotechnical or technical – wood processing technology belongs. The author is flexible in these assumptions, free from the rigidness of the administrative arbitration. He is for syntheisized knowledge, interdisciplinary and transdisciplinary work, and the change of classical paradigm of high education, introducing the necessary innovations.

1. Introduction

This paper is an attempt of presentiong the mission of high education in the field of wood processing technology based on the interpretation of the premises and dilemmas in the development of wood use and future development of wood processing technology. The presentation should encompas a wide range of topics and possible achievements of the wood-technological sciences, which makes them a specific combination of the interaction of natural and technical sciences. This complexity of interactions is a reason for the survival and further development of the wood-technological science within the entire development of biotechnical and technical scientific world as one of the basic scientific disciplines. Wood processing technology can be defined as an integrated application of natural and technical sciences for the purpose of making products from wood as a recycable natural resource. A specific property of this branch of scince is that – besides developing new products based on wood and wood materials – it also deals with both the development of production technologies applicable to the requirements of biomaterials and with the methods of controling t his production.

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This paper also tries to discuss the role and significance of wood and wood-technological science throughout the whole development of man's life. It tries to evaluate the achieved development degree of wood processing technology and wood management, particularly in view of economic valorisation of the entire status of science and national economy.

The prediction of the development courses of products, staff and technological/organisational trends is more than necessity for scientists, economists, business people, polititians and other parties. Questions appear by themselves. What comes along with the highly sophisticated technology in wood processing? What are the sciences and qualifications needed for learning and controling all possible fields connected with the use of wood? Where are the future position and role of wood use in the manegement of the recycable natural resources?

While making such assertions, a futurologist has to be flexible, free from mental rigidity, excessive optimism/pessimism, and emphasis on particular standpoints, ideological dogmatism and various interests that would distort judgement. Accordingly, this paper should be taken as an attempt of learning about the development with all its positive and negative connotations of which the author is aware and is presenting them to the public.

2. The vision of the development of wood management and the scientific research in the field of wood processing technology

The initial premise is that the vision of wood management development is a precondition for the high education mission, upon which the required knowledge and skills of future engineers will be based.

Thus, the vision of the development of wood management and industrial wood processing functions as a modern, organised, interacting, complex association of producers and traders of wood and wood products, services and consulting trade companies and infrastructure institutes.

It has a high proportion in the industry within the gross national product of Croatia. Its export orientation are competitive products of high quality and a high processing degree, outstandingly profitable, evenly dispersed across the Republic of Croatia. Employment in all counties keeps the population at home.

Such wood management and industrial wood procesing is established through strong development of production, technology and production control. It is environmentally safe and, in terms of ecosystem management and the general concept of sustainable development, it is ecologically efficient.

Accordingly, Croatian wood management, besides investing in modern technology, must thoroughly change its attitude toward the development of the product and market. These categories have been entirely neglected. The absence of programme defining is asserted as the weakest link in wood economics. There are only a few producers in Croatia to compete with their production programmes on foreign markets, and to ensure further development and processing with their present production programme. All others must redefine their programme orientation. Such redefinings result in the products of high individual competition values on the world market.

With such constellation, Croatian wood management must choose the proper programme orientation, the course, method and strategy for the market on which it has mainly been present until today.

Investments into new technologies and the development of products, markets and staff cannot be avoided in order to retain the present position in the international exchange, and to prevent the reduction of the proportion within this global market.

Considering the significance of Croatian wood economy and the development of wood processing, it is to be expected that future reseaach will be focused on the development of new products, the production techniques and technolgies, and the methods of computer-aided production control, together with improved quality of the use of all kinds of wood that so far have not been commercially accepted.

The following final research targets can be defined:

1. We should expect considerable extension and change of the production programmes in wood management firms, while products will dictate the development of the technologies.
2. This will require the development of new production techniques/technologies and management methods, with their introduction into wood management plants.
3. The to date inadequate export structure should be considerably improved through new design and product competitiveness.

These targets entail the following presumed research results:

- new planning methods for new products will change the assortment (production programmes) of wood economy;
- The new planning methods for unconventional technologies will ensure a more efficient use of the production and other resoruces, with an emphasis on a more efficient use of the recycable natural resources.

This all implies the change of conventional paradigm in the functioning of wood management engineers. These are certainly the jobs in product development, production processes and the methods of production management, specifically in wood processing.

3. Development and mission of high education

The development of high education in the field of wood processing technology has historically been accompanied by the development of biotechnical sciences. Accordingly, with an emphasis on the biological component in the education of graduated forestry engineers, the first bifurcation in the education in 1947 brought along the first radical changes of the curriculum. This enabled the establishment of the forestry/industrial course with clearly emphasised technical component along with the biological. The second significant change was the result of the development of wood-technological scientific disciplines within the biotechnical science, so that in 1960 new changes of the curriculum took place, further emphasizing the technological processing. The present renewed curricula in the field of technological wood processing, together with a strong biological and technical component, contain a strong field of the production management by both conventional and unconventional methods.

The first phase of high education was certainly dominated by natural sciences within the curriculum structure. Gradually, technical disciplines prevailed. A further trend was the dispersion of the collegium, so that the programme had a tendency of sub-specialisation with an emphasis on technical disciplines.

While discussing the access of new knowledge and sciences into the wood processing technology, there is a question on how ready we shall be to follow the world trends, how capable for coping with the technological changes. There are some parallel indicators that may help in creating predictions.

In order to correctly define ourselves against the development of the future knowledge in wood technology, we should first predict the courses of social development, which then largely depend on the development of science, technology, economy and individuals, as well as the future jobs.

The presented vision of the development of the industrial wood processing speaks of the course of requirements for new knowledge. Therefore our view, focused forward, does not have only futurological significance; it rather enables the understanding of our own role in the endless series of generations.

Since the conventional approach to the management of recycable natural resources will be abandoned, the development will inevitably imply structural changes. These will entail the problems listed below, which will affect the development of wood processing. Accordingly, the main target of the scientific research and education will be how to use the recycable natural resources to a degree lesser than the one to which the resources are renewed. The new optimisation methods of the recycyble natural resources stocks will create new dimensions for the wood processing technologies through the following investigations:

a) With the high demands for wood particle boards, new properties and various unconventional geometrical shapes of boards will be developed, together with the new improvement methods, the production of boards without using glues, and manufactured boards from recycled wood;
b) The changes in primary wood processing will result in sawing of higher quality, i.e. following the wood growth – radial sawing.
c) All types of timber will be used, including those that are classified today as non-commercial timbers. In future there will be no wood species that will not be technologically processed.
d) Introduction of sophisticated computer-aided wood processing technologies into the production concept of the future wood manufactures.
e) The research will be focused on prolonged durability of wood and wood products in use, which will require new technologies for wood protection and modification of wood properties.
f) The first and basic question in the production of final products is what is it that the future has in store for us in terms of home furnishing. What will the homes of the future look like? It is predicted that man's home of the future will become an automised field; the kitchens will be supplied with sophisticated technologies; the bathrooms will be the central places of homes; families will thus be reunited. Such predictions entail new products and new constructions. As it is expected that man will favour biomaterials, wood will be irreplacable in terms of today's knowledge. Eco-trends are today already among the characteristics of the production of wood articles.
g) In spite of the opinion that wood will be in many fields replaced by new unconventional materials, predicitons are that it will compete successfully with other conventional materials in the fields where it is not used today.

The idea of the principle by which an engineer controls both people and processes/procedures created by him, will in future be realised as modern production paradigm.

The process of creating products, not the product itself, will become the measure of quality, while the production technology will be the one of higher complexity (several size orders) than the complexity of the product itself.

4. Proposal for basic curricula and education programmes in the field of wood processing technology

Rather than the lack of raw materials, a crucial futurological question is thus, how to use knowledge as a resource, and how to acquire it through high education for wood processing engineers.

It is clear that progress is impossible without parallel increase of overall specialist knowledge. Education is the foundation of the development of the wood processing technology, a prerequisite of its survival. Interactions between the low efficiency levels of an economy and low degrees of knowledge – and vice versa – are well known. With increasing complexity of work in wood managements, any activity is unimaginable without adequate knew knowledge. The control of very complex work with wood processing technologies is accessible only to those with high education, which also correspponds with their social status.

For these reasons, graduated engineers of wood technology should be eduacted in a new way.

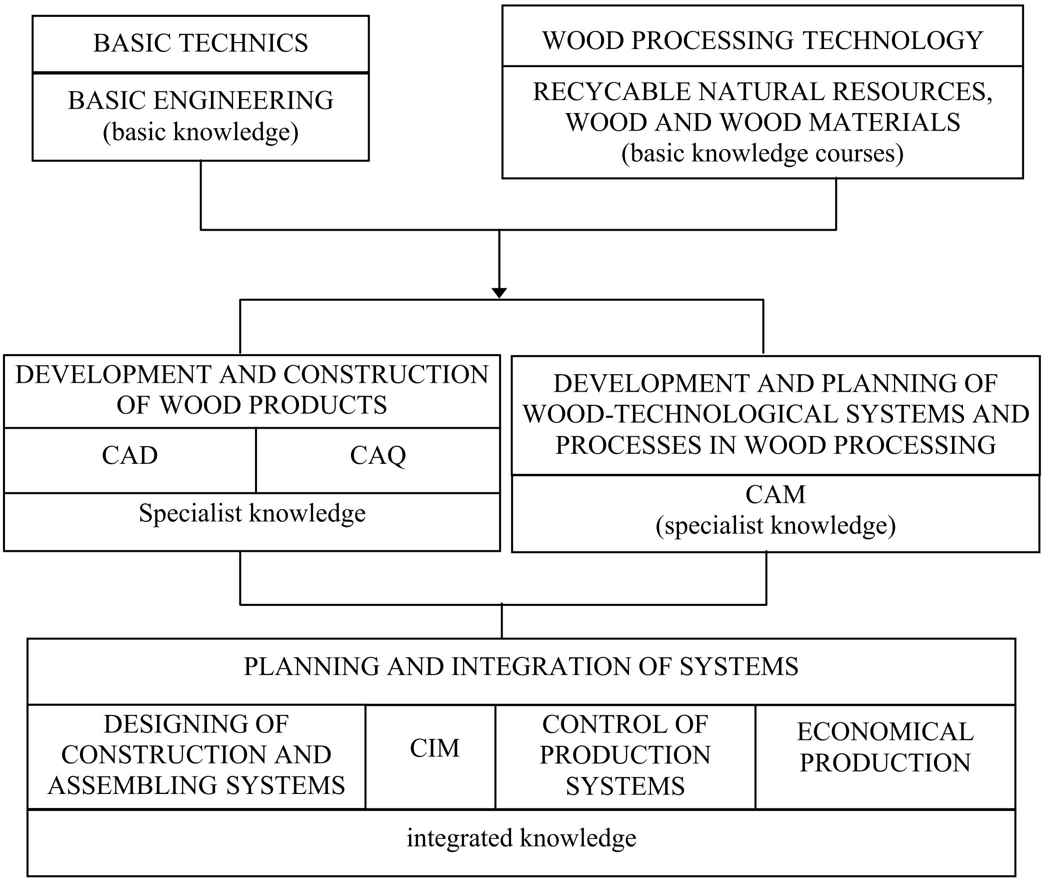

Fig. 1.

Accordingly, the predicted structure of the curriculum for wood technology engineers has been proposed so that total studies are divided into common collegia and specialist optional collegia within a flexible modular form of studies.

Basic specialist subjects will encompass the science on wood and wood materials, while basic engineering subjects include mathematics, physics and the basics of technical sciences. The specialist knowledge will include the following basic units: the theory of technical systems; constructions and product quality; computer-aided production control; flexible technological systems and CA-systems with an emphasis on mechanical wood processing with unconventional technologies, and the production of final wood items of the constructions connecting different types of natural materials, semi-products, and household devices, or those strictly connected with wood and wood materials.

In addition to the basic integrated engineering education, specialist and post-graduate studies with new quality and in an unconventional way will have to be developed through work in institutes on research projects, in teams of different specialists and under mentorships. It should be expected that this will be carried out in the following basic fields: wood and wood materials; technology and technological processes in wood processing, and constructions and production management.

The world of the future will not be intensive any more in terms of work, raw materials, or energy. It will only be intensive in terms of the size of the knowledge used. It will be a transition to the work intensive in knowledge. Our wood-technological department predicts these trends in its development visions.

The to date methods of solving the employment problems of graduated engineers have thus come to an end. Employment will not be a problem in terms of quantity a ny more, but rather a quality issue in a new restructured wood processing and furniture manufacture.

5. Conclusion

We shall end this discussion with the question raised at the beginning. Can we, and how precisely, determine the future development of high education in the field of wood processing engineering?

Facig the changed value systems within society and technics, we encounter the inevitability of changing the present (conventional) paradigms of the wood-technological and also technical and biotechnical professions.

First, interdisciplinary and transdisciplinary work is necessary. This means that the new paradigm requires efficient connection of natural, technical and other knowledge as synthesised engineering knowledge for the required solutions o f the increasingly complex engineering tasks.

The sysnthesis of knowledge should become the basics of the high education prpogrammes for engineers of wood processing technology, which would generate the change in the system of supporting creativity and inventiveness of future engineers.

Although this paper is only an attempt of finding answers to the question, it should be taken as an initiative in the field of solving many issues of the development of wood use and wood-technological sciences. In view of the global development of bio-technical and technical scientific fields, it offers a list of guidelines and answers about how wood processing technology as the science of integrated application of natural and technical sciences for the purpose of the production and use of recycable natural resources will behave and survive in the future.

The future, somebody said, cannot be predicted, it should be created. What we are doing today, and what we have inherited from previous generations is essential, combined with the vision of development of the required engineering knowledge and the new wood processing technologies.

The placement of a particular engineering into a particular group is only conditional; wood processing engineering will thus develop in concordance with t he development of technics and biotechnics.

The achievements of all are expected to offer solutions on how to ensure the produciton of raw materials, or semi-products, from the recycable natural resources. Wood as the material of the future offers a number of possibilities, among which there is also the development of the wood processing engineering

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Engineering Education for Environment Protection

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Abstract

The last two-three decades have confirmed a growing understanding that no part of our world is immune to environmental consequences of man's activities. There is a pressing need for international co-operation and solidarity to preserve our forests, safekeeping our water and oceans, and stabilize the Earth's atmosphere. Ecology has traditionally dealt only with natural systems. The new field of eco-engineering is beginning to study industrial behavior and biogeochemical cycles as a part of a system, using the results to design environmentally friendly products and processes. For true integration, we need to merge the two ecological systems - natural (biosphere) and industrial (techno sphere) -with the right consideration of space and time.

The strong interest in protecting the environment has placed new responsibilities especially for the engineers. The need for advanced and continuing education and special training for engineers is acute. For eco-engineers is quite important to understand all possible problems that can occur in the environment. The fundamental knowledge from environmental chemistry, toxicology and ecology, sub disciplines making up the ecotoxicology, is necessary. The aim of ecotoxicological research is to recognize, predict and analyze the effects of potentially toxic substances in the environment. Ecotoxicological knowledge may be used to give advice on the seriousness of a particular case of pollution, on the maximum allowable concentration of a substance in the environment, or on the decision as to whether new chemicals are permitted or not.

The University of Zagreb decided that all of its engineering graduates starting career as e.g. designer, managers, researchers or any other professional in any area related to environmental protection and management, should be prepared for the challenge of sustainable development. Therefore, in academic year 2004/05 starts to introduce new postgraduate program with the environmental oriented knowledge and skills on graduate and postgraduate level. The significant issues are addressed in new eco-engineering education curricula: development of sustainable technolo-

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gies and solutions to complex ecological problem (terrestrial and aquatic restoration; bioremediation, composting and biological treatment of wastewater, waste management and treatment; recycling technologies etc.).

During the program for eco-engineering, post-graduate students will come to terms with the causes of environmental degradation as well as the social and political factors which shape and direct technological change.

Key words: *environment protection, eco-engineering, high education, Croatia*

Introduction

We live on a planet with finite resources, with only one input from the outside - the energy from the sun. While our technologies can rearrange matter to better suit our convenience, and extract energy by reaching further and further into the depths of the Earth, the limits to this process have become evident. A return to "ecological thinking" is necessary if we would like to survive. Our deep involvement and preoccupation with technological thinking *to the exclusion of ecological thinking* has been a major contributor to environmental degradation.

A comparison of ecological thinking with technological thinking is important to our understanding of why conventional technologies have worked with little regard for the environment, except as a source of raw material or a place to dump - or even as conditions and constraints to conquer.

Technology is the result of human effort to transcend limits placed on us by space and time. Population explosion has made us aware that the extent to which we can overcome space constraints is limited. Speed and efficiency are the main metrics of success in technology, which has led to a lack of appreciation of time - that it takes time to build the complex intricate system that houses and nurtures us as part of it. This lack of respect for time that is embedded in our technological thinking has been one of the most salient factors in degrading environmental quality. To feed our technological ways of life, we currently destroy 24.7 million acres of ancient forest, pump 6.6 billion metric tons of CO_2 into the air, and pump 24.9 billion barrels of oil out of the Earth *each year*.

Technologies have typically focused only on narrow segments of the entire system to which the specific technology relates. For example, the design and marketing of the automobile had no forethought about the disruptions large numbers of automobiles would have on land, on air, on energy use, on social units such as cities and families, on all aspects of our ways of life.

Technological thinking has traditionally characteristics that are contrary to holistic, systems thinking - but this has slowly begun to change. The emerging practice of eco-engineering looks at products as part of a larger cycle and attempts to reduce the environmental impacts of production, consumption, and disposal.

Ecology has traditionally dealt only with natural systems. The new field of eco-engineering is beginning to study industrial behavior and biogeochemical cycles as a part of a system, using the results to design environmentally friendly products and processes. For true integration, however, we need to merge the two ecological systems - natural (biosphere) and industrial (techno sphere) -with the right consideration of space and time (Moser, 1994). We are still a long way off from this undertaking! (Figure 1.)

The last two-three decades have confirmed a growing understanding that no part of our world is immune to environmental consequences of man's activities. There is a pressing need for international co-operation and solidarity to preserve our forests, safekeeping our water and oceans, and stabilize the Earth's atmosphere. The strong interest in protecting the environment has placed new responsibilities especially for the engineers. This asks, besides other objectives, for sound environmental education and training everywhere. The need for advanced and continuing education and special training for engineers is acute.

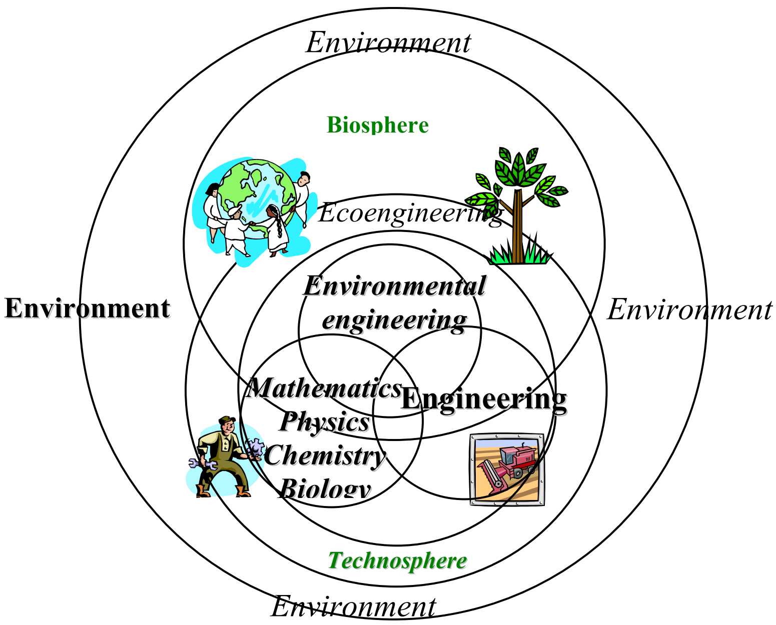

Fig. 1. The two ecological systems -- natural (biosphere) and industrial (technosphere)

Dispersal of substances in the environment

Many types of human activity cause the release of harmful substances or the alternation of the properties or quantities of normally harmless substances in such a way that they do become harmful. These substances need not always be man-made. For instance, aluminum is an integral component of the earth's crust and as such totally harmless. However, as soon as the aluminum in the soil dissolves due to continuous deposition of acidifying substances of anthropogenic origin, it may cause damage to plant roots. Contaminants of the environment are called *xenobiotics* (foreign to the body). A distinction is made between *primary pollutants* (substances as they are emitted) and *secondary pollutants* (substances formed in the environment under the influence of primary pollutants). List of some well-known substances and their main anthropogenic sources is shown in Table 1 (Walker *et al*, 1996).

The fate of a substance in the environment depends on many different factors. Between *emission* (discharge) and *immission* (exposure), a number of transport processes, also called *transmission*, take place and can be grouped as *distribution, adsorption* and *transformation.*

Table 1. Examples of some categories of pollutants and their anthropogenic sources

Category	*Example*	*Major source*
Heavy metals	Cadmium	Metal processing industry
Eutrophying substances	Phosphate	Domestic waste water
Polycyclic aromatic hydrocarbons	Benzopyrene	Waste incineration
Organic solvents	Benzene	Motor traffic
Chlorinated organic compounds	Polychlorinated biphenyls	Large electrical installations
Pesticides	Acetylcholinesterase inhibitors	Agriculture
Air pollutants	Sulfur dioxide	Oil refining
Climate-affecting substances	Chlorofluorohydrocarbons	Cooling systems
Radioactive substances	Cesium-137	Nuclear industry

Xenobiotics have a tendency to distribute quite heterogeneously over various organisms. Factors influencing accumulation of substances in an organism include: position in the food chain, body weight, and the availability of certain physiological processing mechanisms. Depending on its properties the substance will be distributed over the various compartments of the environment (soil, water, air). This distribution is primarily determined by substance properties such as volatility, water solubility and lipophilicity. The chemical form in which a substance is emitted may be changed due to physicochemical factors - sunlight or biological factors - microorganisms. The persistence of a substance is one of the most important factors determining its harmfulness to the environment.

Indeed, the entire concept of toxicity needs to be evaluated from the viewpoint of a risk/benefit concept associated with the consumption of any given material. In fact, *Paracelsus* (1493-1541) over 400 years ago pointed out that "*all substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy*". Since all substances can produce injury or death under some exposure conditions, it is evident that there is no such thing as an absolute safe substance or chemical that will be free of injurious effects under all conditions of exposure. As a corollary, it is also true that there is no chemical that cannot be used safely by limiting the dose of exposure.

Therefore, for eco-engineers is quite important to understand all possible problems that can occur in the environment. So, the fundamental knowledge from environmental chemistry, toxicology and ecology, subdisciplines making up the ecotoxicology, is necessary. The aim of ecotoxicological research is to recognize, predict and analyze the effects of potentially toxic substances in the environment. Ecotoxicological knowledge may be used, for instance, to give advice on the seriousness of a particular case of pollution, on the maximum allowable concentration of a substance in the environment, or on the decision as to whether new chemicals are permitted or not.

It is not easy to make a well-founded analysis of an environmental problem; the results or recommendations are often more complicated than the outside world expects. This is inherent to the complexity of ecosystems. It is possible, however, to apply a number of theories from modern ecology to the analysis of environmental problems, so that a differentiated and well-founded opinion can be formulated.

By means of ecotoxicological risk assessment, it is possible to calculate the chance that certain undesired effects on the environment will occur. The environmental risk is usually determined on the basis of the predicted concentration of a substance in the environment and the distribution of sensitivity in a community.

Education of eco-engineers

Eco-engineering differs from civil, environmental, agricultural and bio-systems engineering in it reliance on ecological sciences as the basis for design. Eco-engineering is the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both. It involves the design, construction and management of ecosystems that have value to both humans and the environment. Eco-engineering combines basic and applied science from engineering, ecology, economics, and natural sciences for the restoration and construction of aquatic and terrestrial ecosystems. This field builds on other branches of engineering, especially civil, chemical, and mechanical engineering. It also builds on information from many of sciences, such as chemistry, physics, hydrology, geology, atmospheric science, and several specializations of biology e.g. ecology, microbiology, and biochemistry. Students who elect to become eco-engineers will become familiar with many of these areas because maintaining and improving the environment requires that problems should be evaluated and solutions found using a multidisciplinary approach (Matlock *et al*, 2001).

Eco-engineers may be competent to address any number of biological and environmental engineering problems, including bioremediation, composting and biological treatment of wastewater. Developing and protecting the credibility of eco-engineering, as a profession requires clear definition of the body of knowledge. A practicing eco-engineer must be master prior to being certified. Eco-engineer is relatively new profession. Eco-engineers must have a uniform body of knowledge to establish professional direction, identify areas of need within the profession, and insure that the practice is well based on ecological theory. The core curriculum should provide a sound foundation in ecological theory integrated with applied ecology and ecological design.

To educate the students for this profession a new postgraduate curricula are needed. The new postgraduate program should combine, traditional subjects of engineering graduate study with new environmental subjects such as: ecosystem, environmental legislation, environmental economy, water quality management, solid waste management and sustainable development.

The history of engineering activities includes many developments, also in Croatia (e.g. Kaštelan' bay), which have resulted in the degradation of the environment. The engineering of the future, now more than ever has the potential to have absolutely enormous environmental impacts. There is now, therefore a need for engineers to intelligently manage both the natural resources used in development and the residuals generated from this development (EC CARDS program-priorities). The goal of engineering education should be to produce engineers who are both technically competent and environmentally conscious. Although an assessment of the impact of proposed large or small development project on the environment has been required by law in the Croatia for more than twenty years (Environmental Protection Law-Chapter IV; Articles 25-32) this should be more effectively implemented in according to EU policies and regulation, and to be carried out as in other EU countries. Therefore a special profession is needed to carry out this.

Higher education of eco-engineers in Croatia

Higher education program in Croatia mostly have Environmental Engineering integrated into the Faculty of Civil Engineering as Sanitary Engineering. Students enroll and graduate as Civil Engineers after five (5) years. Faculty of Chemical Engineering and Technology has been established in 1997 as student's elective (max 10 students/year). Students graduate as Chemical Engineers after five (5) years specializing module of five units in Environmental Engineering. On other Faculties offering Diploma degree in engineering there are some specialized obligatory or individual choice subject in Environmental Engineering. None of those programs is internationally recognized.

Therefore the University of Zagreb decided as far back as 1995 that all of its engineering graduates starting career as e.g. designer, managers, researchers or any other professional in any area related to environmental protection and management should be prepared for the challenge of sustainable development and started to introduce new postgraduate program with the aims:

- To increase environmental oriented knowledge and skills as well as research capacity on the graduate and postgraduate level
- To cover up the novel general educational process dealing with man's relationship with earth and to include the relations of energy, pollution, resource allocation and conservation, technology and economic impact to the total environment
- To incorporate the appropriate environmental education at all academic levels by interdisciplinary approach
- To instill graduates with principles that will enable them to analyze and solve a wide range of problems and situations facing environmental engineers today and in the future
- To develop a sound environmental engineering education and training covering not only waste disposal problems but also the reduction of the source of pollutants and wastes, and how to prevent such pollution by low-waste technologies

Meanwhile the *Bologna declaration* in Croatia was accepted requiring firmly anchorage the University of Zagreb in the international scientific community. Therefore environmental new courses should be included within the frame of existing engineering curricula on all (undergraduate, graduate and postgraduate) levels. The implementation of the modular curriculum concept in the postgraduate studies, the organization on a unit-credit basis and the implementation of the opportunities for continuing professional development are engaged. The approach allowed the compilation of tuition contents in a modular structure and therefore facilitates the implementation of environmental education corresponding to the local and international universitaria.

A number of significant issues are addressed in new eco-engineering education curricula. These issues are divided into two general categories:

A. Development of sustainable technologies
B. Solutions to complex ecological problems

-terrestrial and aquatic restoration
-bioremediation, composting and biological treatment of wastewater,

- waste management and treatment
- recycling technologies etc..

with:

Basic scientific courses	10-17%
Basic engineering courses	10-17%
Professional elective courses	25-50%
General elective courses	25-50%

The programs require students to achieve post-graduate eco-engineer degree in civil, chemical, biochemical, electrical, mechanical etc. engineering.

Ensuring that engineering post-graduates address sustainability in their work requires more than just teaching them to assess the impact of their activities on the environment and how to install pollution control devices. During the program engineering post-graduate students will come to terms with the causes of environmental degradation as well as the social and political factors which shape and direct technological change.

Conclusions

The growing understanding that practically no part of our world may be excluded from possible environmental consequences of man's activities, results in co-operation and solidarity to preserve our Earth. The strong interest in protecting the environment has placed in a great manner new responsibilities especially for engineers. Besides other objectives, for the environmental education and training everywhere, the need for advanced and special training for engineers is indispensable.

Eco-engineering is the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both and combines basic and applied sciences from engineering, ecology, economics, and natural sciences for the restoration and construction of aquatic and terrestrial ecosystems. Students who elect to become eco-engineers will become familiar with many of these areas because maintaining and improving the environment requires that problems should be evaluated and solutions found using a multidisciplinary approach. Eco-engineers may be competent to address any of biological and environmental engineering problems, including bioremediation, composting and biological treatment of wastewater. Eco-engineer is relatively new profession. To educate the students for this profession a new postgraduate curricula are needed. The new postgraduate program should combine, traditional subjects of engineering graduate study with new environmental subjects such as: ecosystem, environmental legislation, environmental economy, water quality management, solid waste management and sustainable development.

The University of Zagreb decided in 1995 that all of its engineering graduates starting career in any area related to environmental protection and management should be prepared for the challenge of sustainable development. Therefore, in academic year 2004/05 starts to introduce new postgraduate program with the environmental oriented knowledge and skills as well as research capacity on the graduate and postgraduate level. In new eco-engineering education curricula numerous issues are divided into two general categories: development of sustainable technologies and solutions to complex ecological problems. The programs require post-graduate students to achieve eco-engineer degree in civil, chemical, biochemical, electrical, mechanical etc. engineering. During the program engineering post-graduate students will come to terms with the causes of environmental degradation as well as the social and political factors which shape and direct technological change.

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Education of Food Technologists for the Future

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Abstract

How many of us have been renewed, refocused and sometimes retreated some time during our careers? It can be a very hard experience, but usually, good comes out of it.

The knowledge is developing so fast that issues we learned during our educational processes can not be the knowledge for the whole life .

Maybe, we all do not need to move fast, but if we are responsible for education, having in mind that education is the backbone of development and prosperity of every society, we should be aware of our responsibility for knowledge implementation on different educational levels where we act as professors, scientists, or in other roles.

Food science and food technology are one of the fastest developing areas. It is evident that technology is at hand to make life easier and healthier for the consumer. However, to benefit from incredible power of technology, it is inevitable to establish new educational standards for undergraduate curricula in food science, to feature outcome-based measures of learning, to create a formalized assessment program, and achieve greater flexibility in designing curricula.

Many limitations can be overcome not only by a consistent, dedicated effort to educate students but also by the legislation and executive branches of the various regional and governmental bodies, and the executives and boards of industrial corporations.

It is to believe that the coming years and decades will demand of food industry to pay a much greater attention to scientific aspects of consumers' needs and desires, and to develop high quality products with highly educated engineers.

Keywords: *food technology, education, renewing knowledge*

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Introduction

Do we know the rate of our knowledge? Do we know the rate of outdatedness of our knowledge? The knowledge that we get during our educational processes can not be the knowledge for the whole life?!

According to some authors (Peters, 1997), the knowledge that we get becomes outdated in four years, at least (1).

We are always inclined to say that the world is changed so much that evrything is changed, but it is still incredibly important that people first of all get the best education they can – to learn, to build their skills as strongly as they can, to enter into their career, their job, and then to continue to learn (2).

To reach the goals, every state should have national policy in each sector of education.

To achieve the goals in education it is of exceptional importance partnerships between *government* (governmental bodies, national and regional), *educators* (schools, universities, institutes) and *industry.*

Food Science and Food Technology

Food Science is the discipline in which the biological and physical sciences and engineering are used to study the nature of foods, the causes of their deterioration, and the principles underlying food processing (3).

Since *food science* was recognized as an independent discipline over 110 years ago, systemetic approach to food analysis, as well as to new processes, has been developed**.** Because of the increasing complexity of the food ingredients, processes, and processed foods presented for analysis, the *food scientists* has had to adopt techniques from different disciplines. The economics, rapidity, sensitivity, reliability, and ease of use of the techniques are already making an impact in the food industries. Development of chemical and, in the post-2nd world war period, food-processes engineering had strongly influencend the development of processing systems as well, and the entire food industry (4).

Food technology is the application of food science to the selection, preservation, processing, packaging, distribution, and use of safe, nutritious, and wholesome food (2). Food technology as a profession is responsible for the technical aspects of development of food products, food processes, and distribution of these products to consumers.

Technology is the *engine* of economic growth of every society, with science as its *fuel* (Nettleton, 1994)(5).

Food should be of national importance for every government.

Food technologists with knowledge of nutrition and familiarity with agricultural technologies should help to provide better health and quality of life for all population and to reinforce country's economy.

New consumer's demands have stimulated further efforts on improving already existing and finding new processing solutions aimed at optimization of processing system towards increased efficiency and flexibility with minimal damage of products, dynamic process control by adopting TQM (Total Quality Management) and HACCP (Hazard Analysis and Critical Control Points) concepts and maximum appreciation of ecological factors (4).

Food scientists should work with government and industry to develop and extend their knowledge needed for the food technologies of the 21st century.

The most important understandings for food scientists are:
1. What is needed to be done to make food safer?
2. What does it take to better deliver health benefits from food?
3. How can processing companies develop environmentally-friendly technologies?
4. What break-through developments will capture the edge in global markets?

These multi-disciplinary, long-term questions need answers. They present an unprecedented opportunity to faciliate collaboration among government, industry, and academia to advance the nation's expertise in food.

Education in Croatia

Food technology was introduced in Croatia more than 80 years ago.

In Croatia there are two academic institutions (in Zagreb and Osijek) with programs in food science and technology, which have mission teaching, research and outreach. These institutions are now struggling to determine how balance research and education. Close collaboration between these two academic institutions will be necessary to advance the objectives in curricula and research in food technology (biotechnology). In addition, of great importance will be closer collaboration with specialists from other sectors, how food technologists and biotechnologists will be able to give answers for inovations in food industry (Cross-Industry Technology Transfer).

According a new Law for high education and scientific research (2003) all Universities in Croatia are under process of revision of their Curricula.

Universities and Ministry of science, education and sport should evaluate the effectiveness of academic selection, guidance, and preparation of undergraduate and postgraduate students how they can be able to reach their goals in the professional development. The fields of specialization must be distributed over the disciplines required for the food science courses. But of most importance should be to establish *minimum standards* for undergraduate as well as for postgraduate curricula. These standards should be designed to present a minimum core of courses that can serve as the basis for preparation for the B.S. degree in *food science*. The intention of these minimum standards should be to add rigor and encourage critical thinking and problem-solving skills of the students of the food science. Students pursuing coursework by these minimum standards should have the foundation available to them for their professional development. Besides these minimum standards other educational skills should be integrated into food science courses too. Of big importance is, also, to create curricula which will be compatible with those in developed countries (EU - for example according to Bologna declaration in 1999, and USA). This criteria for professional development should be obligation for government (Ministry of science, education and sport – National Comittee on Education) as well as for food industry.

To reach this goals (results) the «easy job» will be to renew curricula (establish or evaluating existing food science programs), but of most importance will be also to provide to *food science faculties* adequate facilities and equipment for teachning laboratories (up-to-date), adequate facilities to conduct the chemical, engineering, microbiological, and processing exercises – pilot plant facilities, (in this area the situation is in recent years better) how students will be able to learn principles of unit operations and unit processes involved in food processing and preservation as well.

Library facilities and holdings need to be adequate support, encourage and stimulate independent study and research by both the students and faculty.

The faculty staff should be of size and competence commensurate with the diversity of courses offered.

IFT (Institut of Food Technologists, USA) first established minimum standards for undergraduate curricula in *food science* in 1966, and reviews the minimum standards for approval of food science programs every ten years.

The most important in this requirements is the question *whether graduates truly have the skills necessary to start their careers in the food industry.*

If we want to participate in the EU and the world race for regional development (such as the EU project: Innovating Regions in Europe-IRE) we have to be well informed (educated). On the top of this is the fact that government funding for education and research is not enough. Besides, food companies (food industry) do not support enough universities for educational and research programs (some companies have their own R&D sectors).

The government must develop better industry-government consortia to establish the tax-credit system for education and research.

«Croatia belongs to the circle of countries that will be able to meet its own food needs and will be able to export an important part to the markets of developed and developing countries.» (6). Is that so?

Conclusion

We (academia) will not proceed into the future or succeed if we all wait for someone else to do on these issues, and we certainly will not succeed if no one, including industry and government, is going to support education and research. Better communication between these institutions has to be establish in the future.

They present an unprecedented opportunity to faciliate collaboration among government, industry, and academia to advance the nation's expertise in food.

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Education and Training of Technologists and Biotechnologists and Their Effects on Educated Expert Position in Production Plants

Marijan Bošnjak

Abstract

Price and quality of any product largely determine commercial product effects. There is a series of factors affecting both the price and quality of given product. One of such factors appears to be the manpower and management adequateness, which depends on both the fundamental individual characteristics and educational individual history. Series of practical examples support such a statement. In the case of technologists and biotechnologists, one can emphasise the successful start of industrial antibiotic production in PLIVA Company and the later continuous progress of that company. They resulted due to an investment into manpower education and adequate employment as well as due to followed world trends with reference to the research, innovations and employed manpower adequateness for production and commercial progress. However, it is more convincing to point out the importance given by European Union to the education and training. This can be clearly evident from activities of EFB Working Party on Education in Biotechnology (EFB-WPEB) during more than already 25 years. EFB-WPEB fundamentally advanced an understanding of the need of continuous and adequate education in accordance to needs of industry, but EFB-WPEB contribution seems to be more significant when one considers activities with reference to the code of conduct, harmonisation of qualifications and an advancement of postgraduate study. Negative examples from industrial practice also confirmed an importance of adequate education, especially with respect to management. Inadequate managements are not capable to recognise the advantages of better production technologies nor to apply them.

Key words: *Education effects. Technologists. Biotechnologists. Expert positions. Manpower capability. Research success. Production efficiency. Management adequateness. Company progress. Commercial consequences.*

It is known that an applicability, price and quality of any product largely determine commercial effects referring to given product. It is also known that there is a series of factors affecting both the price and quality of given product. Production plant size and equipment quality, production technology, availability of corresponding raw materials, manpower and management adequateness, are the main factors, although one cannot neglect the effects of other factors which can influence the situation on the world and local markets. However, it is important to point out that the management and manpower play the most important role in commercial survival of any production, regardless whether this is a new one or that with long tradition, whether it is based on some licence, or on own technology developed in own research laboratories, regardless the degree of its complexity. Since the management and manpower adequateness are substantially dependent on fundamental individual characteristics (“hardware”) and educational individual history (“software”), education and training programmes should never be neglected. Therefore, it was quite normal that already long-time, primarily in EEC and later in European Union, education and training programmes obtained an adequate relevance, with being in the focus of interests of EU administration.

Occasionally, on the basis of my personal experience I can attest the importance of adequate education for a successful participation in research programmes, production plant design and management, and in advancing industrial production. In 60’s, the PLIVA Company decided to extend its production programme by developing an industrial production of antibiotics. Such a decision was in accordance with world trend and resulted as a consequence of Company Management adequacy. The Main Director, the Technical Director and the Director of the Research, were all of desirable personal characteristics and acceptable education and knowledge. They followed the world trends and estimated that Company progress could not be realised without an employment of corresponding manpower and if continuous and adequate education and training of experts would be neglected. Induced by PLIVA pharmaceutical company, which showed a serious need for employment of adequately educated experts suitable for installing and managing of antibiotic production, and being financially supported by the same company, the Department of Biotechnology of the Faculty of Technology of the University of Zagreb has organised the first postgraduate study (1960/61) focused on the Chemistry and Technology of Antibiotics. This showed to be an excellent attempt even in European relations because of absence of any experience of such a kind, and because the students who successfully terminated the mentioned study were chosen to start the industrial production of oxytetracycline, an antibiotic showing then to be very attractive with respect to its price and amounts needed for medical and other applications in the country. The study was combined with experimental practice in the company, in laboratory and pilot-plant scale of investigated biosynthetic processes, as well as abroad by visiting the plant of antibiotic production in an industrial scale. The success was so evident that PLIVA was induced to increase its interest for further collaboration referring to education programmes. Due to the successful start of industrial antibiotic production the management of Pliva decided to direct own development towards more pronounced production of products based on biotechnology and to enhance production of those based on chemical technology. Since the management already had a good experience referring to employed experts who terminated their BC.level study at the Faculty of Technology of the University of Zagreb, no doubt on the success of such orientation appeared. In addition, because the orientation to the research in own laboratories asked more sophisticated education, PLIVA enhanced a collaboration with University and research institutions in the country and abroad. The practice of continuous education and training was accepted with more believe and caused an evident company progress in many area. PLIVA became known company in the world relations, as an industrial producer of antibiotics (oxytetracycline, azitromycin), vitamins (vitamin C and vitamin B6), sulphonamides, baker's yeast, vaccines, and some chemicals of excellent quality and acceptable price, while covering almost all national needs referring to pharmaceuticals and partly to cosmetics. Progress of PLIVA was mainly based on the development of own production technologies, own patents and finally owing to the discovery of the new antibiotic substance of excellent application properties. Orientation to own research and to the continuous education and training of the manpower employed and that planned to be employed, as well as decision to invest more in industrial capacities of those productions which were based on own technologies led PLIVA on a position, which induced some powerful world pharmaceutical companies to show more interest for a collaboration with Pliva. It is important to point out that education and training programmes were mainly realised appreciating a good collaboration between sides, university professors and people in the company. It was a normal practice to include the experts from the company as teachers in realising corresponding specific parts of education programmes and, *vice versa,* to enable visits of students to company plants and to perform experimental practice in company laboratories for chosen students. Scientists and other experts from company participated at national and international scientific meetings by presenting own works and by following the progress made by others. Therefore, PLIVA was well informed on the world trends simultaneously showing that it followed these trends. I do not know whether such or some better practice actually takes place in mentioned company and corresponding university institutions. If not, then I am afraid that some bad consequences for national future could appear. My impression is that confirmed relevance of adequate education in successful industrial development of PLIVA Company induced managements of some Croatian and even other companies in the former state (Yugoslavia) to appreciate more and more the advanced education and training programmes for their people.

The European Federation of Biotechnology (EFB) was founded in September 1978 in Interlaken (CH). The Association of Chemists and Technologists of Croatia (predecessor of the actual Croatian Society of Chemical Engineers), through its Section of Biochemical Engineering, was approved as the EFB member already on 10 September 1984, and I became its representative to the General Assembly. I can mention that the Association of Chemists and Technologists of Croatia was recognised in EFB by activities of its Section of Biochemical Engineering and Section of Chemical Engineering, especially because these activities referred to the education and training. The Seminar on Biochemical Reaction Engineering (Supetar, Island of Brač, 3-5 Oct. 1988) and Bioreactor Engineering Course III entitled "Fermentation Process and Down-stream Processing" (Supetar, Island of Brač, 1-8 Oct. 1989) were organised. The Bioreactor Engineering Course III was particularly successful. The total of 108 participants attended the course. 25 lectures delivered by invited speakers and 12 posters were presented. The EFB Working Party on Education in

Biotechnology (EFB-WPEB) was established in 1979, when it started by setting two broad and ambitious key objectives, one relating to an inventory of activities in biochemical education across Europe and the other relating to an inventory of continuing education/postgraduate education. The publication "Manpower and Training Implications of the Expansion of Biotechnology Based Industries" (1) appeared as a remarkable result of WP activity. In general, one can consider an insight into activities of EFB-WPEB represents the best basis for an expression of the significance of education for a successful work of technologists and biotechnologists. Occasionally, I became the member of EFB-WPEB since November 1987. Therefore, I can select the most relevant events from the announced history of the mentioned WP, with an emphasis on WP activity consequences referring to biotechnology development and application and especially to positions of employed biotechnologists. However, I should also point out that education is not the only factor influencing positions and activities of people, and therefore a technological progress. It is known that in some cases managers educated *e.g.*, in law, economy, chemistry, *etc.,* showed more understanding for biotechnology and its development than some of those having postgraduate education in a biotechnology field. Fast progress asks more attention to ethics, and WP did not neglect ethical problems, although these have not been in the focus of WP activities during the first period, when more attention was given to the organisation of Summer Schools for staff and postgraduate students, to the training/education schemes to disseminate good practice, to the public awareness of biotechnology, to the harmonisation of qualifications in biotechnology across Europe, to the exchange of teaching materials, to the improvement of communications within and outwit working groups, *etc.* Series of very successful meetings of WP was organised, and activities were focused to the well defined specific programmes, *e.g. COMET II.* On the basis of reliable forecasting of trends in biotechnology and other area, as well as on the basis of the success and outcomes of the Delft Meeting on "Manpower and Training Needs for Biotechnology in Europe in the '90s" (2), WP became capable to enhance its activity with focusing to specific programmes to solve particular tasks according to their priority and funding initiated by the Commission of European Communities. As demonstrated in the second edition of *BEMET NEWS* (3), the First BEMET Annual Conference held in Louvain-la-Neuve on 29 November - 2 December 1991 was a great success. In line with then current EC policy developments in Eastern Europe, the Conference addressed the issue of Central/Eastern Manpower, Education and Training in Biotechnology. The *BEMET NEWS* (3) is plentiful with essential information referring to this Conference, but for purposes of this report I selected only the part, *i.e.* I decided to mention titles of three articles: a) Manpower and Training Needs for Biotechnology in Central/Eastern Europe (author L.Nyeste), b) Biotechnology in Croatia: Education, Training and Future Trends (author M. Bošnjak) and c) Experience in the Validation of Courses and Training Programmes in Biotechnology throughout Europe (author G. Street). In the article indicated under b) I gave almost the complete information with reference to the situation at that time, *i.e.* to the war time. I pointed out that the enormous destruction and harm caused by the war would prevent biotechnology from being classified as a priority, but with expecting that in further phases biotechnology would certainly get the place it deserves. I am still expecting the start of mentioned further phases. From the content of *BEMET NEWS* one can conclude that WP approach was serious, analytically profound and precise, with precise planing of future activities. One can find *e.g.,* the detailed information on the Second BEMET Conference planed to take place 18-20 September 1992, in Orense near Santiago de Compostela, Galicia, Spain. The theme was planed to be North-South regional variations and needs for manpower, education and training in biotechnology in relation to the Northern region of Europe. I also attended this meeting.

The further progress of WP activity was also evident, as documented by a brochure referring to the BEMET Meeting: Harmonisation of Postgraduate Qualifications in Biotechnology in Western Europe. The Meeting was held at the Technikum Winterthur Ingenieurschule, Switzerland, November 1994 (4). At the Meeting, the results of previous meetings referring to harmonisation of education in biotechnology were summarised. However, I would like to mention that the main goal of the Meeting was to find the optimal solution with respect to the harmonisation of postgraduate qualifications. The reason for harmonisation of qualifications was considered to be an achievement of recognition among member states with an emphasis on benefits which could appear because of facilitated human mobility throughout the Union, established chartered status of biotechnologists, the needs of industry, the establishment of a code of behaviour, *etc.* With respect to European Masters in Biotechnology and Eurodoctorate in Biotechnology the benefits were expected to be due to: recognised qualification, levelling of knowledge, entry to doctoral training in another member state, entry to Charter, international mobility (Masters) and PhD "plus" (linguistic, cultural experience), europeanisation. Series of conclusions and recommendations resulted with reference to existing problems, future projects and initiatives, funding, European Diploma, European Register of Biotechnologists, *etc.* The next progress step which should be mentioned here seems to be the Biotechnology Network Plenary Meeting, held 22-23 May, 1998 in Perugia, at the University of Perugia. More than 20 partners from different European countries participated in the Meeting. Meeting was focused on already mentioned problems referring to Educational and Industrial Needs, Core Curricula and Harmonisation, Eurodoctorate and Euromaster Degrees, Quality Assessment and Control of Courses, Advanced Short Courses. Meeting was successful and one of its benefits was the list of the booklets edited by Mariapia Viola Magni. List refers to titles elaborating themes: Biotechnology: Industry and Research, Biotechnology and Education, Biotechnology in Finland, Biotechnology in Belgium, Biotechnology in Austria, Biotechnology in Spain, Biotechnology in Norway, Biotechnology in Greece, Biotechnology in United Kingdom, Biotechnology in Italy, Biotechnology in Denmark. The need to establish the Code of behaviour was discussed at the Meeting in Winterthur, November 1994. Engagement of WP in this direction was so intensive that positive effects resulted very soon. Based on the proposal of Dutch experts the procedure for preparing the final text of the Code of Conduct for Biotechnologists started. After many consultations and discussion the more elaborate proposal was submitted to the EFB-WPEB to be discussed and adopted at the Meeting held in Frankfurt/Main on October 16-18, 1995. The discussion was very fruitful and resulted in an acceptable text of the Code of Conduct for Biotechnologists. The brochure titled *"Code of*

Conduct for Biotechnologists" (5) appeared already during 1995, simultaneously with the article of the same title published in *Prehr.tehnol.biotehnol.rev. 33* (6). Publishing of the Code of Conduct clearly demonstrated that in the advancing the education and training programmes none of aspects was neglected. Meeting held in Perugia preceded the Joint Meeting, EFB-WPEB and Biotechnology Network. This meeting was held 5/6 Sept. 1998 in Brussels, rue de Montoyer 75. Reports on Background and Workprogrammes for the period Sept. 1996 - Aug. 1998 were given. Then, after a discussion, the detailed plan of the Workprogramme for the period Sept. 1998 - Aug. 1999 was accepted. In the Workprogramme, again, the emphasis was on: Educational and Industrial Needs, Core Curricula and Harmonisation of Qualifications, Eurodoctorate and Euromasters Degrees, Quality Assessment of Courses, Code of Conduct for Biotechnologists, Advanced Short Courses, Strategic Forecasting and, Project Monitoring. I did not follow systematically the further activity of EFB-WPEB, but I am certain that it was intensive and continuously approaching to the final optimal solutions.

In addition to the activities of EFB-WPEB, there is series of other proofs which can be used to explain the importance of continuous and adequate education and training. The advanced specific courses organised by Delft University of Technology, the courses organised by NATO Advanced Study Institute, Bioreactor Engineering Courses organised by EFB and, from recently, Annual Meetings of Croatian Society of Biotechnology can be considered as good examples.

Some negative examples, especially if compared with those positive ones, can also be used to demonstrate an evident significance of adequately educated personnel in finding right decisions with respect to the progress of productions based on biotechnology. Perhaps the following typical examples merit to be mentioned here. The first is the positive one and refers to the improvement of nutrient media continuous sterilisation system, which was in the use in the antibiotic production plant. The system suffered of many disadvantages, mainly caused by inappropriate heat exchange part of the system. Some forty years ago I proposed to the technical management to apply the redesigned system of heat exchange. In my proposal the advantages of redesigned system were explained very simply, with few words and a simple scheme. Since the leading people of the management were experts of excellent experience and adequate knowledge referring to chemical and biochemical engineering, the advantages of redesigned system were recognised and my proposal was accepted. After less than one month the proposed system was applied. Its advantages were proven in practice, and the system was in the use for very long-time. The second example refers to the proposal of improved technology of L-sorbose production. During the last two decades of the 20th century, with different intensity, I was engaged in experimental study of the L-sorbose production process kinetics. Based on literature data and those of experimental study that I have performed together with my colleagues, the improved procedure of L-sorbose production was developed. Advantages of the new procedure were proven in a series of laboratory experiments and were supported by corresponding scientifically established data expressing the process kinetics relationships, especially those relevant for process scale-up. According to this finding, the new technology of industrial L-sorbose production was proposed. The decrease of the costs of L-sorbose production for a given production plant capacity was predicted to be about 200 thousands € per year. The other advantages of new technology were also indicated and adequately documented. The management did not accept the proposal. I estimate that the main reason was the management inadequacy caused by its insufficient knowledge of chemical and biochemical process relationships. Without an adequate knowledge it was not possible to decide adequately and wrong decision resulted.

The third example is especially illustrative. As a result of systematic scientific study of bioprocess kinetics of oxytetracycline biosynthesis the bioprocess relationships were enough defined to induce the finding of improved procedure of oxytetracycline production in laboratory scale. Advantages of the new procedure were repeatedly confirmed by series of new experiments. Results were also supported by corresponding scale-down experiments. Based on the established process relationships, computer simulation and other appropriate calculations, a reliable applicability of the new procedure of oxytetracycline production in a plant scale was predicted. Then, the documented proposal was transferred to the production plant management. This management decided to postpone the acceptance of the proposal and asked experimental confirmation in pilot-plant scale. Such experiments have been performed and laboratory results have been confirmed in a series of batches. The proposal was repeated by submitting additional proofs. Without adequate verification the acceptance was postponed again. New trials with submitted new argumentation did not lead to the satisfactory answer, since the mentioned management suffered of insufficient knowledge of process relationships. Two or three years later the situation changed, since the leading position in the main management of corresponding production division took the person of adequate education (biotechnologist) and personal characteristics. He engaged the main author of the proposed method by giving him the manager position in the antibiotic production plant. The new procedure was applied immediately, since even the first experimental batch was quite successful. No differences between particular batches were observed during the whole period of new method application. The annual reduction of oxytetrcycline production costs was 500 thousands €. I estimate the company loosed about 3 millions € because of inadequacy of previous production management.

An excellent example of positive effects of appropriate and continuous education and training on production efficiency and production plant quality seems to be that originated from the collaboration of the Yeast production plant in Savski Marof (near Zagreb) with the Faculty of Food Technology and Biotechnology of the University of Zagreb. Appropriately educated and trained experts (with attained Ms. Sc.and Dr. Sc. Degrees) advanced the production technology and product quality. Then they developed the own software for a computer control of the production process and the modern production plant for yeast production resulted. This was vended to the foreign buyer, who after buying advanced his other yeast production plants worldvide (unofficial information). I do not know whether the merits of Croatian experts have been appreciated in any extent.

Discovery of the antibiotic azithromycin and its computerised industrial production for the world market can be considered as one of the most attractive examples demonstrating how an orientation on the research and adequate continuous education and training, as well as an employment and preparing of high quality experts (those with Ms. Sc.and Ph. D.) can lead to extremely good results recognised even worldwide. This success of PLIVA company is well known in Croatia and world-wide. Actual more pronounced company orientation to external intellectual power can be useful. Never before PLIVA had so well equipped own research laboratories. Modern research laboratories and modern production plants of PLIVA company can be considered as a good basis for further successful activities. However, it seems that the practice of neglecting the experience transfer, together with simultaneous progressive decreasing of systematic collaboration with Universities of Croatia, could damage the national system of education and probably the national research basis. I am suggesting an establishing of mechanisms which define better the obligations of national economy subjects with respect to national education and research institutions.

Conclusion

Adequate education and training reflect on management adequteness and employed manpower capabilities, playing key roles in both a research success and a company progress. Therefore, the continuous collaboration of industry with corresponding educational institutions appears to be necessary.

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Recommendation

The interested for more detailed information or for obtaining available documentation should refer to the General Secretariat of the European Federation of Biotechnology. One of its addresses is: DECHEMA e.V., Frankfurt/Main, Theodor-Heuss-Allee 25.

The secretariat for BEMET publications is: The Biochemical Society, 50 Portland Place, London, WiN 3AJ, UK.