Engineering Education in a Highly Globalised World

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Abstract: The paper presents important aspects of the reform of higher education in Europe through the principles of change and modernization present in the Bologna Process.
By applying a SWOT analysis, there were identified the challenges to the European higher education system: need for qualified professionals, certificates' recognition, students' mobility, university autonomy, rapid changes of the economic environment etc.
Taking into account the strategic objectives of educational reform determined at the post-Bologna reunions of Barcelona, Bergen etc., developed into policies and strategies, models for engineering education were realized and then an input-output model for the mechanical engineering study programme.
Finally, the paper presents an engineering education system in which input and output are outlined and which brings to the attention of specialists in academic management the industry's requirements and the abilities of young students

Key-Words: reform, modelling, engineering education, industry.

1 Introduction

At this beginning of a new centurt, the manner in which society is organised goes through radical, visible changes, reflected especially within the social institutions.The university, as one of the most durable institutions of civilisation, is also comprised in this transformation process, even if for it change is not something new. The university was not rigid throughout history, it constantly changed to serve the interests of society as good as possible. Currently, the very varied in which this institution can be found, from the traditional university to the virtual one, are but stages in a long series of transformations.

The European's traditional education was always modeled by a history that showed that it is more prudent to not expose yourself, but also to not calm down the fever of a hurrying century, living with the illusion that there is time for everything. According to Kant, education is the activity of disciplining, cultivating, civilising and moralising the human being, and its goal is to develop within a person all the perfection of which he is susceptible. On the other hand, according to Herbart, it is also the action of a person's training for his own sake, developing lots of own interests.

It is therefore not by chance that the very countries that knew to invest in education programmes and perfected their educational standards obtained remarkable results and durable economic growths. Examples therefore are not limited to the advanced countries on the Atlantic shores, but include also Japan, China, South Korea, Thailand, Chile, Czech Republic, Switzerland or Hungary., who allocated significant parts of their public budgets for education, through large-scale programmes.

Throughout the world, educational systems are confronted, on the one hand, with the impact of the new knowledge and communication technologies, with the rapid rithm of changes, and on the other hand with the effects of society's globalisation, of the increasing interdependencies between nations and cultures.

In promoting globalisation, which is perceived as a harmonised reunion of local diversities, education is more and more frequently considered to be at the same time a factor (an instrument for promoting globalisation) and effect (suffering significant changes due to globalisation).

Globalisation is a reality, pushed forward by the unbelievable advance of information and of information technology, especially in trade, finances, transportation and product manufacturing. Globalisation means a world open towards the capital, towards goods, services and ideas, including the education market. As was expected, education is called to not only react to globalisation tendencies, but moreover to play a decisive role in developping future desirable societies, inducing within society qualitative changes that can preserve the diverse nature of communities, but also the tolerance based on communication and on a better knowledge and understanding of the interests of every participant in this process.

2. The SWOT Analysis Applied to Higher Education in Europe

Tackling the current challenges of higher education, some essential aspects can be emphasised following the applying of a SWOT analysis (table 1):

- The opportunities regarding the need for qualified professionals, certificates' recognition and students' mobility are characteristic for the states and universities undergoing an integration process. In the same manner act the power of university autonomy and the universities' interest for individual development and professional careers.
- One should not neglect the threats and weaknesses due to the rapid changes of the economic environment and to the weak accountability.

The political and factual answer of the European Council to these challenges has unfolded for almost 10 years, since the Declaration from Bologna and today quantifies three major elements:

- European education should become a "world quality reference";
- The EU will invest in research and development 3% of GDP, by 2010;
- Europe will become by 2010 "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs, greater social cohesion".

Their development could be realised through three strategic objectives – competitiveness, mobility and employability, detailed in the following.

By competitiveness, we understand the development of capacity to attract foreign students through quality, transparency, diversity and visibility.

The requirements in this regards are:

- World-wide readability of degrees by employers and individuals;
- Information about learning outcomes (knowledge and competences);
- Friendly students services;
- Dissemination of European knowledge production;
- Transnational programmes.

The mobility of students, academics and staff is promoted through comparable study structures and the recognition of studies carried out abroad, implying also:

- Quality of education institutions;
- Flexibility for accepting the core knowledge.

Employability is important, because the outcomes are relevant for the labour market.

Influence factors in this regard are:

- Quality assurance of the programs;
- Clear objectives of learning outcomes;
- Developing competences (knowledge, skills, attitudes).

It is necessary to develop a new educational style focused on:

- Broad scientific knowledge
- Capability to apply knowledge
- Learning capability (from others, from experience, from new developments)
- Horizontal competences

Opportunities	**Threats**
- Individuals' need for training - **Need for qualified professionals** - Resources coming mostly from public sources - Professors as civil servants, members of national bodies - **Certificates' recognition** - **Students' mobility** - Widening of the educational offer area - Resources for professional re-conversion - Dynamic professional associations	- Competition with the other universities - **Too high or too burdening expectations** - Educational systems regulated by states - Frequent legislative changes - Lack of motivation for higher education - **Rapid changes of the economic environment**
Strengths	**Weaknesses**
- **University autonomy** - Self-evaluation - **Universities focused on individual development and professional careers** - Determination of training and qualification areas based on - local market demands - High diversity - Existence of an organisational culture	- Largely supply-controlled - **Weak connections with companies** - **Less services to offer to students and to companies** - Overlong studies - High dropout rates - Mismanagement - Teachers as civil servants - **Weak accountability** - Inefficient institutional management

Figure 1. Challenges of the European Higher Education

One question arises: what would be the policies and strategies on medium and long term?

The answers are comprised in the following five ideas, all viable and having a strategic value, the first two being materialised in the iconic model of the unfolding of engineering education (figure 2):

- The development from teaching to learning and from knowledge to competences;
- The involvement of professional bodies in the curricular development;
- Financial support for joint degrees;

The answer to this is found in the curricular development, which is influenced by following aspects:

- considering how developments in engineering, science and technology can be incorporated in the curriculum;
- considering how changes in the environment influence the role and responsibility of the engineer;
- regularly reviewing the subject area which should be included in the engineering curricula, to best fit engineers to fill their role in the 21st century;
- examining how the change of teaching and learning strategies and the new educational technologies influence the curriculum development;
- considering how the quality and effectiveness of the curricula can be assessed.

Moreover, the moment of analysis is very important, the expectations being related to the transition from input-oriented towards output-oriented curricula. The input descriptions refer mainly to the course contents, whereas for output descriptions, we take into account the graduates' characteristics: abilities, knowledge, skills and competences.

The example of a mechanical engineering study programme suggestively presents a possible result of the expectations (figure 3). In the following, details on its contents are given.

Thus, graduates of the mentioned study programme are expected to have knowledge of:

- Applying scientific research results more effectively;
- Developing European/national centres and networks of excellence, excellence in human resources.

According to the declaration from Bologna, engineering education will have three levels: BSc, MSc and Ph.D. (or a professional career), representing a fundamental change dictated by the high competition of industrial organisations and by globalisation.

The feedback of this construction reveals the requirements for curricula, i.e. what knowledge, skills, competences are required for successful careers.

- the basics of mechanics and fluid mechanics;
- the basics of materials science and strength;
- the basics of thermodynamics and heat transfer;
- economics relations in designing and exploiting machines and systems;
- foreign languages;
- information technologies.

They should understand:

- the principles of operating common machines: pumps, fans, turbines, engines;
- the impact of materials and machines on the environment;
- the impact of machines and systems on the environment,

and have the ability to:

- carry out design of machine parts and systems using CAD codes;
- calculate mass balance, energy balance and power systems efficiency;
- use common measuring equipment to control mechanical and power systems;
- explain the impact of materials and machines on the environment;
- explain the basics of operating and maintaining mechanical systems;
- work in a team;
- solve conflicts;
- be creative.

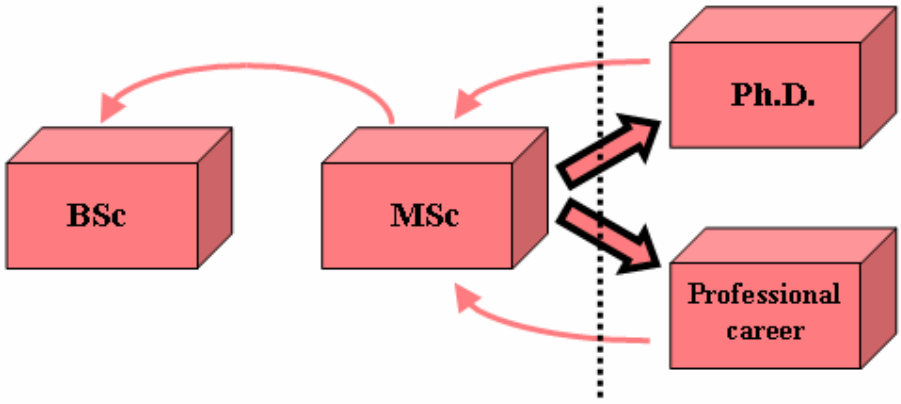

Figure 2. Iconic model of engineering education according to the Declaration from Bologna

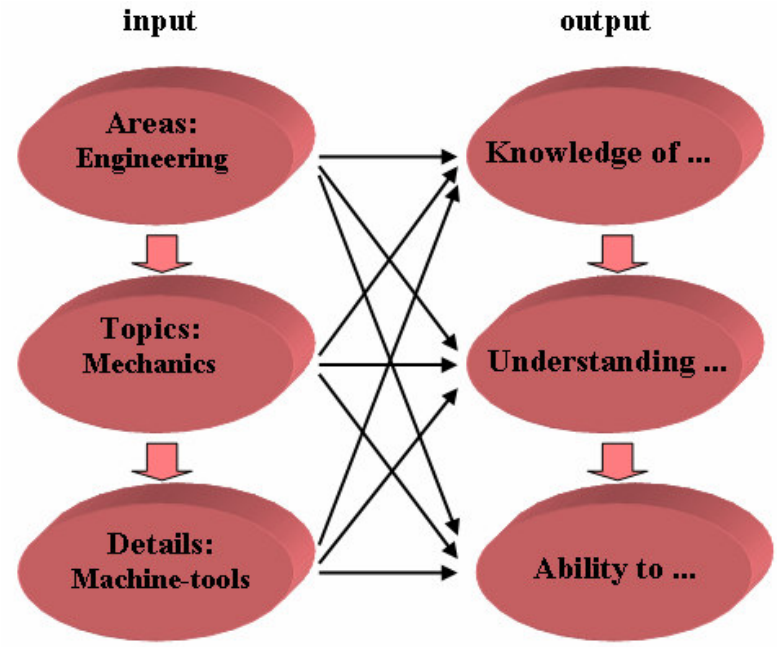

Figure 3. The input-output model for the mechanical engineering study programme

3. Conclusions

The designing of an engineering education system (figure 4) in which input and output are outlined brings to the attention of specialists in academic management the industry's requirements and the abilities of young students.

Possible answers are defined in the following.

The requirements from the industry are strongly multiplied:

- mobility within the labour market;
- receptiveness to employing engineers from other countries;
- personnel specialised in restricted (narrow) domains;
- all engineers should have a minimum of engineering-related skills, knowledge and abilities in order to function in an engineering environment;

For the industry, all engineers should be able to:

- communicate information, ideas, problems and solutions to both specialist and non-specialist audiences;
- adapt to changing technologies and new techniques as part of lifelong learning process function efficiently in project groups and teams;
- understand the interaction process between people working in teams and adapt to the requirements of the working environment;
- understand the influence of engineering activity on all life and environment, and prove a high moral and ethical approach to engineering tasks.
- apply their learning ability to undergo appropriate further training of a professional and academic nature;
- critically assess arguments, assumptions, abstract concepts and data, in order to make judgements and contribute to solving complex issues in a creative process;
- show appreciation of the uncertainty, ambiguity and limitations of knowledge;
- plan, supervise and carry out research and development projects;
- find solutions to particular technical and human problems arising in the working environment;
- apply skills and qualities needed for employments requiring personal responsibility and decision-making;
- accept responsibility for related decision-making, including usage of supervision;
- show awareness of connections with other disciplines and engage in inter-disciplinary work.

Finally, the ability to be an active learner implies:

- making learning accessible all the time;
- teaching students “how to learn”;
- making learning more attractive and reachable for more people;
- enabling access to a wide range of information from any source;
- unfolding activities centred on real life problems;
- motivating students to learn by using e-learning methodologies

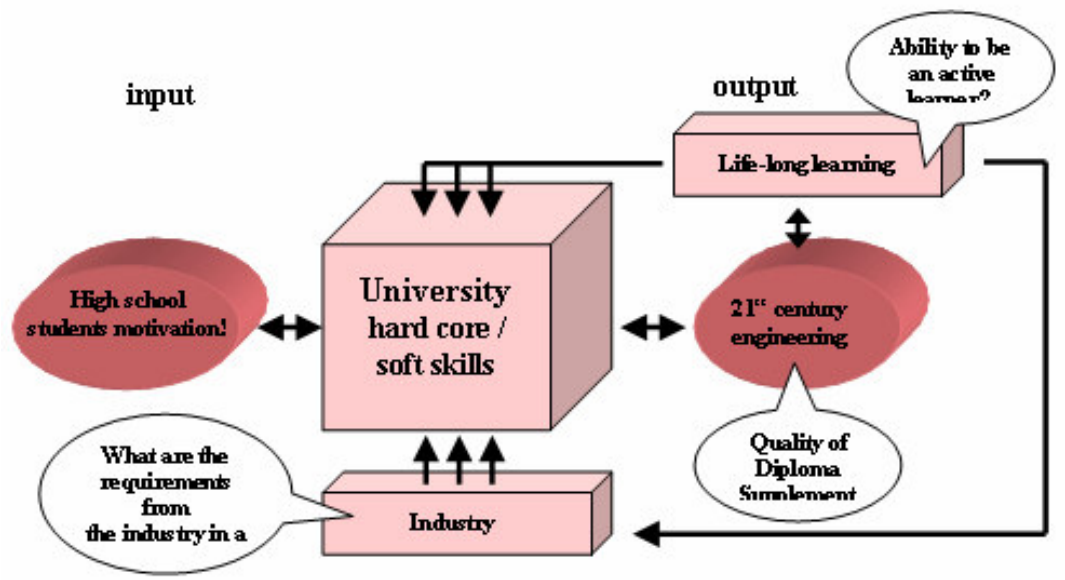

Figure 4. Input-output model for the engineering education system

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