A New Curriculum Design for an Engineer-Constructor Study Program

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Abstract – **A model of engineering education in the field of construction is introduced in this paper. It is designed by following the criteria of the Bologna Declaration, the European and domestic labor market, as well as the specifics in the existing level of development of the engineering faculties in Macedonia (infrastructure, human resources, labs, equipment, etc.). This model can serve as a basis for reform of the existing models of engineering education, with a sole purpose to increase efficiency and to effectively increase the level of quality in the field of engineering education.**

Keywords – **Study program, Curriculum, Engineering, Constructor.**

I. INTRODUCTION

The modern economy requires that engineers quickly and easily adapt to the changing needs of the world around them. "Engineers of the future", in addition to technical knowledge, should possess a wide range of personal, interpersonal and systemic knowledge and skills that will enable them to function successfully in actual engineering teams and to produce real products and systems, meeting the needs of the organization and society in general.

Of course, this raises the question of reform in higher education of engineers. Bologna Process, through its requirements for defining the results of education and competences that every engineer should obtain after completing his higher education, is actually a request for a different placement of the interaction between higher education and the labor market.

According to the analysis of the labor market, employers and managers require engineers who, after completing their higher education, will be prepared to engage in the work process that will continuously update and upgrade their skills and knowledge, to communicate effectively and work as a team.

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Great challenge and of primary importance for the engineering faculties in Macedonia is to educate cadres who will be able to engage in the economy.

At global level, there are many different approaches to the implementation of the reform of national systems of higher education in the technical sciences. Analyzing some models of higher education of engineers, one can conclude that the role of industry and the economy as a whole is crucial in all of the engineering education reform.

II. CRITERIA TO DESIGN A NEW STUDY PROGRAM

Two major parts can be identified in the criteria to establish a new approach for the design of a new *engineer-constructor* study program.

The first part includes the *external criteria* as an objective of the Bologna Declaration, and consists of several *blocks*. The *first block* of external criteria is enforced by the Bologna Declaration itself:

- Adoption of a system based on two cycles (undergraduate and graduate)
- Establishment of a credit point system (ECTS)
- Promotion of the mobility of students, teachers, and administrative staff
- Adoption of a system of easily readable and comparable degrees
- Promotion of European cooperation in quality assurance
- Promotion of an European dimension in higher education
- Added the third cycle of doctorate studies

The *second block* of external criteria is dictated by the European labor market, representing the supply and the demand for mechanical engineering staff and its engagement in- and out of the borders of the EU member states. The *third block* of external criteria is dictated by the Macedonia's candidate-status for the EU membership and the need for harmonization of the legislative in the other, indirectly connected sections with the high education.

The second part contains the *internal criteria* relating to:

- Labor market in the Republic of Macedonia, population, level of education and competence, supply and demand trends (similarly, the analysis of the employment policy, the current trends for motivating students to study mechanical engineering, etc.);
- Existing technical infrastructure in the higher education area and the field of engineering;
- Human resources: management, teaching staff, administration;
- Technical conditions: laboratories, equipment, ICT;

- Weaknesses and opportunities from the old curricula together with the gained experience;
- Required profile of mechanical engineers on the labor market of the Republic of Macedonia and the whole European area.

III. SUBJECT AND OBJECTIVES OF THE STUDY PROGRAM

In this paper, an educational model for engineers-constructors that are required on the Macedonian labor market (especially in the Pelagonia region) is offered. During the creation of the model, all the necessary internal and external conditions that must be met for the successful implementation of the model are taken into consideration. The essence of this model is in an *integrated interdisciplinary designed project* that runs through the entire engineering program of study, through the introduction of integrated training block.

By defining such a model for education of engineers-constructors, according to the criteria that originate from the Bologna Declaration, European and domestic labor market, and the specifics of the current level of development of engineering faculties in Macedonia, the aim is to educate staff that will be able to effectively and efficiently integrate in the economy. Despite the direct beneficiaries, i.e. the students, indirect beneficiaries, i.e. the parents, the local community, universities, the labor market and the entire society, will benefit as well. Therefore, the process of defining a model for the education of engineers-constructors means raising the level of quality in the engineering education.

The subject of the study program is to educate students in the engineer-constructor vocation, in accordance with the needs and the level of development of the country, very complex engineering problems in the mechanical and civic engineering, which in the direction of society development must be resolved. The study program of engineers-constructors is designed in such a way that it provides the acquisition of competencies, knowledge, and skills that are socially justified and useful.

IV. PEDAGOGICAL AND DIDACTIC APPROACH IN THE DESIGN OF THE ENGINEER-CONSTRUCTOR MODEL OF EDUCATION

Creating a stronger bond between the teaching methods and the engineering educational programs requires a transmission of a wider spectrum of knowledge, skills and opinions to the young students. The undergraduate engineering education program encompasses some tension between two growing needs. From one side, there is the need of engineers that hold technical knowledge that is more on the theoretical perspective, and on the other side, there is the need of engineers that hold interpersonal skills that allow them to function more successfully in the real engineer's teams and in the real working environment.

Education experts claim that by using various teaching methods they provide a better strategy of implementing the learning process to an engineer-constructor student. The goal is to involve the student to be more active in the educational process where he/she can contribute with deeper knowledge of the theoretical material by developing skills of independent learning. This is the only effective way of developing and modeling the expert abilities and skills required for completing the selected material.

V. STRUCTURE OF THE STUDY PROGRAM

The requirements that are given for the creation of an engineering profile that will respond to the needs of the European area of the labor market, which Macedonia is willing to accept, opens several dilemmas. This paper is composed to provide and answer through defining a new proposal of a curriculum that will allow finding the optimal solution of the existing problem.

The basics of the new structure are the four areas of construction science given in Fig. 1 [7]. Each area is represented by two subjects in each year of the studies (given in bold type in Tables 1 and 2).

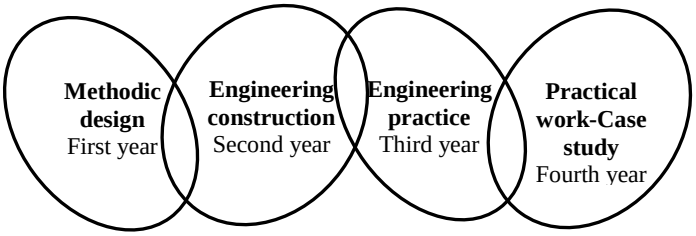

Fig.1. Structure of the education of engineers-constructors

The curriculum proposal with the structure trough the four years (8 semesters) is given in Tables 1 and 2.

TABLE I
THE FIRST AND SECOND YEAR (SEMESTERS 1-4)

Subject	Teaching hours	Credits
Introduction to industrial design	2+2	6
Statics and strength of materials	2+2	6
Engineering mathematics I	3+3	9
Methodical construction	3+3	9
Foreign language	2+2	6
Structural materials	2+2	6
Engineering mathematics II	3+3	9
Computer Aided Design	3+3	9
Product and process technology	2+2	6
Machine elements 1	2+2	6
Elected topics in engineering	3+3	9
Parametric modeling of mechanical constructions with Mechanical Desktop	3+3	9
Engineering metrology	2+2	6
Engineering programming	2+2	6
Kinematics and Dynamics	3+3	9
Structural design	3+3	9

TABLE 2
THE THIRD AND FOURTH YEAR (SEMESTERS 5-8)

Subject	Teaching hours	Credits
Machine elements 2	2+2	6
Technical regulations and mechanical rights	2+2	6
Mechanical design and methods of optimization	3+3	9
Reliability in design	3+3	9
Methods of diagnostics and maintenance	2+2	6
Basics of the Finite Elements Method (FEM)	2+2	6
Mechatronic design	3+3	9
Construction in relation to noise and vibration	3+3	9
Business and Entrepreneurship	2+2	6
Ergonomics in construction	2+2	6
Project Management	3+3	9
Product design and development (project)	3+3	9
Selection and application of materials	2+2	6
Constructing and testing prototypes	2+2	6
Constructive product development	3+3	9
Practical design (project)	3+3	9

Therefore, in order to provide a greater flexibility of the study program, during the academic years, in addition to the compulsory subjects, elective subjects are also projected. These are chosen from groups of elective subjects, while students have an opportunity, according to their own aspirations and desires, to choose one subject either from the Faculty of Technical Sciences – Bitola, or the "St. Kliment Ohridski" University, or any other university in the country or abroad. At the same time, certain conditions that are prerequisites for attending the classes of the optional subject should be fulfilled.

The ratio of European credits that are earned by certain types of subjects is in accordance with the existing legal norms in the Republic of Macedonia and the "St. Kliment Ohridski" University. Each subject brings a certain number of European credits (ECTS), and for the completion (graduation) of the first cycle, it is necessary to achieve the minimum of 240 European credits.

VI. QUALIFICATIONS AND COMPETENCIES OF GRADUATE STUDENTS

Acquired skills and competencies associated with the proposed items in the curriculum are given in the following Table 3:

TABLE 3
ACQUIRED SKILLS AND COMPETENCIES

Skills and competencies	Features	Subjects
Global and Strategic	Allows to reach knowledge implemented worldwide	Foreign language Business and Entrepreneurship
Industrial	Skills and knowledge are not scientific and professional and are required in advanced undergraduate studies	Introduction to industrial design Health and safety of work Eco-design Technical regulations and mechanical rights Methods of diagnostics and maintenance Constructing and testing prototypes
Social	Creating engineer with high ethical and moral standards	Ergonomics in construction
Practical	Direct involvement of students in activities or situations of real life, which provides the basis for integrated knowledge of intra- and inter-engineering and non-engineering	Project Management Constructive product development Product design and development (project) Practical design (project)
Professional	Acquiring professional and technical competencies required to perform specific engineering tasks	Mechatronic design Methodical construction Computer Aided Design Parametric modeling the mechanical constructions with Mechanical Desktop Structural Designing Mechanical design and methods of optimization Reliability in design Construction in relation to noise and vibration The selection and application of materials
Scientific	Laying a solid foundation in engineering, enabling future engineers to restructure and to include the changes in the scientific field and to develop interest in design	Engineering mathematics I Engineering mathematics II Kinematics and Dynamics Statics and strength of materials Structural materials Product and process technology Elected topics in engineering Engineering metrology Engineering programming Basics of the Finite Element Method

VII. CONCLUSION

Successful business owners demand engineers to quickly and easily adapt to the new changes in the working environment. Nowadays, the new and more sophisticated technologies require more techniques with extensive knowledge and set of skills such as flexibility, multidisciplinary competence, teamwork, problem solving and project work.

According to the analyses of the needs in the labor market, the employers and the managers seek for engineers that, after their education, can easily find their gained skills and theoretical knowledge in a practical usage in the working environment.

In this direction, this paper defines a model of an engineer-constructor that is required on the Macedonian labor market, especially in the Pelagonia region. In the process of creating this model, many internal and external criteria are taken into consideration. The essence of this model is in the design of an integrated interdisciplinary project that runs throughout the academic engineering program by introducing integrated learning block of training.

Therefore, the main purpose of this structured model can be defined in several main benefits:

- General knowledge of several different scientific areas close to each other, and closely related to constructional work;
- Ongoing practical work during the four-year apprenticeship;
- Upgrade of the construction work knowledge and skills by gaining practical experience of using the theoretical knowledge in the real working field;
- Practical realization of the process of construction through the use of software, measurement equipment and final preparation of complex real problem with participation in a team.

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