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Advanced Mechatronics Education Concept Design at Bánki Faculty of Óbuda University

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***Abstract*— "Mechatronics is the synergic integration of Mechanical Engineering with Electronics and Intelligent Computer Control" [1]. This definition expresses very well the modern mechatronic knowledge. At the Óbuda University the mechatronic course was firstly introduced in September 2005, what does not mean that institution has not any prior experience about mechatronics. After the introduction of the BSc level of the Mechatronic course, in September 2009 has been started the MSc level, however in part-time course only. In 2011 the English mechatronic BSc and in 2015 the MSc course was launched. These constant renewals leaded the professors to the continuous curriculum developments. This paper presents a new mechatronics education design concept. The new viewpoints introduced in this plan highlight the importance of project works and fulfil all the key criteria and international requirements.**

Keywords—Mechatronics; Teaching plan, Credits; Ministry of Human Capacities MHC; Project Based Learning;

I. INTRODUCTION

The growing needs of Hungarian industry after 1990 forced the national higher education institutions to train highly qualified professionals to satisfy these claims of industry. Following the political changes, after the recession, the Hungarian industry achieved significant progress in year 2000. The decisive factor was the increase in exports, thanks to domestic suppliers cooperating with the multi-national industrial concerns (Audi, Mercedes, Opel, Suzuki) using modern mechatronic devices. To keep this advanced development skilled engineers are required, who are proficient in modern design, familiar with new technologies and operating methods and are able to apply them in practice. In the interest of meet these social and industrial needs, Budapest Tech (September 2005) decided to launch the Mechatronic BSc level course.

A. The short history of the mechatronic

Based on the available literature the term "mechatronics" was first introduced in Japan in 1969 to describe the integration of mechanics and electronics [2],[3],[4]. The term is widely used in Europe and is generally understood by engineers but is less recognized by the general public [6]. The evolution of the systems from mechanical to mechatronic can be seen on figure 1. the complete product. In order to enable production process optimization it is necessary to monitor the operation cycle of machines, current machine occupancy and the workpiece path in the process (transport time and current position). The machine control unit can use the information about the current position of the workpiece and the time required for getting to the next position when deciding upon which product should be chosen for processing if the machine serves multiple product lines.

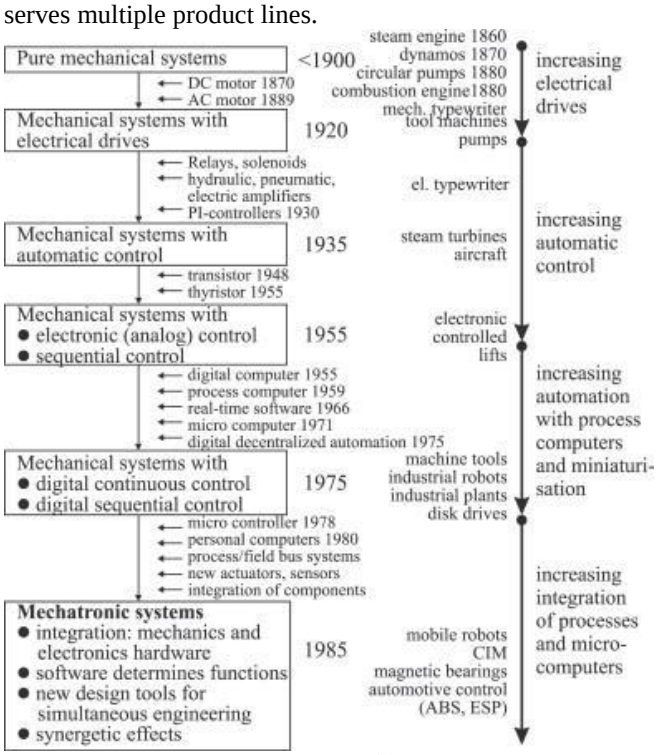

Fig. 1. Historical Evolution until creating of first Mechatronic Systems [7].

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B. The short history of Institute of Mechatronics and Vehicle Engineering

The simplified historical line of formation of nowadays mechatronic institute is the following. Let's start at the beginning:

- 1879, "Public Secondary Industrial School of Budapest", what later operated under the name "Hungarian Royal Public Higher Industrial School" (year 1898)
- At the ceremony of the 75th anniversary of its foundation, after the World War II., the institution adopted the name of "*Donát Bánki*" [8]
- 1969 College rank
- 1991 Donát Bánki Mechanical Technical College
- 2000 Budapest Tech, by integration of three highly rated colleges in Budapest:
  - Donát Bánki Mechanical Technical College-later Institute of Mechanical Engineering
  - Kálmán Kandó Electro-Technical College– later Institute of Electrical Engineering
  - Technical College of Light Industry-later Institute of Light Industry
- In frames of Donát Bánki Institute of Mechanical Engineering has been created the department of *Machine and System Engineering*, what was the predecessor of current institution.
- 2010 Óbuda University, with 5 faculties, from which our faculty is the Donát Bánki Faculty of Mechanical and Safety Engineering, where can be find our current institute, *Institute of Mechatronics and Vehicle Engineering*, with two departments (dept. of *Mechatronics*, and dept. of *Vehicle Engineering*) and one emphasized professional group (*mathematic & informatics*)

II. THE TEACHING PLAN DEVELOPING

A. The starting conditions

In case of starting a new professional course in Hungarian higher education, first of all it is required to submit the request for application of introduction of this course, to the proper Secretary of Ministry of Human Capacities (*MHC*). Here, the education Committee (group of expert in education and in industry), elaborating the directives, valid from the given academic year. This directive contains the general features (as level of qualifications, attitudes, responsibility, etc…) and competencies of the graduates of different professions. These features are commonly named as *"educational and outcome requirements"* (EOR) of the given profession. One of these professions is "Bachelor/Master Level of Mechatronical Engineering", where the graduates are titled as "Mechatronical Engineer" [9].

Generally, in this directive are stated the followings:

- denomination of the profession (Mechatronical Engineering)
- qualification (Mechatronical Engineer)
- level of qualification (BSc/MSc)
- educational area (technical)
- length of education (BSc-**7** semesters/MSc-**4** semesters)
- number of credits (BSc-**210** credits/MSc-**120** credits)
- aims of education
- competencies to be acquired
- other features, as basic characterization of the given profession

B. Basic characteristics of the Mechatronic Course, based on directive EOR

The basic characteristics of the mechatronic course is beginning by the features obtained from MHC, where are stated the scientific disciplines/areas of the profession from which the course is built up. These areas (*with the recommended min-max credits*) are, see Table I.

TABLE I.

BSc Level	***MSc Level***
Natural Sciences (40-50 credits)	Natural Sciences (25-35 credits)
Economics and Human Sciences (14-30 credits)	Economics and Human Sciences (10-20 credits)
Basic Mechatronic Knowledge (70-105 credits)	Basic Mechatronic Knowledge (15-35 credits)
Specialized Mechatronic Knowledge (min 40 credits)	Specialized Mechatronic Knowledge (40-60 credits, together with thesis credits)

The first 3 rows of Table I. contain the main knowledge areas, while the last, 4th is the specialization one. What is this mean? The mechatronic course, depending on the particular institution (university/college), can have several specializations, e.g.: bio-mechatronics, opto-mechatronics, robotics, nano-mechatronics, etc..

Óbuda University, over the basic (main) mechatronic knowledge, has one specialization on the BSc level *(Industrial Robot Systems*), and two specializations on the MSc level (*Vehicle Informatics and Mechatronics of Intelligent Robot Systems*).

The basic characterization of the course is continuing by the defining of requirements regarding *foreign languages* and defining of requirements of *internships* [10].

C. Basic characteristics of the Mechatronic Course, at the Bánki Faculty of Óbuda University

Of course, at all curriculum development, the Hungarian institutions, have to start by the decreas issued by MHC, what is mean that the main knowledge areas and the basic requirements are given, certainly between some min-max limitations (credits). What are not exactly given, the subjects, which are belongs to the given main areas. Here the institutions have some options to state the subjects, which are mostly typical to the local mechatronic education. It is enough to compare the mechatronic education at the faculty of electrical engineering/faculty of mechanical engineering/faculty of informatics. Depending on which faculty is the "parent institution" of the course, in basic knowledge area "*Basic Mechatronic Knowledge*" (see Table I.) will dominate the subjects of that given faculty. To avoid this small insufficiency, at our faculty it is organized as follows.

Started by the latest definition of the mechatronics, "Is a synergetic integration of physical systems with IT and complex-decision making (in the design, manufacturing and operation of industrial products and processes)", further see

Fig. 2, at the Óbuda University, on the mechatronic education are sharing three faculties: John von Neumann Faculty of **Informatics**, Kálmán Kandó Faculty of **Electrical Engineering** and Donát Bánki Faculty of **Mechanical** and Safety Engineering. By this sharing of the professional subjects is ensured the maximum quality of mechatronic education.

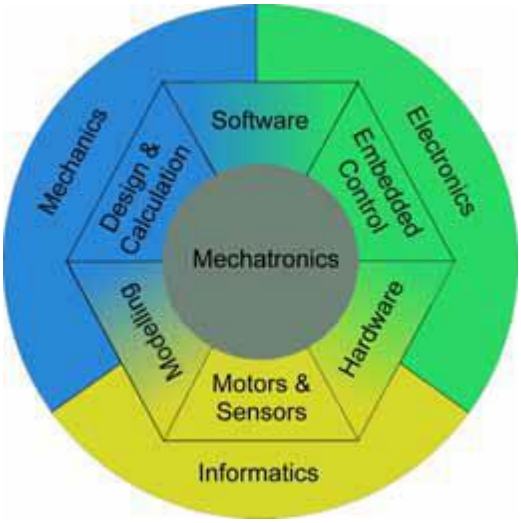

Fig. 2. The basic definition of mechatronics after Y2K.

The above mentioned definition is giving the *professional basis* of the course. Furthermore, the professors have to be sure that students have the basic knowledge about mathematics, physics, material sciences, …etc., and therefore these are improved by the first main knowledge area (*natural sciences*), see Table I., above. The today's engineers have to be able to plan the budget to start some mass production or to prepare some prototype, and also has to have some managing skills. That why between the main knowledge areas inserted the *Economics & Human Sciences*.

Compared the classical engineer to mechatronical one, it should be noted, while classical engineer is acting in one field of knowledge, the mechatronic engineer has to solve interdisciplinary tasks, maybe in more complex environment. This means, has to think more broadly, and the tasks, if it is possible, to divide to subtasks, and solve them separately then integrate them again into one operating mechatronic system.

During mechatronics engineering education, it has to be shown that significant disadvantages can occur by using sequential development processes which in the majority of cases can lead to suboptimal mechatronic products. The objective is to teach a procedure in the sense of simultaneous and concurrent engineering [11]. Most important therefore are organisational abilities and steps which have the aim of multidisciplinary team work instead of the old-fashioned so-called "Throw-it-over-the-wall" way of thinking [12].

Essential basis for the mechatronic development process and therefore one of the first aspects in education is the underlying methodology. The guideline VDI 2206 [13] describes a flexible procedure model which is based on the V-shaped model on the macro-level and the cycle of problem solving on the micro-level as illustrated on Fig. 3.

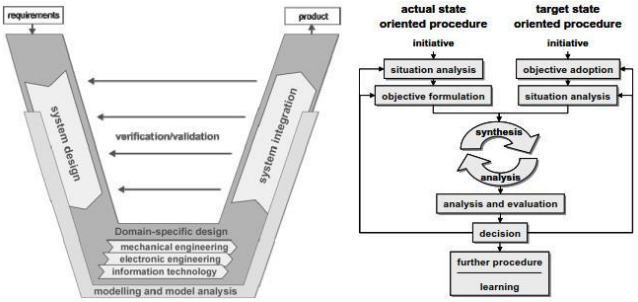

Fig. 3. VDI 2206 proposed methodology for mechatronic development

According to the V-model a first step is to determine and analyse the requirements of the future product. Afterwards an interdisciplinary conceptual solution is divided into sub-functions and domain specific subsystems are developed simultaneously. These subsystems are integrated to one mechatronic product while being steadily verified and validated [14].

Returning to the mechatronics education concepts of the Óbuda University the whole new teaching of mechatronics is designed under previously mentioned feelings. The task of teaching plan developers to harmonize the ministerial decrees, didactic concepts and the needs of the industry and certainly consider the human (professor's) resources of the university. Starting from this fact the university shared the professional subjects between above mentioned three faculties (see chapter: II., *C*), where the "*natural sciences*" are taught by the emphasized professional group of Institute of Mechatronics and Vehicle Engineering, namely "*mathematic & Informatics"* (see, chapter I., *B*). The teaching material of this knowledge area (*natural sciences*) is centrally (think to University level) given on the BSc level, but on MSc level the subjects can be chosen by the specialists. The situation is the same in case of "*Economics and Human Sciences*". At the Óbuda University the topics, subjects and the requirements of the mechatronic course are the same in both (Hungarian and English language) education forms, i.e. the curricula are totally identical. The personal background of this course is provided by the long-term expertise of the teaching staff.

As in abstract of this paper can be read, the mechatronic education is actually running on BSc and MSc levels in full-time and in part-time education, both in Hungarian and English languages. In addition, the MSc correspondent learning has been started at the *Alba Regia Technical Faculty of Óbuda University* (Székesfehérvár), moreover we are cooperating with Salgótarján in form of *"Adult Education Programs"*, and seems to outline a cooperation by the "*VTS*" in Subotica, Serbia.

In mechatronic education at the university we have one specialisation on BSc level, namely "***Industrial Robot Systems****"* and two specializations on MSc level: "***Vehicle Informatics***" and "***Mechatronics of Intelligent Robot Systems***". The subjects of the levels (BSc/MSc) are defined in such a way, that they build up on each other. In this way the university would like to provide the possibilities of further education of the BSc graduates on the same university. The modern education concept is about the "***Project based***

learning". In interest of this requirements of future, the latest teaching plan of mechatronics (numbered by "*E*") was created based on this. There are the subjects "*Project Work I,II*"; and besides of this all, the cooperative education was arranged and the internships of the students. In following have a short look to the regulations given by MHC, regarding credits, contact hours and other rules:

- number of contact hours/week/subjects (variable)
- number of credits/semester (27-33 credits)
- stating the internships requirements (summer internship 6 weeks, integrated professional internship 14 weeks)
- stating the minimal entry requirements for English/German courses (intermediate language exam)
- stating the credit transfer rules
- defining the compulsory and optional subjects
- etc…

If these rules are kept, this ensures the balanced academic life of students, such as mentors, professors. Moreover, in each developing have to be considered the available HR and laboratory background, too.

In TABLE II.,III., the subjects assigned to the different main knowledge areas can be seen.

TABLE II.

BSc level- Spec. *Industrial Robot Systems*	
Natural Sciences	Mathematics 1,2; Eng. physics; Intro to Mechatronics; Mechanics 1,2,3 Electrical Eng.; Engineering Materials; Basics of Mat. Technology.
HR & Economics	Macro- & microeconomics; Business Economics 1,2; Quality assurance; Legal knowledge; Basic of Management
Basic Mechatronic Knowledge	Informatics 1,2, Machine design 1,2; El. machines & drives; CAD systems; Material technology; System Engineering; Control Engineering; Programming languages; Digital Techniques; Pneumatics and hydraulics; PLC knowledge; Manufacturing eng.; Electronics; Precision mechanics; Interfaces;
Specialized Mechatronic Knowledge	Industrial robot progr. & simulation; Robotics and production automation; Industrial robot kinematics & dynamics; Mechatronic system diagnostic; Basic operation of mobile robots; Vehicle mechatronics; CAD designing; IT networks; Diploma work / Project works.

TABLE III.

MSc Level , and specializations: 1, 2				
Natural Sciences	*HR & Economics*	*Basic Mechatronic Knowledge*	*1. Vehicle Informatics*	*2. Mechatronics of Intelligent Robot Systems*
Optimizati-on methods	*Business Economics*	*Embedded systems*	*Vehicle's information systems*	*Intelligent systems*
Eng. physics	*Engineering management*	*Micro-, Nano techniques*	*Vehicle dynamics*	*Multi-agent mobile robot systems*
Selected Chapters of Mechanics		*Engineering optics*	*Vehicle electronics*	*Modern productive technologies*
Electricity		*Modelling & Simulations*	*Transport's information technology*	*Adaptive Control Systems*
Selected parts of Thermo- & Fluid dynamics		*System & Control theory*	*Multi-agent mobile robot systems*	
Material Sciences		*Mechatronic constructions*	*Reliability of the mechatronic systems*	
		Sensors & Signal analysis		
		Intelligent Eng. Systems		
		CAD systems		
		Fuzzy systems		
		Self-organizing systems		

III. EVALUATION OF THE REALIZED TEACHING PLAN

If the subjects in TABLE I., II., are carefully checked, the attentive reader will recognize, that subjects in MSc course are based on subjects given in BSc course. It was very important, that the MSc subjects must give more specific, more exact knowledge and provide an advanced scientific interest to the students.

Finally, there are compared the credit points assigned to the main knowledge between the recommended by the MHC and the earned in reality. The recommended credits by the MHC can be seen in TABLE I. above, while the earned credit points, after the finalizing the teaching plan development, can be seen bellow, on Fig. 4 and Fig. 5.

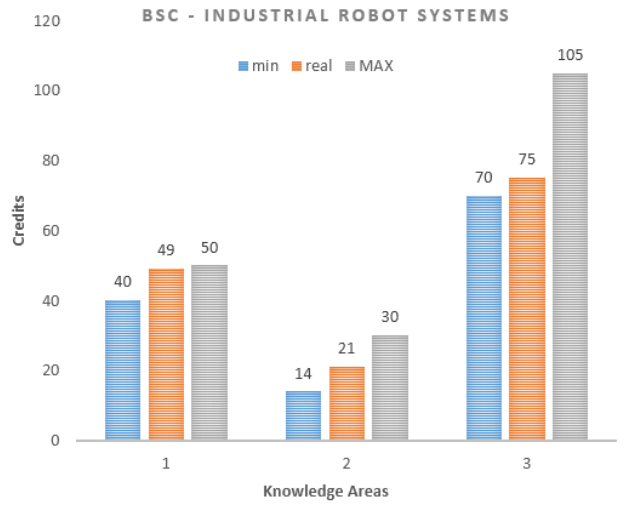

Fig. 4. The really earned (middle) vs min-max recommended credit points at the BSc level of Mechatronic Teaching Plan

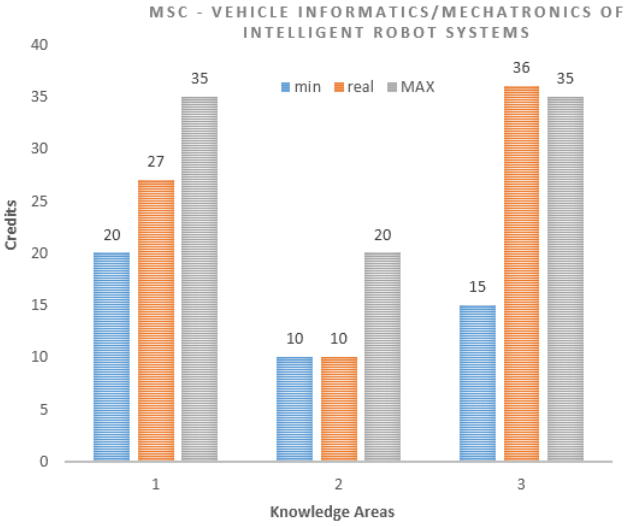

Fig. 5. The really earned (middle) vs min-max recommended credit points at the MSc level of Mechatronic Teaching Plan

Compared the TABLE I, with Fig. 4. and Fig. 5., on figures just 3 knowledge areas can be seen, however in table are given 4. This is because the 4th row in the table is additional (shaded), and here are considered just the first 3 rows. Secondly, the two specializations on MSc level earned the same credit points, that is why are joined. As can be seen the middle column is almost everywhere being between the desired min-max limits except the last MSc (*Basic Mechatronic Knowledge*). This is, where the credits should be decreased or subject should be deleted from teaching plan. Both caused big problem for teachers/professionals, but the compromise will be find.

IV. CONCLUSION

As can be seen from above discussion, "mechatronics engineering" is a highly interdisciplinary professional area. The mechatronics engineer is working in various professional fields, with employees from different disciplines, and from this all have to form a project team in order to achieve the best results. That is, why the Mechatronics Teaching Plan development requires very careful planning. By the introduction of subjects *Project Work I, II* we would like to get closer to this concept. First of all, it is not sufficient to pass the knowledge solely in the fields of mechanics/electronics and IT, but instead we have to focus of the courses which must emphasise the integrative aspects.

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