BME Education Program Following the Expectations from the Industry, Health Care and Science

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Abstract— **This paper presents the BME educational program implemented in AGH University of Science and Technology in context of history and current state of biomedical engineering and medical physics education in Poland. A particular attention is paid to program adaptation procedures. This aspect is an often discussed factor increasing the efficiency of educational process and the attractiveness of the studies. Education variants has been defined accordingly to the development of particular BME branches and forecasted employment requirements. The aspects of measurements and evaluation of teaching quality, advisability of the methods and adequacy of presented topics are also presented throughout this paper.**

Keywords— **biomedical engineering, medical physics, BME education, multidisciplinary learning, education quality.**

I. Introduction

The education on medical physics and engineering in Poland started in years 30th of the XXth century [1] with creation of the Radium Institute in Warsaw by Maria Sklodowska-Curie. Prof. Cezary Pawlowski, one of the assistants and then collaborators of Mme Curie organized first courses on medical physics and biomedical engineering in the Physics Department of the Radium Institute.

The first course of medical engineering started at the Faculty of Electrical Engineering of Warsaw University of Technology in years 50th. Then at the Faculty of Electrical Engineering, Automatics, Computer Science and Electronics of the AGH University of Science and Technology (former University of Mining and Metallurgy) in Krakow Prof. Ryszard Tadeusiewicz organized first courses of biomedical engineering in years 70th.

Until academic year 2005/2006 education in biomedical engineering was proposed as specialization in other fields of studies e.g. mechanics, automatics & robotics, electronics. The development of new technology in medical diagnostic and therapy caused the need for a new approach to biomedical engineering education [2]. Therefore, a consortium of six technical universities - in alphabetic order: AGH University of Science and Technology (Krakow), Gdansk University of Technology (Gdansk), Silesian University of Technology (Gliwice), Technical University of Lodz (Lodz), Warsaw University of Technology (Warsaw) and Wroclaw University of Technology (Wroclaw). The consortium has elaborated the new program of education and then applied to the Ministry of Science and Higher Education for creation a new field of studies "Biomedical Engineering" (BME). In June 2006 Ministry has accepted the application. AGH University of Science and Technology was the first in Poland to enroll the students in BME in academic year 2006/2007. In 2007/2008 all members of the consortium had their students in BME. In 2009/2010 education in BME is offered by 11 technical universities in Poland.

The education in medical physics in Poland [3] started in 1950 with the Technical Physics specialization at the Warsaw University of Technology in Warsaw created by Prof. Cezary Pawlowski and at the AGH University of Science and Technology (former University of Mining and Metallurgy) in Krakow by Prof. Marian Miesowicz. In years 70th Medical Physics program has been initiated at Warsaw University in Warsaw and at the Jagellonian University in Krakow. In 1990 Radiation Physics and Dosimetry specialization has been established at the AGH University of Science and Technology in Krakow. Since 1991/92 it was transformed in Medical Physics and Dosimetry in close cooperation with the Collegium Medicum (Faculty of Medicine) of the Jagellonian University. In academic year 2009/2010 about 15 universities and technical universities train students in medical physics.

II. Organization of the Teaching Program

A. General layout

The BME teaching in the Multidisciplinary School of engineering In Biomedicine AGH University of Science and Technology is programmed accordingly to legal regulations including national standards for academic teaching by the

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Ministry of Science and Higher Education [4] and to the guidelines of Bologna Process (including the Educational Credits Transfer System). The current offer consists of (fig. 1):

- a single 1-st degree (Bachelor/Engineer) 7 semester track,
- five domain-oriented 2-nd degree (Master) 3 or 4 semester tracks,
- a single 3-rd degree (Doctoral) 8 semester track.

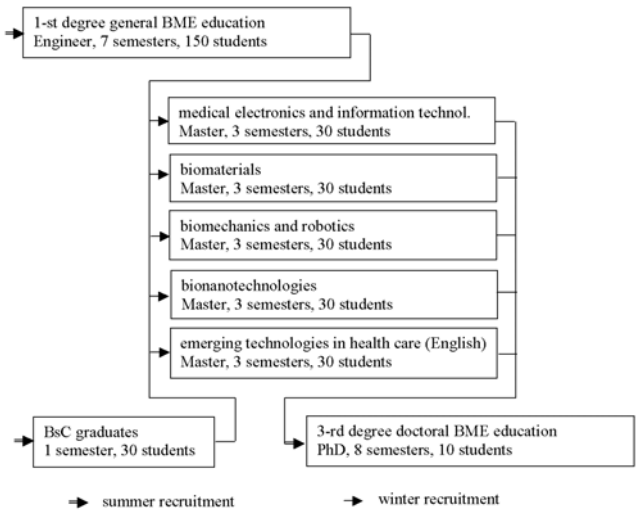

Fig. 1 Education tracks scheme for biomedical engineering at MSIB AGH-UST

After a careful review of the needs from prospective employers, availability of existing infrastructure and resources and detailed studies of reports from more experienced colleagues, we decide to formulate and put into the practice several rules and mechanisms allowing for a broad basic education in all possible BME domains and fast adaptation of the program to the variability of unstable local employment market.

B. BME-specific solutions

The education in biomedical engineering is a particular challenge in (at least) two aspects [5, 6]:

- mulitidisciplinary approach including life, technology and human sciences,
- broad range of the domain difficult to comply with the need of precise definition of the professional specialization field,

Three postulates were formulated as a background of the temporal organization of the proposed program:

- the well-established fundamental knowledge comes first and the recently developing domains follow,
- the general knowledge comes first and the lectures corresponding to particular specialization, students' interests and employers requirements follow,
- the easy-to-understand topics precede the specialized knowledge and lectures based on recent achievements of medical technologies.

Although the curricula proposed by many universities assume first the education of technological backgrounds, followed by the life-sciences specialization, we postulate to start the teaching from the fundamentals of all basic topics: mathematics, physics, biology, chemistry, medical and information sciences. In result all obligatory lectures presenting well established canon of knowledge is put forward and being a reliable background for the subsequent modern technology-oriented lectures, leaves place for the program adaptivity in 4-7 semesters of the 1-st degree. Putting the elective lectures as late as possible shortens the program adaptation delay in case of fast changes of employment conditions (e.g. recession or new opportunities).

C. Program adaptation mechanisms

Despite in the 1-st degree program a single track (for 150 students each year) is proposed, various measures were implemented in order to increase the adaptation range of the proposed tracks. They include:

- supplementary lectures freely selected from the offer,
- elective lectures selected by topics usually based on the students interests,
- alternative lectures selected by advancement degree usually based on students skills or ambitions
- individual study tracks (offered for best students, under the individual supervision of an associate professor they can modify the curriculum by up to 15%)
- individual study schedule (offered for weak students, under the individual supervision of an associate professor they can adapt the schedule to their particular studying conditions)
- obligatory individual activities: personalized projects, summer stages, diploma projects and international exchange.

- elective students activity: educational meetings with industry-proposed young engineers challenge, student scientific societies, participation in volunteer-based programs or events in hospitals and hospices.

Besides the high flexibility, a wide offer of elective elements, involves students as partners in the educational process and trains their responsibility and flexibility required in a workplace of biomedical engineer.

The 2-nd degree program (proposed also for 150 students yearly) requires the students to select one of five offered parallel tracks. Four of them are taught in Polish and oriented towards main branches of biomedical engineering:

- medical electronics and information technologies,
- biomaterials,
- biomechanics and robotics,
- bionanotechnologies.

Fortunately, in the formulae of multidisciplinary school benefiting from human resources and infrastructure of five faculties the support for these tracks is sufficient for complying with high requirements of teaching quality.

The fifth track, named *emerging technologies in health care* and taught entirely in English is prepared for the 2011 offer. It aims at prospective international PhD students or workers of global-range medical companies.

The tracks are oriented to the particular needs from the prospective employers, however a common root consisting of 6 mandatory lectures helps to maintain the general BME education within the range required by Ministry standard. The 2-nd degree tracks are composed of:

- mandatory lectures, common for all tracks - 30%,
- mandatory track-oriented highly specialized lectures - 40%,
- elective lectures - 30%.

The offer of elective lectures is track-independent, allowing several intra-track combinations increasing the program adaptability. Additionally, the individual study tracks and schedules and personalized activities enrich the offer for the master studies. The total amount of lectures proposed in 1-st and 2-nd degrees of BME studies in AGH University of Science and Technology is currently 116.

The 3-rd degree (doctoral) program, despite of the single track, is highly individualized and proposed yearly for 10 people only. All the lectures are given in English, and the curriculum proposes elective lectures as well. However the main stress in this degree is put on the individual research made under the supervision of a professor, publication and industrialization of results. Although not formally required, the research is usually performed in close cooperation with other scientific and medical institutions in Poland and abroad.

D. Education control mechanisms

No adaptation can be responsively made without the unbiased measure and evaluation of results. This rule well-known from the control theory is fully applicable in teaching-learning process. In this aspects students, teachers and employers are all involved as partners in scoring and evaluating of the education. Measurements are performed in both qualitative and quantitative ways including:

- standardized student poll concerning the university staff,
- student polls concerning the teaching process and conditions,
- student scores on final exams analyzed for specific lectures,
- employer score on student performances (planned),
- summer stage supervisors opinions,
- opinions from diploma project supervisors and reviewers.

All the gathered information completed by remarks from staff and students international mobility programs are thoroughly analyzed by the Board of MSIB. Consequently, ordering a course from a particular faculty is an independent decision of the Board, usually based on the teaching quality.

The educational aspects are also discussed on the national level, the MSIB is organizing a biannual National Conference on Biomedical Engineering Education (OKIBEdu), being a meeting of students, professors and employers throughout the country [7].

III. RESULTS OF PROPOSED TEACHING APPROACH

The adaptivity of the proposed educational tracks allows for huge number of possible combination of lectures, limited only by availability, law and industry requirements. The practice shows, that more advanced are the students, their selections is more justified. The selection background is still various, but random choice is avoided. Some impatient students claim that in first semesters they have to learn a very broad range of fundamental sciences, despite of their precisely-defined interests in biomedical engineering. Such position is rather typical for beginners and changes

with the time and with successive recognition of the employers preferences.

The track of biomedical engineering has a reputation of one of harder in our University and therefore attracts mainly good candidates. For 150 candidates accepted in 2009, the average high school finals was 92,2% (minimum 85,5%). Nevertheless, although the total capacity of our offer was fairly high, we were far from satisfying 1005 candidates interested in studying (6,7 persons per one place).

Recently, first 81 graduates of 1-st degree studies received their Engineer Diploma. Although they are almost all candidates for the 2-nd degree (Master), first evaluation of the proposed approach can be reliably made.

IV. CONCLUSIONS

The education program for the biomedical engineering faculty has a long tradition in the AGH-UST, its elements are taught since nearly 40 years. Let us remind two first textbooks [8, 9] dedicated for learning of particular elements of biomedical engineering knowledge, printed by AGH-UST publishing house in 1978. However, until the year 2006 the faculty has not been established by the regulations, and the particular biomedical engineering lectures were given as elements of other engineering faculties (electrical engineering, material sciences, etc.). The proposed program resulted from the analysis of strengths and weaknesses of that approach. We stressed on the necessary background of all sciences developed from the beginning of the study and giving a motivation for future work. The flexibility is a principal factor to guarantee high employment ratio for the graduates. We are looking forward to strengthen our cooperation with the industry and to involve the employers' representatives in defining the future needs.

Permanent elements of BME teaching process enhancement are every year performed students anonymous surveys, with questions about teaching quality, personal relations between students and teachers, curricula contents and mutual relations between particular lectures, labs and seminars. Very important role in this didactic optimization efforts plays mentioned above biannual National Conference on Biomedical Engineering Education (OKIBEdu). During such meeting of students, professors and employers we can exchange opinion and take into account points of view both students and teachers, researchers and entrepreneurs, scientists and practicing doctors and engineers. Especially fruitful are mentioned discussions when are not closed to the problem one particular university (e.g. MSIB), but can be developed throughout the whole country.

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