New Study Program in Bioengineering and Medical Informatics at University of Defense from Belgrade

Spasic-Jokic V. M.[1,2], Vasilijic S.R..[1], Ninkovic M.B. [1], Vucevic D.B. [1] and Ilic T.V.[1]

[1]Medical Faculty Military Medical Academy,
University of Defence,
Belgrade, Serbia
[2]Faculty of Technical Sciences,
University of Novi Sad,
Novi Sad, Serbia

Abstract— **The paper presents new study program in bioengineering and medical informatics developed at Medical Faculty Military Medical Academy, University of Defense in Belgrade, Serbia, in the frame of BioEMIS TEMPUS activities. The courses were aimed to educate well trained specialists in medical physics, medical engineering and medical informatics and to establish new programs in specialist studies incorporated in continuing professional development programs for professional licensing. This electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document.**

Keywords- bioengineering, medical informatics, modular approach, specialist studies, BioEMIS.

I. Introduction

Biomedical engineering uses engineering, mathematics and computational tools to simulate and understand real-world medical engineering problems. Bioengineering is an evolving discipline in engineering that involves collaboration among engineers, physicians, and scientists to provide interdisciplinary insight into medical and biological problems. Modern Health Care Services are provided with ever-increasing demands for competence, specialization and cost effectiveness. [1-3]

EEC Directive 97/43/Euratom (Official Journal of the European Communities No L180, 9.7.1997) recognized special groups of, generally, technical professionals whose training and competence enable the development and use of complex techniques and equipment, optimization, quality assurance, including quality control, and other matters relating to diagnostic and therapy techniques including ionizing and non-ionizing radiation protection of patients, staff and general public. Biomedical engineering Departments generally serve a variety of medical specialities as are radiological field (radiotherapy, nuclear medicine, X-ray diagnostics and radiation protection), magnetic resonance and ultrasound imaging, physiological measurements, clinical applications of non-ionising radiations (lasers, ultraviolet light and microwaves), bioengineering, electronics, information technology, general data processing and computer technology [1-3]. The role of biomedical engineers in these areas is expected to increase in the future.

Generally the total number of staff required in hospital depends upon:(i) the range of applications of technical service to medicine; (ii) the scale of organizational and management responsibilities (number of clinics, population served); (iii) the amount and complexity of equipment and procedures used in related clinical specialities; (iv) the number of patients examined and treated in the relevant modalities and the complexities of these examinations or treatments; (v) the load for formal teaching and training and (vi) the level of participation in maintenance, development, research and clinical trials [4]. Minimum staffing levels should be calculated from factors depending both on equipment load, number of patients treated and sophistication of treatments. General guidelines are based upon WTE (whole time equivalent) for assessment of minimum staffing levels for routine clinical work in various medical disciplines [4].

There is no doubt that a biomedical engineer must be an engineer that possess broad knowledge of fundamental engineering and physical sciences' principles, and must be able to apply a multidisciplinary approach to solve problems dealing with diagnostics, treatment, and prophylactics of the patients and population. To arrive at this capability, a student interested in Biomedical Engineering (BME) must be offered a study program that provides specific education and training in biomedical engineering. Problems that biomedical engineers are expected to solve today vary tremendously and this diversification can only be expected to increase further with new and rapidly emerging technologies and demands of the health sector. For this reason any BME study program must provide a sound BME foundation together with specialisation elements within a narrow field of BME, which address the current and future needs of the Society [5-6].

The main objective of our work in the frame of TEMPUS project titled Studies in Bioengineering and Medical Informatics (BioEMIS), was to propose an updated specialization study curriculum in the field of biomedical engineering, in order to meet recent and future developments in the area and address new and emerging interdisciplinary domains that appear as a result of the R&D progress and respond to the demands of the BME job market. Adoption of the core program structure will facilitate harmonization of studies as well as student and staff exchange in Europe.

II. Specialistic Program at University of Defense

A. General

The programs offered at Military Medical Academy (MMA) will emphasize the confluence of basic engineering science and applied engineering with the physical and biological sciences, with emphasis in the areas of biomechanics, cell and tissue engineering, therapy and biomedical imaging. This joining of the diverse scientific fields is complemented by strong academic and research collaboration with various MMA departments.

The specialization programs in biomedical engineering prepare students to apply the principles of engineering and applied science to problems in biology and medicine, to understand the dynamics of living systems, and to develop biomedical systems and devices. Modern engineering encompasses sophisticated approaches to measurement, acquisition, storage and analysis of data, model simulations, and materials and systems identification. These techniques are used in the study of individual cells, tissues, organs, and entire organisms. The increasing value of mathematical models in the analysis of living systems is an important sign of the success of contemporary biomedical engineering activity [3,7].

After achieving the learning outcomes the students should use the acquired knowledge in further education including lifelong learning. Students should be able to communicate effectively in both oral and written form, to participate in social debates pertaining to technology, to carry out independent and multidisciplinary team work, to perform project management duties, and to understand the societal impact of engineering solutions. Students will be able to identify and formulate challenges in the biomedical and health science domains which belong to the biomedical engineers. Students should learn to work as members of multidisciplinary teams and to apply advanced methodologies at the interface between engineering and medical sciences [3, 7-9].

Students will be able to apply engineering expertise to the design of devices, systems, algorithms, software, models, materials, methods or processes in order to meet the desired functional and regulatory requirements for the commercialization of medical devices. They also should be able to design and carry out a research plan to test hypotheses, to analyze and interpret the results in the context of the research, and to report the results according to scientific principles [3,7-9].

B. The Structure of the Specialization Program

The main structure of the study program consists of 5 mandatory courses (core courses) which are evaluated with total 30 ECTS and certain number of elective courses (30 ECTS in total). Specialization work brings 10 ECTS. Core subjects consist of four courses and one research project related to the selected topics. Students are required to choose at least 10 ECTS electives from the selected specialization. Study program and ECTS distribution are given in Table 1 [7,10-11].

TABLE I. DISTRIBUTION OF ECTS

No.	***Course***	***ECTS***	***Structure***	***Note***
1.	Physics and regulatory mechanisms of the human body	5	3+1+1	Mandatory
2.	Introduction to telemedicine	5	2+3	Mandatory
3.	Ionizing and non-ionizing radiation and protection	5	3+1+1	Mandatory
4.	Ethics in biomedical engineering	5	2+2	Mandatory
5.	Research Project related to the selected module	10	8	Mandatory
6.	Processing of Physiological Signals	6	2+3	Elective
7.	Computer Networking	5	2+2	Elective
8.	Medical Imaging Methods in Radiology	5	1+2	Elective
9.	Visualization techniques in nuclear medicine	5	1+2	Elective
10.	Laser application in therapy	6	3+3	Elective
11.	Methods of Radiotherapy	6	2+2	Elective
12.	Non-invasive brain stimulation	4	1+1	Elective
13.	Biomaterials and biocompatibility	5	2+2	Elective
14.	Stem cells in therapy	5	1+1	Elective
15.	Cell biology and immunology for engineers	5	2+2	Elective
16.	Techniques in Molecular Biology and Applications to Gene Expression	6	2+2	Elective

C. Modular Approach

We recognized four study specialization directions as the defining components for the BME specialization program. We have not strictly and officially divided them. In any case, it is possible to identify the four directions: Medical informatics; Bioimaging; Biomedical Engineering in Therapy and Cell and Tissue Bioengineering [11-14].

III. Discusion

The development of a biomedical engineering practioner working in health care or in industry, and the maintenance of effective performance depends on three components- Education, Training and Continuing Professional Development.

A. Education

The results of the review of the existing Biomedical Engineering educational programs in Europe have shown that the number and proportion of undergraduate and postgraduate BME programs is increasing. Biomedical Engineering programs experienced a rapid growth after the year 2005 and especially during the last five years. The study identified that Biomedical Engineering programs are available in almost all European countries. Approximately 200 Universities across Europe offer in total more than 300 BME programs, even around 50 % at the level of MSc and specialization study. This results in an increased number of Biomedical Engineers available on the market today. It can be expected that this trend will continue as a response to an increasing demand of health sector and relevant industry demand for BME specialists. This increased demand and rapid emergence of new technologies in biomedical instrumentation both require an interdisciplinary approach to problem solving [2-3,5-6,8].

The results of the survey were then used as the basis for discussions and to facilitate the definition of the core curriculum for BME programs. The contents of a curriculum are usually described by the titles of the courses included in the curriculum. However, the actual contents of courses with the same title can be quite different among the programs. Moreover, the same contents may be covered by different courses in different programs [2-3,5-6,8].

To avoid such ambiguity, it was decided that a more appropriate way to define the curriculum is in term of modules with well defined contents and with no overlap in contents between the modules. For example, the contents of one model can be covered by more than two courses. On the other hand, the contents from different modules can be combined within the same selected topic. The use of modules instead of fix program provides for a higher degree of flexibility in designing new BME specialization study programs.

B. Training

Education is primarily related to the acquisition and integration of knowledge leading to understanding. The outcome is generally evaluated by examination and thesis. Training on the other hand is related to the utilization of understanding leading to competencies. There is strikingly little information on training programmes and how they are delivered and evaluated. It appears, however, that like Biomedical Engineering Education, there is considerable national variation. Engineering scheme is of long standing, organized by IPEM and EFOMP and clearly documented [2-3,5-6,8].

The training should be undertaken in hospital based training centre accredited by country authorities. Training should be divided into Part I, which is basic training and Part II, which shows increasing professional responsibility. Part I training often include the acquisition of a specialization degree and lasts for 1 year. Assessment of the non-academic component of the training is carried out in three ways; by continuous assessment during training, by examination of a portfolio of evidence of training, and by viva voce examination. Part II training normally should lasts for a minimum of 1 year and its competence implies the ability, in most instances, to perform without supervision, to make independent professional calculations and judgments, to supervise junior staff and to provide a service in a specified area of work [2-3,5-6,8].

C. Continuing Professional Development (CPD)

It is the responsibility of professionals to maintain and enhance their levels of knowledge, skills and professional competence throughout their working life. CPD is essentially structured and planned method of doing so. Many professional organizations require those registered with, or accredited by, the organization to show evidence of CPD. This also applies to Biomedical Engineering. The essential features of a CPD scheme should cover: definition of what is considered acceptable CPD activity; CPD registration; CPD record and CPD outcomes of individual activities [1,5,8,15].

IV. Conclusion

Within Europe there is considerable variation in the education and training of Biomedical Engineers at the specialization level. This Report advances a harmonized syllabus and structure for education, supplemented by a notional time-table, showing how the syllabus could be implemented.

Training has not been considered within the framework of the project, but there is even more variability than in education. There is a need to evaluate the national practices to identify best practice and develop a harmonized structure for the training of Biomedical Engineers

Acknowledgment

This study is supported by the grant (BioEMIS, 530423-TEMPUS-1-2012-1-UK-TEMPUS-JPCR) of the European Commission Education, Audiovisual and Culture Executive Agency.

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