Tempus

Curricula review for Bioengineering and Medical Informatics degree programmes in the West Balkans

Executive Summary

BioEMIS is a European Commission Tempus project to develop new study programmes in Bioengineering and Medical Informatics at universities in the West Balkans. This report summarises the work undertaken in work package 2.1 to review the curricula for the Bioengineering and Medical Informatics degree programmes in the West Balkans.

Acknowledgments

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1. Introduction

BioEMIS is a European Commission Tempus project to develop new study programmes in Bioengineering and Medical Informatics (BE&MI) at universities in the West Balkans (WB). This report summarises the work undertaken in work package 2.1 to review the curricula for the Bioengineering and Medical Informatics degree programmes at universities in the WB, namely in Bosnia and Herzegovina, Montenegro and Serbia

2. Bosnia and Herzegovina

2.1 Introduction

The University of Banja Luka and the University of East Sarajevo are developing a joint PhD programme in Bioengineering and Medical Informatics. The University of Bihac is developing an MSc in Bioengineering, while the University of Mostar is developing an MSc in Medical Informatics.

2.2 Doctoral (PhD) Studies in Bioengineering and Medical Informatics

The doctoral (PhD) study program has duration of 6 semesters (3 years) with 180 ECTS totally. In two semesters of the first year there are 8 study courses, 4 study courses in each of the semester. In other semesters (next two years) students work on scientific research, publication, PhD thesis preparation and writing. Candidates with master (MSc) level in engineering (electrical engineering and mechanical engineering) and in medicine (all fields of medicine and health care) can be students and can enroll this PhD study program.

In the program there is one obligatory (mandatory, compulsory) study course (study subject) for all students in the first semester. It is the course Organization and methodology of scientific research. In the first semester there is also one more separate compulsory course for students from engineering fields and for students from medicine fields. All other study courses are elective. All elective courses are to be chosen upon obligatory consultations and approval of future (prospective) mentor or adviser (supervisor, major professor).

2.3 Structure of the study program

	Course	**Semester**	**ECTS**	**Teaching hours per week**
I semester				
1	Organization and methodology of scientific research	I	6	3+2
2	Compulsory course	I	6	3+2

3	Elective course	I	6	3+2
4	Elective course	I	6	3+2
5	Research and publication	I	6	5
I semester total			**30**	**25**
II semester				
6	Elective course	II	6	3+2
7	Elective course	II	6	3+2
8	Elective course	II	6	3+2
9	Elective course	II	6	3+2
10	Research, publication and work on PhD thesis preparation	II	6	5
II semester total			**30**	**25**
III semester				
Research, publication and PhD thesis proposal preparation				
11	Preparation and publication of paper from research field	III	10	8
12	Project of PhD thesis proposal (application and defense of the project)	III	20	17
III semester total			**30**	**25**
IV semester				
Research, publication and work on PhD thesis				
13	Preparation and publication of paper from PhD thesis field	IV	10	8
14	Work on PhD thesis	IV	20	17
IV semester total			**30**	**25**
V semester				
Research, publication and work				

on PhD thesis				
15	Preparation and publication of paper from PhD thesis field	V	10	8
16	Work on PhD thesis	V	20	17
V semester total			**30**	**25**
VI semester				
	Research, publication, work on PhD thesis and work for PhD thesis public defense			
17	Work on PhD thesis (preparation of draft version of PhD thesis)	VI	25	21
18	Public defense of PhD thesis	VI	5	4
VI semester total			**30**	**25**
Total			**180**	

Compulsory course for students from engineering fields:

- Fundamentals of Human Anatomy and Physiology.

Compulsory course for students from medicine fields:

- Biomedical Engineering.

Elective courses:

- Biomedical Engineering;
- Biomedical Electronics;
- Medical Devices and Sensors;
- Biomedical Instrumentation;
- Biomaterials;
- Embedded Systems in Medicine and Health Care;
- Biomedical Signal and Image Processing;
- Nanosystems and Nanotechnologies in Medicine;

- Bioelectromagnetics;
- Multimedia Systems in Medicine and Health Care;
- Health Services Management and Policy;
- Health and Medical Information Systems;
- Medical Data Bases;
- Biomechanics;
- Robotic Systems in Medicine;
- Computer Aided Medical Procedures;
- Computer Assisted Surgery;
- Biomedical Data Analysis and Processing;
- Computer Graphics in Medicine;
- Artificial Intelligence in Medicine;
- Computer Aided Diagnosis;
- Biomedical Diagnostic Methods and Devices;
- Therapeutic Medical Methods and Devices;
- Rehabilitation Engineering;
- Telemedicine;
- Methods of Radiotherapy.

Results of the research, publication and work on PhD thesis preparation in the first two semesters have to be evaluated, confirmed and signed by the mentor or adviser (supervisor, major professor).

During the third semester student should to publish one paper from research field in national or international journal or present the paper at international conference (10ECTS). Project of PhD thesis proposal (application and defense of the project) should be defended at Commission for evaluation of PhD theme and candidate (20ECTS).

During the fourth semester student should to publish one paper from PhD thesis field in journal from SCI list or present the paper at international conference (10ECTS). The work on PhD thesis should be defended at end of semester at Commission for doctoral (PhD) studies (20ECTS).

During the fifth semester student should to publish one paper from PhD thesis field in journal from SCI list or present the paper at international conference (10ECTS). The work on PhD thesis should be defended at end of semester at Commission for doctoral (PhD) studies (20ECTS). Before preparation of PhD thesis draft version student should to have minimum

one paper accepted for journal from SCI list. During the sixth student works on PhD thesis (preparation of draft version) (25ECTS) and defense of PhD dissertation (5ECTS).

2.4 Distribution of total ECTS:

- Study courses	48	Obligatory	12
		Elective	36
- Study research work	12		
- Published papers	30		
- Project of PhD thesis proposal (application and defense of the project)	20		
- Work on PhD thesis (preparation of draft version of PhD thesis)	65		
- Public defense of PhD thesis	5		
TOTAL	**180**		

3. Montenegro

3.1 Programme of Applied Spec and MSc modules in BE and MI in Montenegro

Having in mind the above elaborated facts as well as the health care, geographical and economical features of Montenegro, for further decade, will be enough to develop and introduce following education modules in BE and MI:

- Applied Specialization module in BE and MI;
- Applied MSc module in BE and MI.

BE module will be mostly oriented to the fields of medical instrumentation, imaging and rehabilitation management. MI module will be oriented to the E-health with emphasis on patient health recording and management and telemedicine.

It is a proposal to suite Programme in the City of Berane, North Montenegro where exist two 3 years school from related fields, graduated Nursing College and School of Applied Computer Technologies, both of state University of Montenegro. The postgraduate academic titles (Academic MSC and Academic PhD) in BE and MI the students from Montenegro can gain from Partner Programmes in Serbia and Bosnia and Herzegovina, also developed through the BioEMIS.

3.2 Structure of BioEMIS Programme in Montenegro

Draft Programme for Spec and MSc in BE and MI in Montenegro is summarized in Figure 3.1. The names and ECT loads of courses are given by each of 4 semesters.

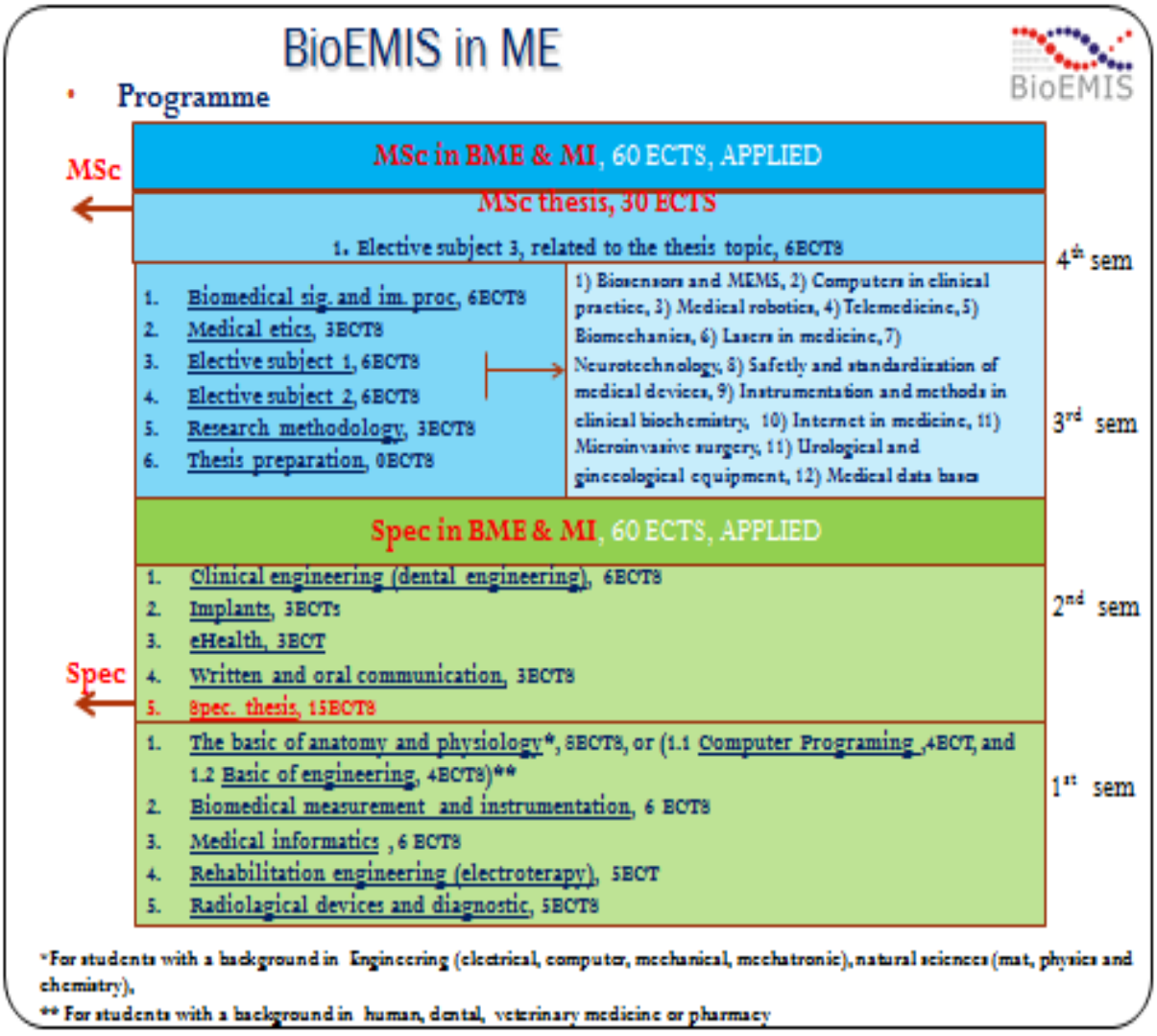

Figure 3.1 Structure of BioEMIS Programme in Montenegro

4. Serbia

4.1 The structure of developed specialization study program

The main structure of the study program consists of 5 mandatory courses (core courses) which are evaluated with total 25 ECTS and certain number of elective courses (20 ECTS in total). Specialization work brings 15 ECTS. Core subjects consist of four courses and one research project related to the selected area of interest. Students are required to choose at least 10 ECTS electives from the selected area. Study program and ECTS distribution are given in Table 4.1.

Table 4.1 Biomedical Engineering study programs and distribution of ECTS

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

All courses were recommended according to basic matrix of courses from selected universities.

4.2 Czech Technical University Prague, Czech Republic: Faculty of Biomedical Engineering (CTU)

Our educational programs and research goals are very similar to CTU programs and orientations in the biomedical and clinical engineering. The main hospital, Military Medical

Academy, which performs all programs in the frame of Medical Faculty has great experience in medical instrumentation, imaging and therapy techniques as well as in medical informatics. According to these, our specialization study aims are to focus the student profile in medical instrumentation used in imaging and therapy methods in medicine. We recognized the importance of understanding and application of basic knowledge in biology, anatomy and physiology in particular and included it in our program following good experiences of CTU. Creating our own specialization program we used topics from CTU courses given below:

- Anatomy and Physiology;
- Project Proposal and Management;
- Ethics in Biomedical Engineering;
- Imaging Systems;
- Medical Devices & Equipment;
- Biomechanics and Biomaterials;
- Biological Signals;
- Laser Applications in Biomedicine;
- Image Processing and Analysis;
- Nuclear Medicine Imaging Systems;
- Ultrasound and Doppler Imaging Systems;
- Ionizing Radiation Imaging;
- Television, Thermovision and Endoscopic;
- Imaging Systems;
- Magnetic Resonance Imaging and Impedance;
- Tomography;
- Microscopy in Medicine.

4.3 Tampere University of Technology, Finland (TUT)

At the beginning of our program we expect relatively small number of students but with great variety of profiles. Tampere University program organized into modules is suitable for our program scheme as it can be customized to suit the needs of individual students. We accepted the scheme with two basic modules: the major module is compulsory for all students and the minor module can be selected freely to complement the major. We selected some of the courses and normalized proposed program at 60 ETCS, appropriate for specialization study program. List of Courses used in our specialization study program creation is given below:

- Tissue engineering;
- Medical imaging methods;
- Medical Image Analysis;

- Digital Image Processing;
- Introduction to Signal Processing;
- Introduction to Pattern Recognition;
- Introduction to Medical Image Processing;
- Human Anatomy and Physiology;
- Biomedical Engineering: Signals and Systems;
- Physical Phenomena of Human Body and their Measurements;
- Biomedical Engineering: Biomaterials;
- Physics and Engineering in Medical Therapy;
- e-Health;
- Processing of Physiological Signals;
- Analysis of Bioelectric Phenomena;
- Modeling of Physiological Signals;
- Methods in radiotherapy;
- Introduction to Medical Biomaterials;
- Tissue engineering;
- Radiation physics;
- Research Project in Biomedical Engineering.

4.4 University of Ljubljana, Slovenia: Faculty of Electrical Engineering of University of Ljubljana (ULS)

At most universities, the BME programs originated from one of the traditional engineering disciplines, such as electrical, mechanical, or chemical engineering. Similarly to ULS our BME program is derived from the interaction between electrical engineering and medicine tend to specialize in biomedical instrumentation, medical electronics, medical imaging and biomedical signal and image processing. Group of courses relevant for our program creation are listed below:

- Engineering and physical sciences focused on BME applications;
- Biological and biomedical science focused on BME applications;
- Ethics (general, medical, research);
- Management & quality assurance;
- Biomaterials;
- Biomechanics;
- Biomedical instrumentation and sensors;
- Biomedical signal processing;
- Health technology design, assessment and management;
- Information and communication technologies in medicine and health care;

- Medical imaging and image processing;
- Research project.

4.5 University of Birmingham, Birmingham, UK (UB)

UB offers programs originating from mechanical engineering often specialize in biomechanics, biotransport and instrumentation. Programs developed at UB aims to understand the physical properties of natural and synthetic materials and to use this understanding to design and develop medical devices. These programs were extremely useful in creation of our own bringing the mechanical dimension to our approach. Group of courses relevant for our program creation are listed below:

- Medicine, Ethics, Society and History;
- Medical imaging and informatics;
- Medical imaging and E-health;
- Micro-engineering and nanotechnology;
- Tissue engineering;
- Chemistry and physical techniques;
- Data modelling and image analysis;
- Bioscience for Engineers;
- Imaging and Image Analysis;
- Computational Tools for Modelling and Analysis;
- Molecular and Cellular Mechanisms of Toxicity and Carcinogenesis;
- Research project.

4.6 Imperial College London, UK (ICL)

ICL Biomedical engineering programs make bridge between different engineering disciplines on one side and medicine and biology on the other side using the engineering approach to help solve problems of medical nature and of health sector in general. Interdisciplinary character is strongly pointed as well as high rate of development and diversification into many highly specialized sub-disciplines. Group of courses relevant for our program creation are listed below:

- Advanced medical imaging;
- Biomechanics;
- Brain machine interface;
- Cellular biomechanics;
- Computational neuroscience;
- Human neuromechanical control and learning;
- Image processing;

- Introduction to biomaterials;
- Machine learning and neural computation;
- Orthopaedic biomechanics;
- Computational methods for bioengineering;
- Research project.

4.7 University of Applied Sciences Gießen-Friedberg (THM)

THM has a long tradition in biomedical engineering and was one of our valuable partners in creation of some previous study programs in biomedical instrumentation. Group of courses relevant for our program creation are listed below:

- Bioinformatics;
- Biotechnology;
- Clinical Engineering;
- Medical Informatics;
- Medical Engineering.

4.8 Pierre-and-Marie-Curie University, Paris, France (UPMC)

A broad palette of course in biomedical engineering developed at UPMC was valuable starting point in creation of our own study program. Medical dimension was particularly important for development of our curricula as the Medical Faculty is our basic program carrier. Group of courses relevant for our program creation cover Medical Engineering specialization in:

- Research and development in medical instrumentation;
- Operational marketing for medical instrumentation;
- Hospital engineering;
- Clinical research associate;
- Medical imaging engineering;
- Robotic systems.

4.9 Technical University Cluj Napoca, Romania: Faculty of Electrical Engineering, Department of Electrotechnics, Medical Engineering Group (TUC)

TUC has a long tradition in biomedical engineering having a few TEMPUS projects dedicated to this topic. Being our old partner in creation of engineering programs we adopted some of their courses focused to electrical engineering more accurate to Medical Electronics. Contribution of different study programs are given in Figure 4.1 and the study program subject structure is given in Figure 4.2.

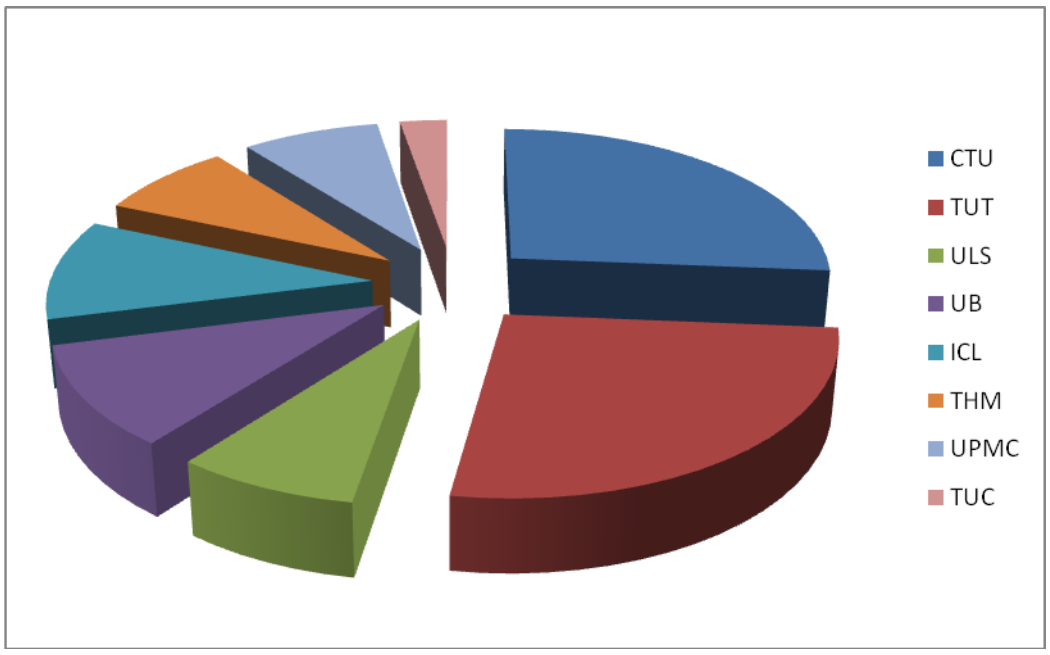

Figure 4.1 Contribution of different study programs.

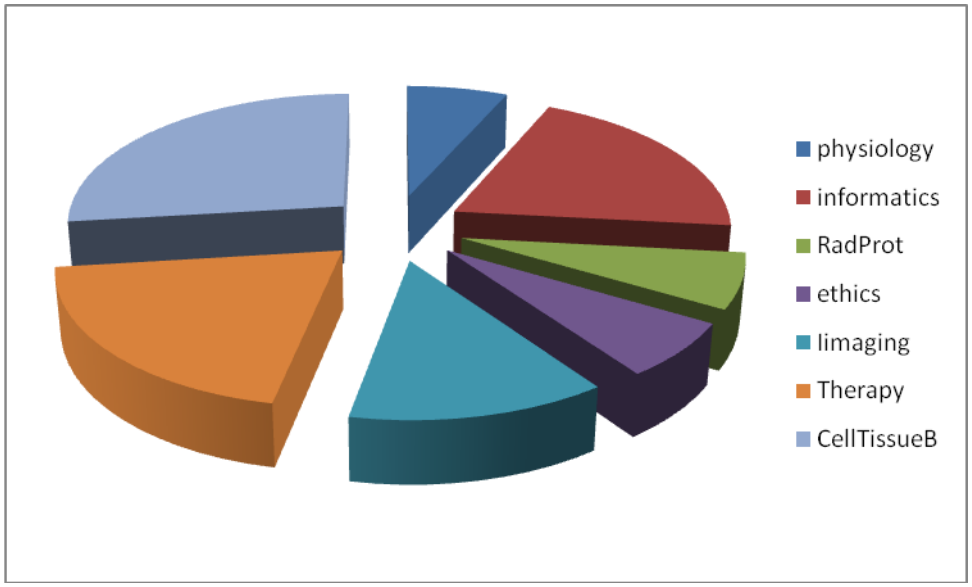

Figure 4.2 Study program subject structure.

The comparative analysis of academic programs that have served as an example and our own, developed as the result of BioEMIS project it is obvious that the two programs were the milestones for our curricula development. These are: study programs in Biomedical Engineering at Tampere University of Technology, Finland and at Czech Technical University, Prague, Czech Republic.