



Tempus

**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 1.2 to analysis the Bioengineering and Medical Informatics degree programmes at universities in the West Balkans.

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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 1.2 to analysis the current 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

In Bosnia and Herzegovina there is no study program in biomedical engineering or medical informatics. Also, an organized society on biomedical/biological engineering has not yet been established. Analysis of study programs and courses in biomedical engineering and medical informatics in Bosnia and Herzegovina included 20 public faculties at 8 universities: 5 faculties of medicine, 4 faculties of health studies, 1 faculty of pharmacy, 6 faculties of mechanical engineering, 2 faculties of electrical engineering, 2 faculties of computer sciences (Table 1).

**Table 1.** Analyzed faculties in Bosnia and Herzegovina

City	University	Faculty	Webpage
Sarajevo	University of Sarajevo	Faculty of Health Studies	<a href="http://www.fzs.unsa.ba">http://www.fzs.unsa.ba</a>
		Faculty of Mechanical Engineering	<a href="http://www.mef.unsa.ba/">http://www.mef.unsa.ba/</a>
		Faculty of Medicine	<a href="http://www.mf.unsa.ba">http://www.mf.unsa.ba</a>
	University of East Sarajevo	Faculty of Electrical Engineering	<a href="http://www.etf.unssa.rs.ba">http://www.etf.unssa.rs.ba</a>
		Faculty of Mechanical Engineering	<a href="http://www.maf1.unssa.rs.ba">http://www.maf1.unssa.rs.ba</a>
		Faculty of Medicine	<a href="http://www.mf-foca.rs.ba">http://www.mf-foca.rs.ba</a>
Banja Luka	University of Banja Luka	Faculty of Electrical Engineering	<a href="http://etf.unibl.org">http://etf.unibl.org</a>
		Faculty of Mechanical Engineering	<a href="http://mf.unibl.org">http://mf.unibl.org</a>
		Faculty of Medicine	<a href="http://med.unibl.org">http://med.unibl.org</a>
Mostar	University of Mostar	Faculty of Health Studies	<a href="http://fzs.sve-mo.ba">http://fzs.sve-mo.ba</a>
		Faculty of Medicine	<a href="http://www.mefmo.ba">http://www.mefmo.ba</a>
		Faculty of Mechanical Engineering and Computing	<a href="http://www.fsr.ba">www.fsr.ba</a>

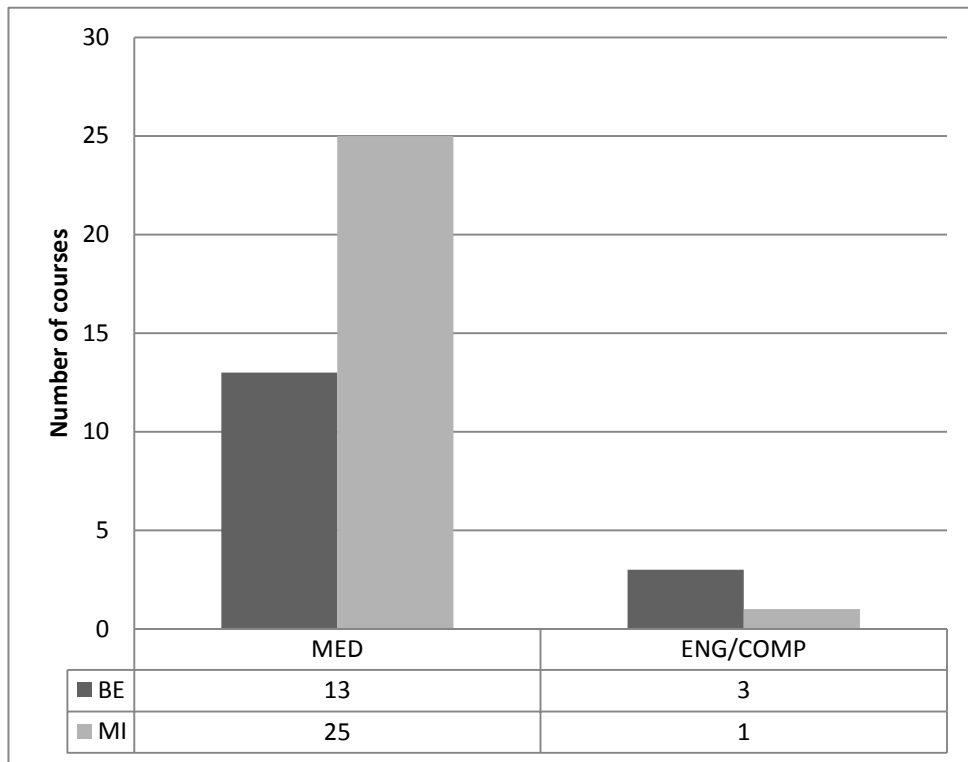
	Džemal Bijedić University	Faculty of Information Technologies	<a href="http://www.fit.ba">http://www.fit.ba</a>
		Faculty of Mechanical Engineering	<a href="http://www.mf.unmo.ba">http://www.mf.unmo.ba</a>
Tuzla	University of Tuzla	Faculty of Pharmacy	<a href="http://www.farmacy.untz.ba">http://www.farmacy.untz.ba</a>
		Faculty of Mechanical Engineering	<a href="http://www.mf.untz.ba">http://www.mf.untz.ba</a>
		Faculty of Medicine	<a href="http://www.medf.untz.ba">http://www.medf.untz.ba</a>
Zenica	University of Zenica	Faculty of Health	<a href="http://www.zf.unze.ba">http://www.zf.unze.ba</a>
Bihać	University of Bihać	College of Nursing Studies	<a href="http://www.vzs.unbi.ba">http://www.vzs.unbi.ba</a>
		Faculty of Technical Engineering	<a href="http://www.tfb.ba">http://www.tfb.ba</a>

## **2.2 Faculties of medicine/health studies/pharmacy.**

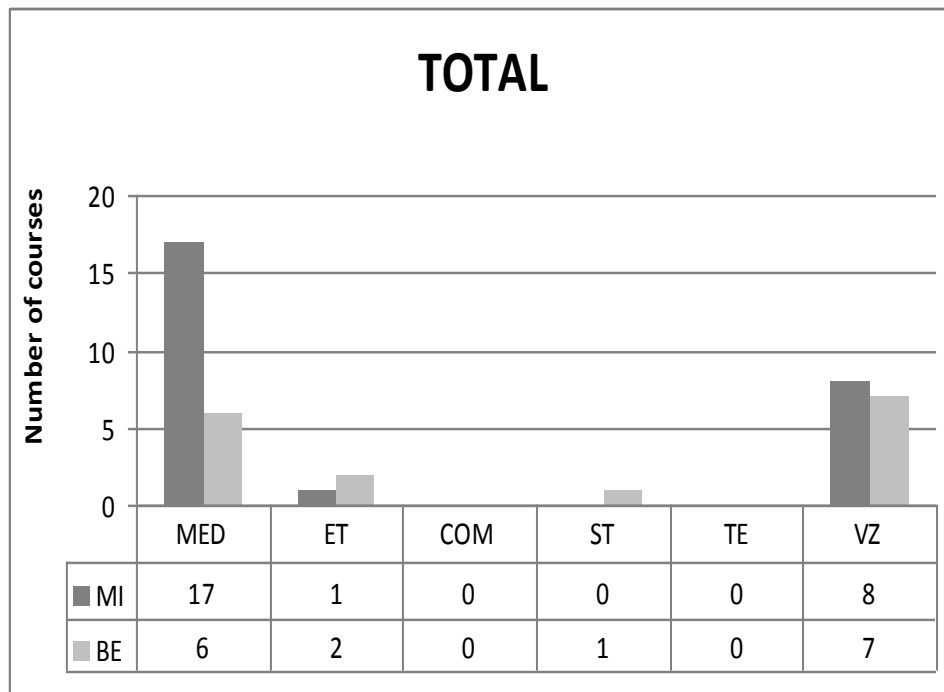
In the analyzed faculties there is no study program in biomedical engineering/medical informatics leading to a university degree. In all of these faculties there are some undergraduate/graduate/postgraduate courses, which are necessary for education in biomedicine. Most of them are mandatory for individual study programs. We classified courses in two groups: biomedical engineering courses and medical informatics courses. Courses in biomedical engineering in these faculties are: biophysics, biomechanics, prosthetics and orthotics, radiology equipment, radiation physics and electronics, new computer technologies, process control, theory of imaging. Courses in medical informatics are: medical informatics, medical statistics, computers in radiology, physical principles of modern medical technology, computed tomography, informatics in radiological diagnostics, informatics in radiotherapy, informatics in radioisotopes technologies, software in pharmaceutical industry, computer processing of laboratory data, radiological informatics, computed radiological methods, digital radiology.

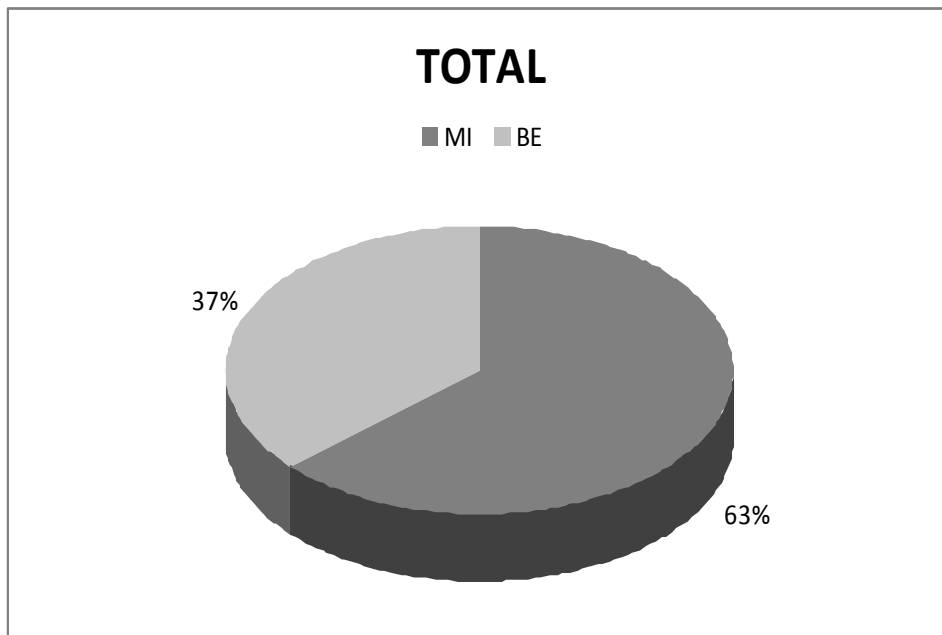
## **2.3 Faculties of mechanical engineering/electrical engineering/computer sciences**

In these faculties there is no study program in biomedical engineering/medical informatics. Courses in biomedical engineering are: biomedical systems, biomechanics. Course in medical informatics is telemedicine and medical informatics. We had no available data for all analyzed faculties in this field. Most courses are in faculties of medicine/health studies/pharmacy, and generally fewer courses are in biomedical engineering (Figure 1).



**Figure 1.** Number of courses in biomedical engineering (BE) and medical informatics (MI) in faculties of medicine/health studies/pharmacy (MED) and faculties of mechanical engineering/electrical engineering/computer sciences (ENG/COMP)

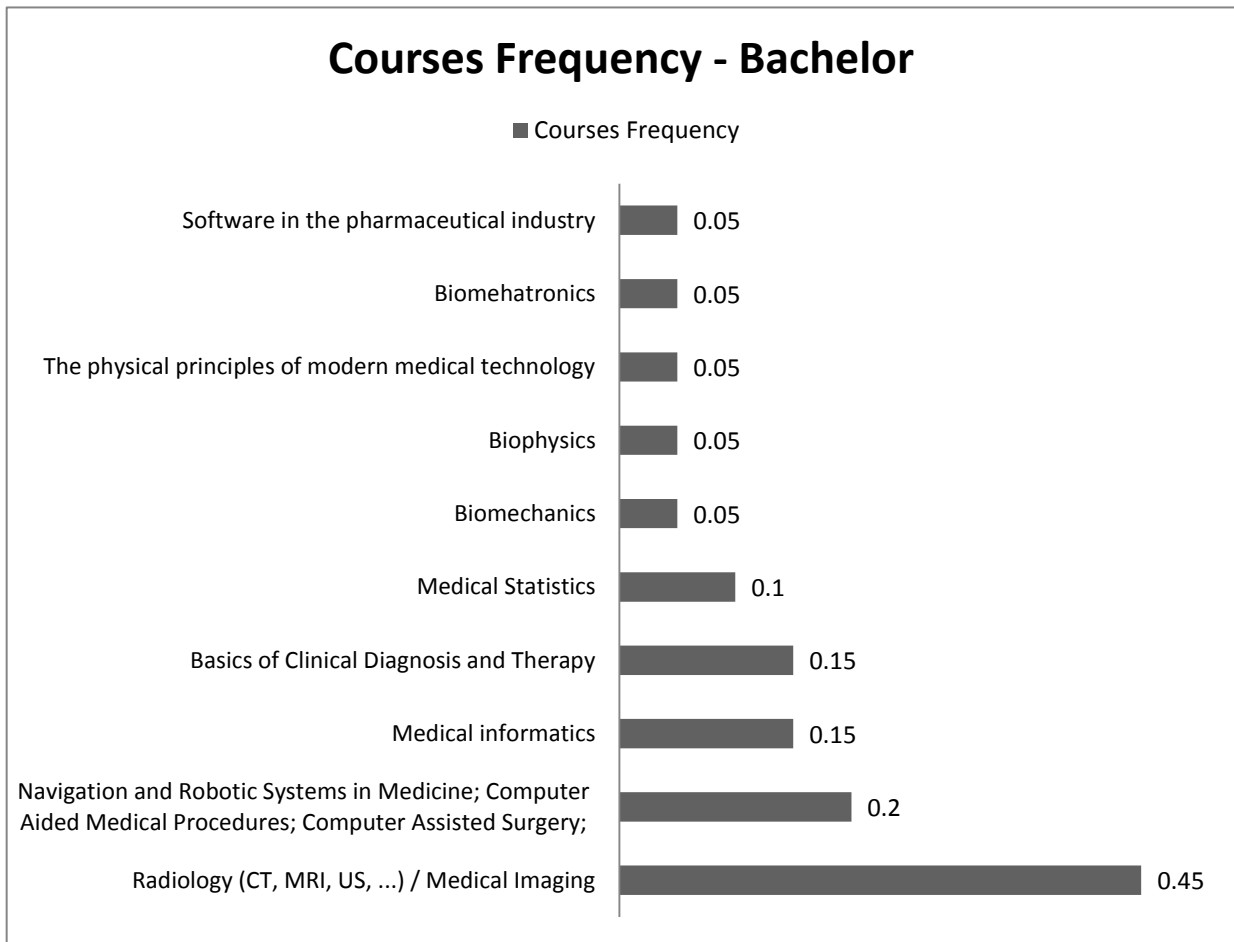




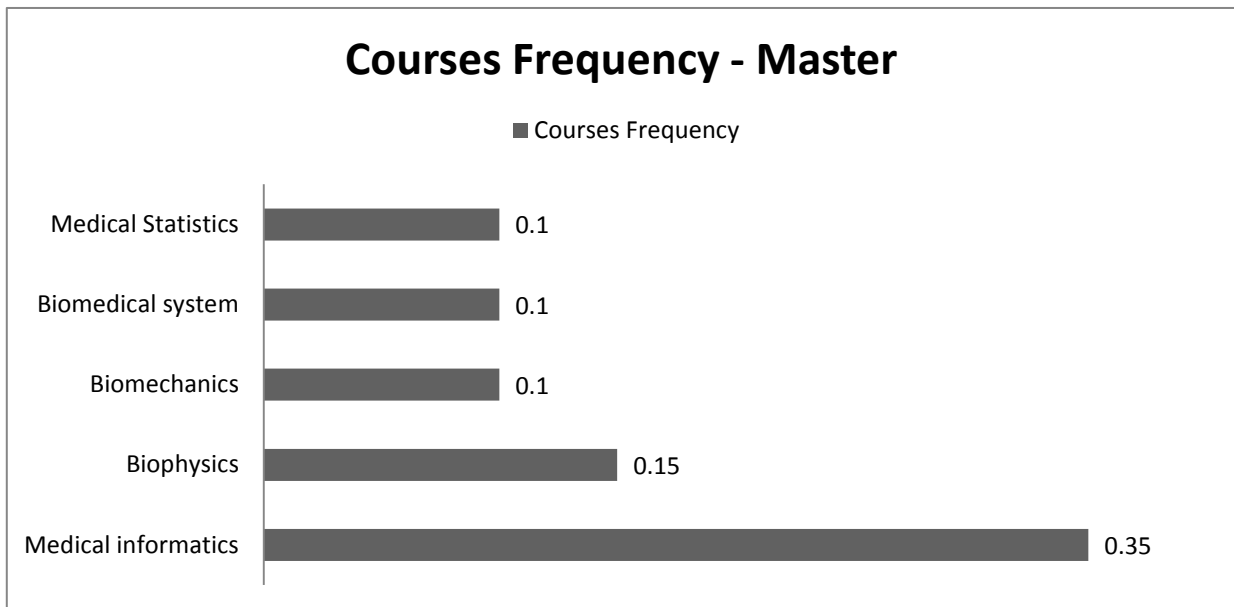
**Figure2.** (A) The number of medical informatics (MI) and biomedical engineering (ME) courses at the analyzed faculties. (B) The total distribution of at all public universities in Bosnia and Herzegovina. MED = Medical school, ET = Faculty of electrotechnics, COM = Computational sciences, ST = Faculty of mechanical engineering. VZ = Faculty of health sciences.

The list and frequency of courses on bachelor and master level is presented in Figure 3. Analysis showed that the most common courses in curriculum at the bachelor level are radiology and medical imaging (Figure 3), while at the master level medical informatics is the most frequent course (Figure 3). Medical statistics and Software in the pharmaceutical industry are the less frequent courses in analyzed curricula.





**Figure 3.** Courses frequency on bachelor level.



**Figure 4.** Courses frequency on master level.

### 3. Montenegro

#### 3.1 State of BE and MI education in Montenegro

Generally seen, the development of Bioengineering (BE) and Medical Informatics (MI) in Montenegro went through the following phases:

- Rehabilitation engineering.
- Medical Robotics and Biomechanical systems.
- Medical Informatics, E-Health and Telemedicine.
- Medical Electronics and Medical Instrumentation.
- Educational modules and courses from fields of BE and MI.

### **3.2 Development of the rehabilitation engineering**

The Institute for Physical Medicine, Rehabilitation and Rheumatology „Dr Simo Milosevic“ JSC Igalo, founded 1949, is considered to be one of the largest and most famous institutions for Multidisciplinary SPA treatment on the Balkans, <http://www.igalospa.com/en/> . It is a pioneer of the modern physical and preventive medicine, rehabilitation, thalassotherapy and wellness, and became one of the leading international centers for rehabilitation of children, adults and seniors. The Institute's Physiotherapy College, now the Faculty of Physiotherapy, was opened in 1976, and turned into the Faculty of Applied Physiotherapy in 2004, which makes the Institute Igalo a member of the University of Montenegro. All activities related to the BE and MI targeted to the rehabilitation engineering are related to this Institute and associated Physiotherapy School (<http://www.fpft.ucg.ac.me/o%20fakultetu/>).

### **3.2 Development of Medical Robotics and Biomechanical systems**

The development of Robotics and Biomechanics in Montenegro dates from 1975 when the Laboratory of Robotics under Faculty of Electrical Engineering ([www.etf.ac.me](http://www.etf.ac.me) ), University of Montenegro was established in close cooperation with University of Belgrade, former famous "Belgrade Robotics School". Additionally to the Medical robotics the research from biomechanics (gait analyses, sensors biomechanics, etc.) were initiated and performed. The laboratory was active till end of 90th, completing several projects and publishing numerous Diploma, MSc and PhD works and scientific papers. Later, to a lesser extent the same disciplines were studied at Mechanical Engineering Department, University of Montenegro with emphasis on bone and spine modeling. Today the Laboratory of Robotics is less active.

### **3.3 Development of MI, E-Health and Telemedicine**

In Montenegro telemedical services have begun to develop from 90th. They were reduced mainly on individualized attempts to transfer the digitized images in pathology between clinical centers in Serbia and Montenegro in the framework of the project " Telemedicine : the first telepathology network in Yugoslavia" , in 1998. In addition, there were activities on digitization and electronic recording images from CT (Computer Tomography) and MRI (Magnetic Resonance) and their transfer to the local environment of the Clinical Centre in

Podgorica using several software tools. Significant achievements in this field are noted in Teleoncology with close cooperation with Institute of Oncology, Sremska Kamenica, Serbia. Also, there were special sessions with topics from telemedicine, organized by regional science conferences that taken a place Montenegro. The main step forward in telemedicine begun by the pilot project “TeleCG- A PILOT TELEMEDICINE NETWORK OF MONTENEGRO”, 2004, implemented by Ministry of Health of Montenegro (<http://www.mzdravlja.gov.me/ministarstvo> ) in cooperation with University of Montenegro ([www.ucg.ac.me](http://www.ucg.ac.me) ). The aim was to link coronary units in the cities of Bar (south) and Berane (north) with Clinical Centre of Podgorica. Later, Ministry of Health of Montenegro continued with activities on development of telemedicine supported by International Virtual e-Hospital Foundation (<http://www.iveh.org/> ) and Balkans Telemedicine Programm were active. Also, the same Ministry organized several seminars with topics from telemedicine.

The Government of Montenegro ([www.gov.me](http://www.gov.me) ) adopted a variety of laws between 2003 and 2008, aimed at developing a more efficient health care system in accordance with international legislation and standards. Among these laws and action plans were the “Strategy for Implementation of ICT in Health Care” (2004), the “Law on Data Collection in the Field of Health Care System” (2008) and the “Health Development Strategy” (2003).

With the beginning of 2004 Montenegro started to implement modern information systems to different parts of its health care systems, starting with public pharmacies (2004), the health insurance funds (2006) and few primary health care institutions (2007). Since 2009 all primary health care centers in Montenegro completed implementation of primary health care information system.

The aims and efforts to implement information systems in all segments of health care fostered the development of several companies dealing with MI in Montenegro, primary writing the software for health care evidence, finance management and process of scheduling patients. Some of them are MG-Soft, Cikom, Digit Montenegro.

### **3.4 Development of Medical Electronics and Medical Instrumentation**

The development of Medical Electronics and Medical Instrumentation devices in Montenegro started by small company EMI Podgorica which custom-designed several instruments for muscle stimulation. At University of Montenegro the development of this disciplines started by establishing a Centre for Applied Electronics within Faculty of Electrical Engineering, 2002, [www.apeg.ac.me](http://www.apeg.ac.me) . From the beginning, the Centre was involved in national and international projects from BE and MI. Some of them are “Research and Implementation of Wireless Sensors for the Acquisition of Critical Biosignals”, Greece-Montenegro , bilateral project, 2006-2008, „New concept in development of Wearable Health Care (WHC)

systems“, national project, 2008-2010, „Development and implementation of embedded systems for medical applications“, 2012.-2015, Apostille FP7 Project. 2011-2014, etc. Activities of Centre resulted in numerous publications, published at international and national journals and conferences. Also, numerous Diploma and MSc thesis were completed. Several prototypes of instruments were designed.

### **3.5 Educational modules and courses from fields of BE and MI**

The above developments and two Tempus projects triggered the development of BE and MI education in Montenegro. The first project was “Structuring and Complementing Continuous Education in Medical Informatics”, TEMPUS CARDS SCM 2005 and the second “Introduction of new study programme in applied electronics”, TEMPUS CD\_40017\_2005, 2005-2008. The first project tried to Establishing Continuing Education Center (CEC) in Podgorica, University of Montenegro and to generate teaching material and infrastructure of continuing education courses in ICT for medical personnel, starting from the results of CD JEP 16072-2001 InCo Health. As a result of the project MI module at University of Montenegro is developed with emphasis to E-government and E-health. It was a kind of academic MSc programme which not yet been put into practice. The second project introduced Spec and MSc studies of Applied Electronics at Faculty of Electrical Engineering, University of Montenegro, and several courses from BE and MI as “Medical Electronics”, “Biomedical instrumentation and measurements” and “Identification systems”. In addition to these courses there are couple of, basically MI oriented, courses in other university units like: “Medical informatics and statistics” at Nursing College, Berane. “Informatics in medicine” at School of Medicine, Podgorica, “Informatics in dental medicine” at Department of Dental Medicine, “Medical informatics” at Department of Dental Medicine, and Doctoral Studies of Medical School, “Biomedical informatics with elements of health statistics” at Faculty of applied physiotherapy. There are some elements of BE and MI at “Specialist studies in radiology” within Medical School of University of Montenegro, but this program is mostly oriented to health/clinical personnel with emphasis on imaging. Many of methodologies and techniques applied in MI are taught by several informatics related programmes organized at state and private universities in Montenegro.

### **3.6 Summary on BE and MI educational modules in Montenegro and conclusions**

The educational modules and courses fully or partially related to the BE and MI in Montenegro are summarized in Table 1.

**Table 3.1.** Educational modules and courses from BE and MI in Montenegro

<b>Module</b>	<b>Host institution</b>	<b>Status</b>	<b>Convenient to the country needs</b>

MSc Module in E-Government and E-Health	University of Montenegro, Faculty of Electrical Engineering	No active	Partially
Spec and MSc in Applied Electronics	University of Montenegro, Faculty of Electrical Engineering	Active	Partially
Specialist studies from radiology	University of Montenegro, Medical School	Active	No
Courses related to BE			
Medical electronics	University of Montenegro, Faculty of Electrical Engineering	Active	YES
Biomedical measurements and instrumentation	University of Montenegro, Faculty of Electrical Engineering	Active	YES
Courses related to MI			
Medical informatics and statistics	Nursing College, Berane	Active	YES
Informatics in medicine	University of Montenegro, Medical School	Active	YES
Informatics in dental medicine	University of Montenegro, Medical School, Dental Medicine Department	Active	YES
Medical informatics	University of Montenegro, Medical School-Doct. studies, Dental Medicine Department	Active	YES
Biomedical informatics with elements of health statistics	Faculty of applied physiotherapy	Active	YES
Identification systems	University of Montenegro, Faculty of Electrical Engineering	Active	Partially

By analyzing “state of the art” in BE and MI education in Montenegro, as well as summary given in Table 1, the following conclusions can be derived:

- There is no convenient active educational program in BE and MI in Montenegro on BSc, MSc, Spec or PhD levels at state university and private universities.

- There are several courses related to the BE and MI at University of Montenegro: 2 from BE at Faculty of University of Montenegro and 5 from MI at 4 Faculties or Departments of University of Montenegro (School of medicine, Department of dental medicine, Faculty of applied physiotherapy and Nursing College).
- At University of Montenegro, Mediterranean University and University UDG there are Faculties of information technologies the course of which should be indirectly related to the MI. Primarily courses from information systems, e-management and data bases.
- No infrastructure for the development of BE and MI, expect one laboratory at Faculty of Electrical Engineering, which only partially satisfied the needs.
- There is a shortage of personnel for the implementation of the teaching in BE and MI in Montenegro.
- The labor market in Montenegro does not recognize BE and MI professions within its qualification framework.

## **4. Serbia**

### **4.1 Introduction**

The essence of the numerous definitions of interdisciplinary studies points out the “combination or involvement of two or more academic disciplines or fields of study” (<http://dictionary.reference.com/browse/interdisciplinary>). In more detailed manner it is “particular branch of learning or body of knowledge such as physics, psychology, or history ..., disciplines that have contrasting substance and syntax, as well as the ways of organizing themselves and of defining rules for making arguments and claims that others will warrant. They have different ways of talking about themselves and about the problems, topics, and issues that constitute their subject matters... Each discipline has its own intellectual history, agreements, and disputes about subject matter and methods and its own community of scholars interested in teaching and learning in that field”. Also, the word *interdisciplinary* itself points to combined fields of study or specialization, which are derived from two or more, i.e. it points to the “between fields of study” (Allen Repko: “Interdisciplinary Research: Process and Theory”, SAGE Publications, Inc, 2008, [http://www.sagepub.com/upm-data/23223\\_Chapter\\_1.pdf](http://www.sagepub.com/upm-data/23223_Chapter_1.pdf))

The actual need for involvement of different fields of knowledge for solving complex scientific and industrial problems, University of Kragujevac (UNIKG, Serbia) recognized more than two decades ago. However, until 2003 the implementations were restricted to a few courses and initiatives scattered over various Faculties (study programs) of the University. Among the first were courses and research initiatives in the broad field of biomedical engineering, followed by a few other fields of natural, technical and management sciences with strong involvement of ICT and emerging technologies. University of Kragujevac ran Center of Interdisciplinary and Multidisciplinary Studies and Research for a several years and organized specialization, master and PhD level study programs. Nowadays the Centre is closed with the motivation of applying different organizational and educational modalities. These have strong foundation in the need to fill a very obvious gap in academic offer and the labor market demands for interdisciplinary skills. In that course, the intention is to enhance the skills and knowledge that students from UNIKG get through their degree studies in a range of interdisciplinary studies, including bioengineering.

#### 4.2 Center of Interdisciplinary and Multidisciplinary Studies and Research

Center of Interdisciplinary and Multidisciplinary Studies and Research (CIMSRI; in Serbian: "Centar za interdisciplinarnu i multidisciplinarnu studiju i istraživanje") of the University of Kragujevac was founded in 2003, and was operational until 2010. Two study programs were organized:

- Biomedical Engineering;
- Management of the Emerging Technologies.

Study program of Biomedical Engineering offered specializations within following streams (axes):

- Bioengineering;
- Biomechanics;
- Computational Biomedicine;
- Sports Engineering.

Table 4.1 illustrates the syllabi of the streams:

**Table 4.1.** Syllabi of the streams for Biomedical Engineering

<b>Biomedical Engineering</b>			
<b>Bioengineering</b>	<b>Biomechanics</b>	<b>Computational Biomedicine</b>	<b>Sports Engineering</b>
<b>Compulsory Courses</b>			
Principles of Biomedical Engineering	Biomechanics	Computer Simulations in Biomedicine	Physiology of Sports and Sports Medicine
Cardiovascular Systems	Experiments and Statistics in Biomechanics	Information Technologies in Biomedicine	Nutrition in Sports
<b>Elective Courses</b>			
Ultrasound in Medicine	Kinesio-mechanics of Spine	MRI	Principles of Biomedical Measurements and Instrumentation
Biomedical Instrumentation	Orthopedics Biomechanics	Image Processing	Cardiovascular Biomechanics
Biochemical Engineering	Biomaterials and Artificial Organs	Biomedical Experiments	Biomechanics of Muscles
Transport Systems	Cardiovascular Biomechanics	Medical Information Systems	Kinesio-mechanics of Spine
MRI	Tissue Biomechanics	Computational Biophysics	Kinematics and Kinetics in Sport
Image Processing	Sports Biomechanics	Clinical Computer Systems	Functional Research of Cardiovascular System
Sports Biomechanics	Ergonomics in Biomedicine	Software Engineering in Biomedicine	Anatomy
Computer Simulations in Biomedicine	Anatomy	Medical Data Bases	Ergonomics in Sport
Bio-micro-electro-mechanical Systems	Dental Biomechanics and Biomaterials	Artificial Intelligence in Biomedicine	Synthesis of Movements
Biomedical Legislative	Biomedical Legislative	Biomedical Legislative	Sports Legislative
Biomedical Economics	Biomedical Economics	Biomedical Economics	Sports Economics

Study program of Management of the Emerging Technologies offered specializations within following streams (axes):

- Engineering Economics;
- Risk Management;
- Agile Production Systems;
- E-Business;
- Integrated Systems of Management;
- Business Process Reengineering;
- Legal Aspects of Management.

Between 2003 and 2010 within study program of Biomedical Engineering two PhD theses were defended and one specialization degree earned. In the same period within the study program of Management of the Emerging Technologies four Master of Science these defended.

#### **4.3 State of the Art**

Nowadays at the University of Kragujevac students can take a number of interdisciplinary courses offered by a variety study programs and specializations. However, these are rarely organized and systemized within devoted study program(s). Interdisciplinary courses, in general, are offered by the following faculties:

- Faculty of Engineering;
- Faculty of Technical Sciences;
- Faculty of Sciences and Mathematics;
- Faculty of Economics;
- Faculty of Medical Sciences.

Significant number of courses assumes intensive involvement of bio-medical and engineering disciplines, where combinations like engineering-medicine, engineering-biology, physics-biology, mathematics-physics, mathematics-biology, engineering-medicine-mathematics and similar appear to be quite common. Moreover, courses that combine ICT disciplines with aforementioned combinations are the most evident.

The scheme depicted in the Figure 1 shows the state of the art in the variety of the interdisciplinary courses, in the broad field of biomedical engineering, offered within different study programs at the University of Kragujevac. The most of those emphasize original area, as the key interdisciplinary counterpart. In addition, mathematics (various disciplines) and ICT are other important constituents of these courses.

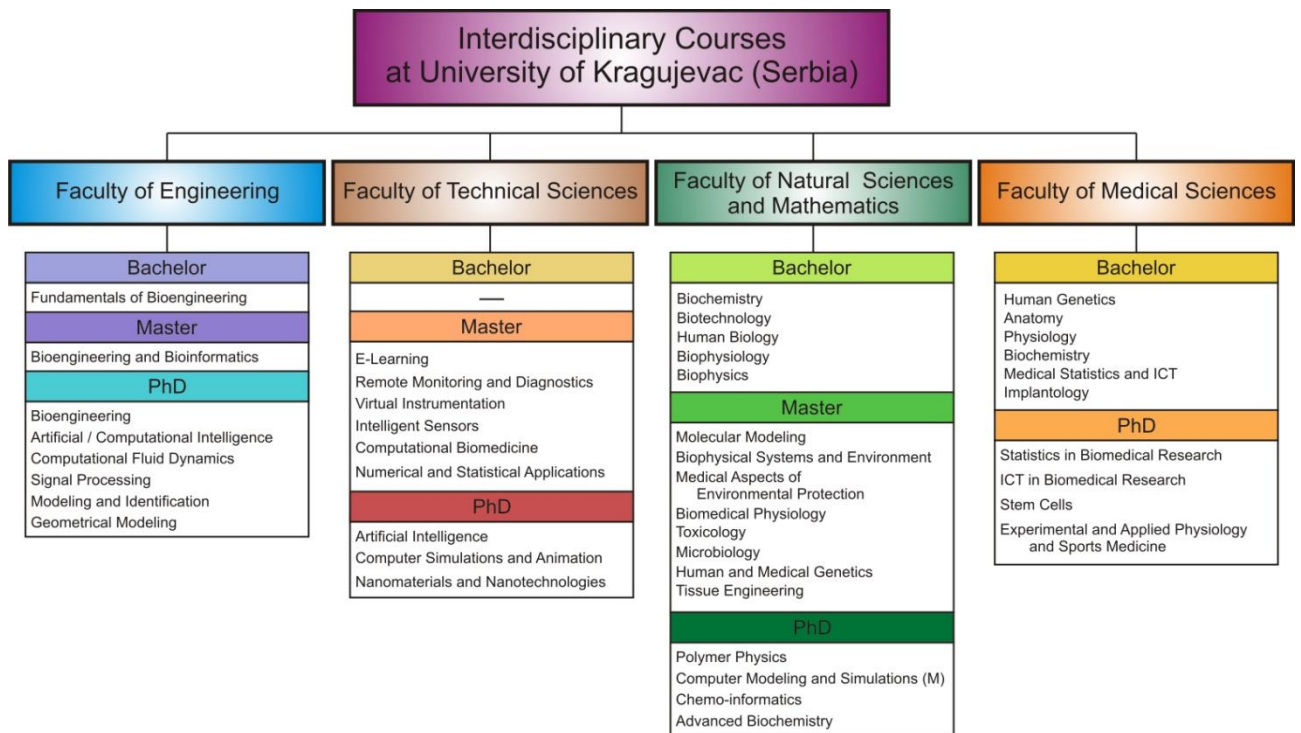
#### **4.4 The Latest Developments**

Recognizing evident trends in educational, scientific, research and market needs some faculties of University of Kragujevac recently introduced and accredited study programs (Figure 4.1) that belong to the Interdisciplinary, Multidisciplinary and Transdisciplinary (IMT) fields according to the standards of Accreditation in Higher Education, issued by Ministry of Education, Science, and Technological Development of Republic Serbia in 2010. Among those are the following:

1. Faculty of Engineering
  - a. Automotive Engineering (bachelor and master levels)
  - b. Urban Engineering (bachelor level)
  - c. Military Industrial Engineering (bachelor and master levels; joint study program with University of Defense, Belgrade, Serbia)
  - d. Engineering Management (master level)
  - e. Business Information Systems (master level)
  - f. **Bioengineering (PhD level; joint study program with University of Defense, Belgrade, Serbia)**



2. Faculty of Technical Sciences
  - a. Mechatronics (bachelor and master levels)
  - b. E-Learning (master level)
  - c. Studies of Technics and Informatics (integrated)
  - d. Teaching Mechanical Engineering (master level; study program for teachers specialization)
  - e. Teaching Electrical and Computer Engineering (master level; study program for teachers specialization)
  - f. ICT
3. Faculty of Sciences and Mathematics
  - a. Ecology
  - b. Teaching Physics and Informatics (master level; study program for teachers specialization)
  - c. **Bioengineering (PhD level; joint study program with University of Defense, Belgrade, Serbia)**
4. Faculty of Medical Sciences
  - a. **Bioengineering (PhD level; joint study program with University of Defense, Belgrade, Serbia)**



**Figure 4.1.** Current bioengineering-oriented courses at the University of Kragujevac