

BIOMEDICAL ENGINEERING EDUCATION IN ROMANIA

Professor Radu V. CIUPA - Technical University of Cluj-Napoca, Romania

Professor Alexandru M. MOREGA - "Politehnica" University of Bucharest, Romania

1. INTRODUCTION

Biomedical engineering is an interdisciplinary domain where all engineering and technological sciences merge into solving the problems that arise in Biology and Medicine. All activity sectors benefit from the recent, fast growing engineering technology:

- modern medical hardware is produced and utilised with technical engineering assistance;
- modern, highly accurate investigation methods through visualisation and measurements demand a specialised, modern instrumentation;
- modern therapy calls for assistance in adapting and individualising the treatment schemes prior to their application, etc.

At a national scale, in hospitals, research services, educational institutions, technical medical schools, or technical assistance and governmental organisms for medical instrumentation regulations and specifications there is *a major need for biomedical engineering specialists*. To respond this demand, consistent educational programs in biomedical engineering are needed.

The biomedical engineering professional education has to rely on the modern engineering curricula, yet to be focused on specific aspects of biomedical engineering. This approach corresponds also to the national goal of integration in the European academic and career-related policies and structures.

An important role is played by the Romanian Society of Medical Engineering and Biological Technology both in the promotion of the biomedical engineering in Romania and in the education and training of the individuals preoccupied by the biomedical engineering and science.

2. THE NATIONAL SOCIETY

The **National Society of Medical Engineering and Biological Technology** was established (in the presence of Professor Helmut Hutten, member of the IFMBE Administrative Council) on June 2nd 2000 when 49 founders were present and was legally recorded on March 30th 2001.

The NSMEBT is an independent scientific organisation, with an interdisciplinary background, aiming at promoting the co-operation, research, application of know-how and dissemination of information related to the utilisation of modern technology in the field of medical, clinical and biological engineering. Some of its objectives and aims are:

- ◆ To participate in the development and promotion of biomedical engineering in Romania,
- ◆ To take part in the co-ordination of activities concerning the professional upgrading of engineers and technicians working in biomedical engineering,
- ◆ To organise national and international conferences,
- ◆ To be involved in improving the curricula for the training and education,
- ◆ To act as consultant while establishing laws, reglementations and standards or norms with reference to the biomedical engineering,
- ◆ To generate and disseminate valuable field-related information to other partners in the technical, medical and biological community.

Our Society has organised an international conference (in June 2000) and a national conference up to the present.

In September 2002 the application form for the affiliation to the IFMBE will be submitted.

Preparations have been made in view of publishing a scientific journal, as an answer to the national level requirements expressed in the domain of biomedical engineering. The first number of the journal will be issued in June 2002.

In October 2003 the National Society will organise the Second International Conference.

The serious commitment of our Society in education is also shown by the fact that the majority of its members is founded of university staff; other members work in research institutes, hospitals, clinics, health care departments, private companies trading medical equipment or offering service for the equipment. However, we are certain that there still is a number of people with significant concern or activity in medical engineering and biological technology whose have not signed up (yet), to become members of our Society.

Another thing to be admitted lies in that besides our Society there are other organisations or societies that are involved in fields, more or less approached to biomedical engineering.

3. BME EDUCATION, TRAINING AND ACCREDITATION

3.1 Education.

The Higher Education structure

The structure of the Romanian Higher Education (HE) system is defined by the *Education Act* (No. 84/1995) that regulates as follows: the organisation of HE institutions, the levels of university education and the types of degree courses, the financing of HE within the framework of university, autonomy, students' rights, and the objectives of university research.

The Ministry of Education and Research and the following councils are responsible for the development of the HE system and for the HE reform in Romania:

- the National Council for Academic Assessment and Accreditation (CNEAA);
- the National Council for the Recognition of Academic Titles, university diplomas and certificates;
- the National Council for HE Funding (CNFIS);
- the National Council for HE Research (CNCSU);
- the National Council for Educational Reform;
- the National Rectors' Council.

The organisational frame has been created in order to guarantee precise co-ordination between the actions and attainments of the above-mentioned councils, the EU programmes (TEMPUS, SOCRATES, LEONARDO, etc.) and the other organisations that assist HE reform.

HE institutions enjoy a high degree of autonomy in their operations, which has led to a wide diversification of the types of institutions, both in public and private sectors.

Higher education institutions and curricula

The number of students enrolled in HE institutions is given below:

- in public institutions (full-time "day" courses) : 300.000 (**450 in BME domain**)
- in private institutions : approximately 150.000.

The initiatives of new curricula launching have been very numerous after 1990, leading to huge diversification. They have been mainly taken to meet the 'lycée' graduates' demand for HE, but the growth of enrolment figures has had neither a direct correspondence in the tendencies of the labour market more has it been intended to increase the external efficiency of HE. Among the difficulties created by this situation, let us note the great difficulties of transfer between the different suggested specialities and the dramatic absence of the logistic instruction base (laboratories, textbooks, libraries, etc.), of the teaching staff, as well as of attractive policies for young staff recruitment in HE and in research.

University HE study programmes are organised at several levels, each level leading to a diploma degree or certificate issued by the specific institution and recognised by the Ministry of Education and Research :

- **Short-cycle (2-3 years):** in university colleges that have the status of Departments within their institutions. College graduates may choose to continue their studies in the framework of long-cycle programmes. The goal of the BME programme is to train students in the arts of

maintaining, repairing and managing medical and clinical equipment, making them highly qualified professionals for the service of their institutions and the society. This type of education operates within more universities in Romania:

1. The Technical University of Cluj-Napoca, the Technical College (Med.Eng.)
2. The “Politehnica” University of Timisoara, the Technical College (Med.Eng.)
3. The University of Oradea (College of Med.Eng.).

Example: TECHNICAL UNIVERSITY OF CLUJ-NAPOCA
Specialisation: Medical Engineering

The length of the courses is 6 semesters, out of which, in the sixth semester, students make field work and practical application in hospitals, clinics, production companies, companies for service, repair, installation of medical equipment and write their graduation paper. Each of the 6 semesters lasts 14 weeks and each ends in a session of exams.

The table below presents a list of subjects with the number of classes allotted per week in the respective year of study:

Course title	Nr. hours/week	Year of study
Mathematics	10	1
Physics	4	1
Computer programming I,II	4+5	1
Physiology	4	1
Electricity in medicine. Biophysics	5	1
Introduction to biomedical engineering	3	1
Biomedical amplifiers	6	2
Sensors and transducers	5	2
Biomechanics	4	2
Electrical, hydraulic and pneumatic systems	4	2
Biomedical measurements	5	3
Data acquisition and teletransmission	5	3
Biosignals processing	6	3
Management	3	3
Prosthesis and rehabilitation	5	3
Radiological devices	4	3

- **Long-cycle (4-6 years):** in universities, institutes and academies, within authorised or accredited faculties and specialities. Graduated receive a “diploma of licence” and may continue in advanced studies according to professional quality requirements established by HE institutions. At present the curricula and syllabi are varied and diverse, although their basic principle consists in having a common-core education in the first and second year (possible, third too); in the majority of cases such courses belong to the electrical engineering field. During the last years of study (the third, fourth and fifth), elective courses are offered in packages (modules) for more specialisation in the domain of medical engineering. This form of education is developed now in 4 universities in Romania:

1. The Technical University of Cluj-Napoca,
2. The “Politehnica” University of Timisoara,
3. The “Politehnica” University of Bucharest,
4. The University of Medicine and Pharmacy of Iasi.

Example: TECHNICAL UNIVERSITY OF CLUJ-NAPOCA
Specialisation: Biomedical Engineering

Individual BME Courses:

Medical Informatics
Bioelectromagnetics
Modelling of Biomedical Systems
Image Processing and Analysis
Medical Electronics
Biomedical Instrumentation
Biomedical Measurements
Expert Systems in Medical Diagnostics

It is necessary to pass all courses mentioned above for obtaining certificate on BME study. Moreover, it is necessary to pass the BME Diploma Thesis.

- **Postgraduate programmes**, including :
 - *Advanced studies* (1-2 years) for university graduates, finalised with a dissertation; the graduates are released a masters degree diploma; the only Romanian University to offer such a course is the “Politehnica” University of Bucharest;
 - *Postgraduate academic studies* (2 years) organised by postgraduate study schools affiliated with universities or functioning as autonomous units; the studies have an interdisciplinary character and aim at widening professional specialisation;
 - *Doctoral studies* (4-6 years) offered by universities and accredited research institutes; normally, only graduates who have already got a Master’s degree are permitted to attend PhD courses. But at present there are no teams, departments or universities to organise PhD courses in BME. PhD candidates are enrolled function of the competence field of the supervisors-university professors. Annually, quite a significant number of dissertations are focused upon biomedical engineering topics.
 - *Continuing education* university courses, targeted at various professional categories. Continuing education is also provided in the form of open and distance education.

BME education in Romania develops both at undergraduate-short-cycle (3 years), graduate-long-cycle (5 years), and postgraduate level (1-2 years). The position of biomedical engineer was not included in the Romanian job list up to March 2001; accordingly, the status of the graduates should improve and a larger number of applicants should be met in the future.

“GR.T.POPA” UNIVERSITY OF MEDICINE AND PHARMACY - IASI
FACULTY OF BIOENGINEERING

- Founded in 1994 at “Gr.T.Popa” University of Medicine and Pharmacy in accordance with the governmental resolution H. G. 568/1995, 360/1997 and having 4 specialities:
 - Bioactive substances and medical biotechnology
 - Biomaterials and prosthetic technology
 - Bioinstruments and medical technique
 - Bioinformatics and health care management

Education

The training program for undergraduate level has been developed, based on an interdisciplinary curriculum. The curriculum has 2 cycles.

Cycle I (terms 1-5) trains the students in fundamental science belonging to the biological, exact, informational and technical domains; the training is completed by the inclusion of a humanities programme:

Basic biological – interdisciplinary sciences: they are included in integrated modules, focusing on Molecular, Cellular and Tissue Biology, in order to prepare the students for the phase during which they study the applications of technical sciences in the field of medicine.

Exact Sciences: Mathematics, Physics, Chemistry.

Informatics: Basic Informatics, Multimedia Informatics and Theory of Systems.

Applied Biotechnical Sciences: Science and Technology of Materials and Biomaterials, Technical Design and Computer Graphics.

Humanities: Modern languages, Philosophical and Functional Anthropology, Physical Education and Kinesiology.

Cycle II (term 6 through 12) introduces the students to clinical science and applied sciences selected according to the requirements of the 4 specialities.

Bachelor Degree

The graduate is awarded the **Bachelor of Medical Bioengineering (BMB)** degree and thus he becomes a **MEDICAL BIOENGINEER** specialised in one of the 4 domains he chose at the beginning of the second study cycle.

Master Degree

Master degree Medical Bioengineering education (one year) has been organised in “Gr.T.Popa” University of Medicine and Pharmacy for following specialities:

- Systems of monitoring and telemedicine
- Progresses in the fields of the bioactive synthesis substances
- The biomechanics of the orthopaedic prosthetic systems
- Health care management

THE ELECTRICAL BIOMEDICAL EDUCATIONAL PROGRAM AT THE DEPARTMENT OF ELECTRICAL ENGINEERING “POLITEHNICA” UNIVERSITY OF BUCHAREST

The Electrical Engineering Department at POLITEHNICA University of Bucharest initiated, in 1994, an optional electrical engineering educational program aimed at specialising the undergraduate students in the final years (fourth and fifth), in the area of:

- electro-physiology (natural and stimulated) phenomena,
- electrical and electronic measurements in the medical diagnosis and therapy,
- electrical drives and equipment used in medicine.

The program was concerned with orienting students' and graduates' interest and knowledge to applied electrical engineering in medicine, that means:

- approaching and understanding electro-physiology phenomena from the engineering perspective,
- using their major specialisation based on classic electromagnetic theory and applications,
- adjusting to the specific medical environment (basic knowledge, concepts and vocabulary, healthcare needs and priorities, specific technologies and instrumentation, etc.).

A major educational CNFIS grant has sustained the efforts of profiling and substantiating what is thought to be a consistent curriculum in electrical biomedical engineering.

The CNFIS project for the biomedical educational program.

The strategic objectives of the proposed project were:

- *Students' professional, career-related orientation*, aimed at explaining the biomedical engineering curriculum, the career-related options, a better information for the selection of their major field of study, the understanding of biomedical electrical engineering as a

discipline, professional goals and possible careers.

- *The re-evaluation of the educational curriculum* focused on the electives for the III – V years of studies, the optional for the I – III years of studies, and on the integration of research in the educational curriculum.
- *The balance between the professional specialisation that is offered and the labour market demand* (both biomedical and classical electrical engineering related positions).

The main components to approaching these objectives were:

- A. *The Educational component* (re-evaluation of the educational program, its focus on biomedical electrical engineering).
- B. *The Research component* (integration of research in the educational curriculum);
- C. *The Infrastructure component* (acquisition of adequate laboratory and computational hardware and software, publications, etc.).
- D. *The Informative component* (labour market trends; technical database; academic exchanges aimed at learning the educational experience of other universities interested in implementing similar programs).

The First Phase of the project (1999) was exploratory. It was aimed at a global modernisation of the present educational curriculum in biomedical engineering with focus on the IIIrd year of studies. It also helped defining the main tracks of action towards an in-depth change of the educational program for all years of study, which is the final objective of the major program.

The Second Phase (2000) was concerned with assisting the IVth year of studies

The Third Phase (2001) that concluded the project has addressed the educational program for the Vth year of studies.

The system of transferable credits – to be finalized in the near future at PUB – will significantly contribute to the individualization of the educational program that is needed in defining a consistent, modern interdisciplinary educational offer.

EDUCATIONAL COOPERATION PROGRAMS

About 20 Romanian students have attended the postgraduate program in BME coordinated by the University of Patras (Greece), along the interval 1995-1999; their attendance is due to the partnership of the Cluj-Napoca, Timisoara and Bucharest Technical Universities with the University of Patras.

Three Tempus projects, financed by the EU were dedicated to the improving of education in the BME field.

EXAMPLE - TEMPUS PROJECT AC-JEP 13449-98: Short-Cycle Multidisciplinary Practically Oriented Studies In The Health Care Domain (SMART)

COORDINATOR: Technical University of Cluj-Napoca, Romania

EU PARTNERS:

1. UNIVERSITÉ PARIS XII Val de Marne, Faculty of Sciences and Technology, CRETEIL France, Prof. **DIDIER GEIGER**
2. UNIVERSITAT POLITECNICA DE CATALUNYA, Electronic Engineering Department, BARCELONA, Spain, Prof. **RAMON PALLAS – ARENY**
3. UNIVERSITÀ FEDERICO II DI NAPOLI, Electronic Engineering Department, NAPLES, Italy, Prof. **MARCELLO BRACALE**, and Assoc.Prof. **ALESSANDRO PEPINO**
4. TECHNICAL UNIVERSITY GRAZ, Biomedical Engineering Department, GRAZ, Austria, Prof. **HELMUT HUTTEN**
5. CATHOLIC UNIVERSITY OF LEUVEN, Electrical Engineering Department, LEUVEN, Belgium, Prof. **JEAN PEPPERSTRAETE**
6. UNIVERSITY OF SHEFFIELD, Medical Physics and Clinical Engineering, SHEFFIELD, United Kingdom, Prof. **BRIAN H. BROWN**
7. UNIVERSITY OF PATRAS, Department of Medical Physics, PATRAS, Greece, Prof. **NICOLAS PALLIKARAKIS**

Objective of the project: Restructuring of two Romanian university colleges for the development of short-cycle studies in health care related sectors, such as Biomedical Engineering and Medical Physics.

Outcomes

1. 2 updated and restructured curricula in BME and MP for the short-cycle education system, in accordance with the EU standards
2. 4 restructured and 6 new syllabi, courses and related teaching materials, methods and tools in BME and MP topics
3. 3 new didactic laboratories for BME and MP courses
4. Updating centre for practical retraining in BME and MP – Continuing Education System
5. New professional competence in BME and MP for 25 RO academic staff and 35-40 technical staff from RO hospitals, manufactures, etc.
6. Data-base for knowledge transfer
7. Information and documentation centre in BME and MP (“Docu Centre”)

➤ **updated courses:**

- “*Medical Engineering. Basic notions*”
 - the target public: undergraduate students in the first year of study college (Medical Engineering) of the Technical University of Cluj-Napoca (30 students/year).
- “*Electricity in Medicine. Bioelectric events*”
 - the target public: undergraduate students in the first year of study from the Medical Engineering college, Technical University of Cluj-Napoca. This course can be used also by the students from Applied Electronics (4th year), from Metrology (4th year), from Physical Engineering (5th year), from Radiology College (1st year) - University of Medicine and Pharmacy Cluj-Napoca (approximately 170 students/year).
- “*Radiobiophysics and Radiobiology*”
 - the target public: undergraduate students in the first year of study from Radiology College-University of Medicine and Pharmacy Cluj-Napoca (25 students/year).
- “*Conventional Radiological and Image Devices*”
 - the target public: undergraduate students in the second year of study from Radiology College-University of Medicine and Pharmacy Cluj-Napoca.(25 students/year);

➤ **new courses:**

- “*Electromagnetic Compatibility in Medical Devices*” - the target public (70 students/year):
 - undergraduate students in the 3rd year of study (Medical Engineering college),
 - in the 4th year (Applied Electronics),
 - post-graduate students (CAD in electrical engineering).
- “*Measurement of Biomedical Parameters*” - the target public (90 students/year):
 - undergraduate students in the 2nd year of study (Medical Engineering college),
 - from Metrology (4th year), Technical University of Cluj-Napoca.
 - this course can be used also by the students from Applied Electronics (4th year) and from Mecatronics (4th year), Technical University of Cluj-Napoca.
- “*Medical Image Processing*” - the target public (50 students/year):
 - undergraduate students in the 3rd year of study (Medical Engineering college)
 - in the 2nd year of study from Radiology College-University of Medicine and Pharmacy Cluj-Napoca
- “*Lessons for the development of applications in C/C++*” - target public (approximately 50 students/ year):
 - undergraduate students in the 1st year of study (Medical Engineering college),
 - in the 1st year of study from Applied Informatics College-Technical University,
 - in the 1st year of study from Electronics and Computer Science-Technical University
- “*Medical Pathology*” - the target public (25 students/year):

- undergraduate students in the 2nd year of study from Radiology College-University of Medicine and Pharmacy Cluj-Napoca.
- “*Reconstruction of 3D medical models*” - the target public:
 - undergraduate students in the second year of study from Radiology College-University of Medicine and Pharmacy Cluj-Napoca.(25 students/year).
- “*Bioelectromagnetics*” - the target public (50 students/year):
 - undergraduate students in the 2nd year of study (Medical Engineering college),
 - in the 4th year (Electrical Engineering), Technical University of Cluj-Napoca.
- “*Biomedical Instrumentation*” - the target public (approximately 90 students/year):
 - undergraduate students in the 2nd year of study from the Medical Engineering college, from Metrology (4th year), Technical University of Cluj-Napoca. This course can be used also by the students from Applied Electronics (4th year) and from Mecatronics (4th year), Technical University of Cluj-Napoca.
- “*Mathematical Methods in Biomedicine*” - the target public (50 students/year):
 - undergraduate students in the 1st year of study (Medical Engineering college)
 - in the 2nd year of study from Radiology College-University of Medicine,
 - this course can be used also by the students from University of Medicine and Pharmacy.
- “*Physiology - basic notions for bioengineers*” - the target public (25 students/year):
 - undergraduate students in the 1st year of study (Medical Engineering college)

Intensive courses:

No.	The course title	Teacher	No. of participants
1.	<i>Cardiac Electrophysiology and Cardiac Pacing</i>	● Prof. Helmut Hutten (Austria)	38
2.	<i>Biomedical Sensors and Interfaces</i>	● Prof. Ramon Pallas-Areny (Spain)	39
3.	<i>Interference in Biomedical Equipment</i>	● Prof. Ramon Pallas-Areny (Spain)	48
4.	<i>Case studies in Biomedical Signal Processing</i>	● Dr. Leentje Vanhamme (Belgium)	23
5.	<i>Matlab applied to medical engineering problems</i>	● Dr. Steven Wood (UK) ● Dr. Dawn Walker (UK)	26
	Total	6	174

Results:

- 174 students and staff trained;
- the participants were from:

TUCN	students	84
	staff	8
UMP	students	17
	staff	3
Other universities	students	7
	staff	2
Hospitals		4
Enterprises, companies		3
	Total	128

Note: some participants have attended more than one course.

3.2 Training

No coherent training system as postgraduate study can be met as organised to confer professional competencies in BME. Updating and upgrading courses, refreshing courses or similar are mainly organised by universities not in the framework of a well-defined timetable, but following the demand of a group or institution. This situation originates in the relatively small number of experts, in the absence of the position of biomedical engineer (up to March 2001) as well as in the social and economic unfavourable state of Romania during the last decade. We regard the National Society of Medical Engineering and Biological Technology as a body, which is responsible for taking over the main role in establishing an “*Act on Training in Health Care*” on a legal basis.

3.3 Accreditation of Education

Law No. 88/1993 establishes a series of criteria and standards that ground the assessment of curricula as well as of the public and private HE institutions. The assessment and accreditation procedures comprise several stages: provisional authorisation for functioning, accreditation (obtained after the first promotion of graduates) and periodical assessment (all HE institutions and all curricula are submitted to re-assessment every 5 years).

All degrees and study programs must be accredited by the Ministry of Education and Research (through the National Council for Academic Assessment and Accreditation). Otherwise the university is not allowed to award the degrees (this is valid for both state and private universities).