BIOMEDEA I

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The BIOMEDEA conference in Eindhoven, the Netherlands, December 17-19, 2004, was organized by Dick Slaaf. It was the first meeting in a series of 3. The next meetings will be organized by Jan Wojcicki in Warsaw, Poland, (http://hrabia.ibib.waw.pl/Biomedea) April 15-17, 2005, and by Joachim Nagel in Stuttgart, Germany, September 23-25, 2005. BIOMEDEA I was dedicated to education and training in Biomedical Engineering and Sciences and is part of the BIOMEDEA project, which is dedicated to harmonization of BME education in Europe. The conference was also a European preparation to the second Whitaker Biomedical Engineering Education summit. BIOMEDEA I was attended by 49 participants from 20 different countries.

About the BIOMEDEA project:

BIOMEDEA - Biomedical Engineering Preparing for the European Higher Education Area

Modern health care depends on versatile, multidisciplinary teams with biomedical engineers playing an important role, but in contrast to the traditional academic disciplines where consensus about the necessary content of higher educational programs and the required qualifications of professionals could be established over many decades, Medical and Biological Engineering and Science (MBES) as a young, explosively growing discipline did not yet have this opportunity. The Bologna movement has triggered an initiative of the MBES community to promote their European Higher Education Area by harmonizing the educational programs, specifying required minimum qualifications and establishing criteria for an efficient quality control of education and life-long learning.
The objective of the project is to support this initiative through the organization of seminars for all partners involved in MBES education, to develop and establish consensus on European guidelines for the harmonization of high quality MBES programs, their accreditation and for certification and continuing education of professionals working in the health care systems. Adherence to these guidelines will insure mobility in education and employment as well as the necessary safety for patients. Targets for the dissemination of results will be the European universities, political decision makers, ENQA, accreditation agencies, health care providers and students.

The meeting consisted of 4 workshops. The website of the meeting (http://www.bmt.tue.nl/biomedea) contains the presented material and short notes on the discussions.

Workshop 1: The Undergraduate Biomedical Engineering Curriculum

The goals were to delineate the core topics in biomedical engineering science that all BME students should understand, the biomedical engineering science topics, underpinning areas of BME specialization, the critical skills expected of all undergraduate biomedical engineers.

Workshop 2: The Biomedical Engineering Master Curriculum

The goals were to delineate at the graduate level: Intellectual underpinnings for the future of biomedical engineering, Integration of the engineering sciences and modern biology, Engineering opportunities in the clinic, Critical skills

Workshop 3: Educational methods and best practices;

The goals of the workshops were to: Discuss educational method, Illustrate best practices adapted to teaching biomedical engineers how to solve clinical and biological problems.

Workshop 4: Training

The goal of this part of BIOMEDEA was to gather the information necessary to write a survey on BME/CE Training in Europe and to establish guidelines for the minimum requirements for the training of Clinical Engineers in Europe.

BIOMEDEA I PRELIMINARY REPORT

Most BME educational programs in Europe started from a single parent discipline, which delivered methods, theories, instrumentation, structure, and organization. Life sciences were added at a later stage. The parent disciplines usually are: Electrical Engineering, Mechanical Engineering and Physical Engineering. In many cases, BME is only available at the graduate level. More than 150 Universities, Universities of Applied Sciences, Polytechnic Schools and Academies offer programs at all levels with almost no coordination of contents and required outcome qualifications.

In 1999, Europe adopted the Bachelor-Master structure for higher education. The Bologna Declaration is about adoption of a system of easily readable and comparable degrees in order to promote European citizens' employability and the international competitiveness of the European higher education system. Programs should adopt a system of two main cycles: undergraduate and graduate.

- First cycle: minimum of three years; degree relevant to the European labor market.
- Second cycle: requires completed first cycle.
    - Master and/or doctorate degree. Master's degree usually 2 years.

A credit system has to be created to allow student mobility.

For BME, the result should be international recognition of certain professional qualifications of BME graduates. This process is executed by governmental agencies, with little influence of the programs themselves. To stimulate Faculty participation in this process, IFMBE has stimulated the foundation of EAMBES, the European Alliance for Medical Biological Engineering & Science, which was established in 2004.

- EAMBES aims to serve and promote MBES education, training, and accreditation of programs, and to establish and maintain liaison with national and European governments and agencies.
- IFMBE and EAMBES have initiated meetings on education, harmonization, and accreditation to further BME harmonization in Europe and to facilitate student mobility (e.g., BIOMEDEA).

A SHORT SUMMARY OF THE DISCUSSIONS AND CONCLUSIONS OF THE MEETING

Harmonize BME education; do NOT standardize. Define core competencies and exit levels. Given the European custom of prescribed programs for students, it was suggested not to prescribe the individual courses. Harmonization should lead to diversity between programs. Mutual recognition of credits should stimulate student mobility which is still limited in Western Europe.

General: Definition of required BME education will depend on job requirements. A solid knowledge basis in Mathematics, Physics, Engineering, Life Sciences and (Bio) chemistry is required. BME graduates cannot acquire knowledge in each of these disciplines at the level of engineers fully trained in the specified field. Therefore, choices have to be made. Remember that BME has become a discipline in itself. For jobs in research, a specific combination of courses may be excellent in one situation and insufficient in another. Health care systems must be able to fully rely on the qualifications suggested by the degree to guarantee patient safety.

BME Bachelor in Europe

Average contents of program: 180 ECTS (3 years)

- Life sciences: 17 ECTS,
- Mathematical foundations: 25 ECTS,
- Science and Engineering foundations: 57 ECTS,
- BME: 46 ECTS,
- Languages: 5 ECTS,
- General competencies: 14 ECTS,
- Computer programming: 8 ECTS,
- Lab practical: 8 ECTS.

Engineering is the key word. Context is the living material. Flexibility in proportions is desirable. Content depends on exit track. Emphasis should be on underlying concepts.

Research in BME Bachelor education

- Involve research in education process:
    - To be taught by researchers is stimulating,
    - Research compartment is growing.
- Learn to do research by doing research.
- Working in a research lab with advanced equipment is stimulating.

Do Bachelors BME continue to BME Master's program?

- Varies from 15-25% (UK) to almost 100% (Netherlands, Italy, Poland),
- Sometimes limited admission (Germany; in some states it is being discussed to admit only 30%).

Admission to Master:

- Applicants with
  - backgrounds in BME or in areas related to BME can usually be admitted directly,
  - other backgrounds or students from abroad will usually need further preparation before admission.
- Further preparation may be via electives within BME program, or from classes/modules in other programs.

Does Master's degree BME qualify for a specific profession?

- National variations (e.g., clinical engineer/medical physicist).
- Should be academic; specific training afterwards "on the job".
- Academic research important:
  - Learn through doing,
  - Does not exclude job in development and design,
  - Ability to work autonomously and within a team.
- Master in BME aims at providing knowledge and skills to solve BME problems in research, clinical and professional environments.

BME Master in Europe

Average content: 120 ECTS (2 years).

- Lectures:
  - Mandatory: 39 ECTS,
  - Elective: 37 ECTS; varies from none to all.
- Research projects: 15 ECTS.
- Thesis: 29 ECTS,
  - Usually 30-40; extremes 3 and 60.

Lectures:

- Reflect the heterogeneity of the various Master programs,
- If Master's degree is required for specific job, many BME degrees will not cover the right courses.
- Need for specific profession requirements. A student should choose the right program.

Comments: Parent discipline sometimes dominates the type of courses. Entrance requirements usually "typical" of parent discipline. This seems reasonable if profession at which is aimed requires this.

Training

On the job training and entry requirements

Clinical Engineers (CEs) should have on the job training before they can be employed in a responsible position in the clinical environment. The entry requirements for training of a professional clinical engineer depend strongly on the position in question. Basic and senior level clinical engineering positions require a bachelor of science in biomedical engineering or a bachelor of biomedical engineering degree or an equivalent. Applicants for the position of principal or chief should have a master's degree or, on the basis of extensive training and on the job experience, should be eligible to a master's level as "natural career extension". Of course, a clinical engineer should prove his/her competencies and experiences in a clinical environment prior to the acceptance to a specific job.

Duration of training

The required minimum number of years for on the job training is 3. The employer remains responsible for the qualification of the employee.

It would be desirable to establish accredited training centers as the prerequisite for certified and registered clinical engineers.

The core areas of CE training are:

1. Management
2. Technology Assessment
3. Regulatory/QA Issues

4. Repair/Systems Thinking
5. Risk Management/Safety Issues
6. Education
7. Product Development
8. Miscellaneous Topics

Specialty areas are medical electronics and equipment management, information management and technology, rehabilitation engineering, radio therapy technology, diagnostic imaging technology, expert systems, decision support systems, biomaterials and biomechanics. There was no agreement on whether there should be training in specialty areas and in how many, though a preference seemed to point at two.

There should be different levels of clinical engineers dependent on their level of training, like basic, senior, principal and chief.

Future Challenges for BME Education
Expectation of Governmental agencies: A variety of new disciplines is about to emerge and will fill the gaps between highly specialized medicine and engineering.
Recommendation: diversify BME to accommodate such newly developing disciplines. This should lead to differentiation of BME after the long integrative process.

The BIOMEDEA meeting was co-sponsored by the IFMBE http://www.ifmbe.org, *and the Eindhoven University of Technology* http://www.tue.nl, *which was also hosting the meeting, while EAMBES* http://www.eambes.org *endorsed the meeting.*