New five year Biomedical Engineering curriculum at Aalborg University

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Abstract

A new five year curriculum in Biomedical Engineering (MSc) has been established at Aalborg University. The curriculum reflects the multidisciplinary composition of Biomedical Engineering and it contains elements from the medical, engineering and natural sciences as well as humanities and the social sciences.

The main objectives are to focus on the abilities and competencies that are required for biomedical engineers; this curriculum intends to deliver engineers with a good background in mathematics and physics and who are thoroughly trained in the engineering systems-approach.

The curriculum follows the AAU study form with problem-oriented and project-organized studies.

The first five semesters provides basic training in biomedical engineering, mathematics, physics, chemistry, physiology, electronics and applied computer science. In the last five semester three specialities are provided: Sensors, signals and systems (SSS), Medical Informatics (MI) and Bio-mechanical engineering (BM). The curriculum starts September 1st 2000.

Keywords: Biomedical Engineering, M.Sc.-curriculum, problem based learning, project organised learning.

1. Introduction

Biomedical Engineering (BME) is a multidisciplinary field consisting of elements from medicine, biology electrical engineering, chemical engineering, mechanical engineering, physics, mathematics and other disciplines. Over the centuries, scientists and engineers have established such a vast body of knowledge and technology that nobody can ever have a comprehensive knowledge of it all. A continuing specialisation has therefore taken place in science and engineering. The well-established and independent disciplines of today emerged and subsequently branched off as specialisation's from other fields. In this historical development BME is a special case since it emerged in several different parent-fields: Electrical engineering, chemical engineering, mechanical engineering, physics, and other areas all have developed their applications in medicine and biology. Consequently, in most of the places in the world where BME is a graduate program it is typically embedded in one of these fields. The fact that Biomedical Engineering arose from multiple traditional fields makes that it is a very broad field indeed [1].

Most education's in Biomedical Engineering follows this embedding-strategy and is normally constructed as a graduate programme following a undergraduate programme in e.g. electrical engineering.

This strategy raises at least two problems. In order to deliver a Biomedical Engineer, it is not optimal first to provide e.g. electrical engineering for three and a half years and then building BME on top of that. Biomedical engineering requires and deserves a better focus from the start of the education. From a student's point of view the road to BME through electrical engineering is a long one. Many students simply don't even start on that road, or have no idea that it exists. This means that an enormous potential is lost.

As a consequence Biomedical Engineering is now establishing itself as an independent discipline. There are now 22 universities with undergraduate Biomedical Engineering programs in the USA. In Europe there is only one (Eindhoven, The Netherlands).

As a reflection on the above mentioned and the facts that Denmark sees an increasing growth of production and export of biomedical equipment and a growing investment in advanced technology in the health sector, Aalborg University has developed a new 5-year BME curriculum to full-fill the demands of highly qualified BME-professionals in the future.

2. The Aalborg Model

The main objective of the 5-year M.Sc BME-education is to give a strong Biomedical component in an engineering curriculum and to focus on the abilities and competencies that are required for biomedical engineers. The curriculum intends to deliver engineers with a good background in mathematics and physics and thoroughly trained in the system-approach, typical for engineering

The curriculum reflects the multidisciplinary composition of Biomedical Engineering and it contains elements from the medical, engineering and natural sciences as well as humanities and the social sciences. The curriculum follows the AAU study form with problem-oriented and project-organised studies [2]. As illustrated in Fig. 1, both courses and projects cover the curriculum. Each semester (half year) consists of 30 modules of which 13-15 are course work divided into

study unit courses (SE) and project unit courses (PE), and 15-17 modules are project work. The PE-courses are designed to support the projects. The SE-courses are designed to give basic competence.
Each project is solved as a group task by 6-7 students. The groups have their own facilities as room and computers. Examinations are individual.

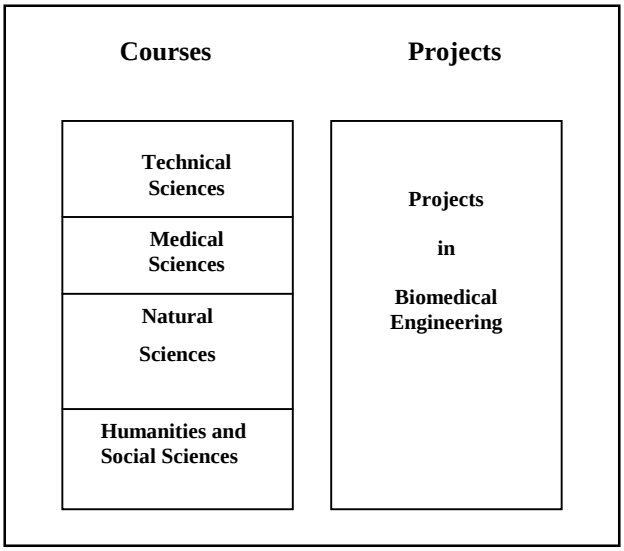

Fig.1. The study is composed with halftime for courses and halftime for projects.

Each semester is described by a theme, see Table 1, which each project will follow.

Semester	Theme
10th	Thesis Work
9th	Thesis Work
8th	Concentration areas: MI, SSS, BM
7th	Concentration areas: MI, SSS, BM
6th	Concentration areas: MI, SSS, BM
5th	Bio Medical Eng. in the Health Sector
4th	Acquisition, Processing and Presentation of Biomedical Signals
3rd	Bio-instrumentation
2nd	Basic year – Reality of Models
1st	Basic year – Models and Reality

Table 1. Semester themes.

On the 6th-8th semester three “concentration areas” are defined. These are: Medical Informatics (MI), Sensors, Signals and Systems (SSS) and Bio-mechanics (BM). Thereafter a two-semester project will lead to the final master thesis.

The curriculum is developed in co-operation between Institute of Electronic Systems, Department of Medical Informatics and Image Analysis, Aalborg Hospital and the Department of Life Sciences (Biotechnology) at Aalborg University.

3. Basic Year

The students will follow a general freshman year: The Basic Study Year. Within this year projects with a Biomedical Engineering orientation will be possible, supported by a few project courses modules. The themes are Models of Reality and Reality of Models. This year provides the students with basic skills in the natural sciences and introduces the problem-oriented and project-organised AAU-paradigm.

Project Examples:

Occupational Health: Mouse Problems
Modelling of Gait
Information Flow in Hospitals
Telemedicine

Courses given in the first year:

Mathematics, SE
Computer Science, SE
Physics, SE
Technology and Society, PE
InformationTechnology, PE
Data Acquisition using PC, PE
Science Theory, PE
Modelling, PE
Medical Terminology, PE
Chemistry, PE

4. 3rd to 5th Semester

The curriculum on these three semesters follows a model we will call ”from components to systems”.
This model presents Biomedical Engineering from a microscopic to a macroscopic level. The semesters introduce Biomedical Engineering with onset from both the electronic engineering and medical viewpoints. In medical terms the students are successively presented for anatomy, physiology and pathophysiology and finally for the clinic. In engineering terms the students are successively presented for biomedical systems viewed from the discrete analogue and digital components view, then for programmable (computer based) systems and finally for complete biomedical systems as used in the clinic.

3rd Semester:

This semester, with Bioinstrumentation as theme, will introduce the students to medical terminology, anatomy and to basic electronics and instrumentation as used in biomedical engineering.
In collaboration with Aalborg Hospital, animal experiments will be included in the course Physiology and anatomy I, which will focus primarily on anatomy through e.g. dissection exercises.

Project Examples:

ECG-pulse Detector
EMG-alarm for Bruxers
Eye Movement Detector

Courses on third semester:
Mathematics I, SE
Circuit Theory, SE
Physiology and Anatomy I, SE
Analogue Electronics, PE
Basic Digital Electronics, PE
Biochemistry, PE
Organic chemistry, PE
Bio-instrumentation and Measurements Techniques, PE

4th Semester:

The fourth semester with the theme: Acquisition, Processing and Presentation of Biomedical Signals, will introduce the students to system design, programming and signal processing in Biomedical Systems. Programmable systems – microcomputers - and their interfacing to bio-medical environments is the core of this semester.
Pathophysiology will be introduced in the Physiology and Anatomy II Course, and visits to Department of Pathology with animal physiological experiments will be included.

Project Examples:

SIDS - Respiration Monitoring
EMG-controlled Mouse
ECG-monitor
Portable Data Logger for Biosignals
Courses:

Mathematics II, SE
Electromagnetism, SE
Physiology and Anatomy II, SE
System Architecture and Integration, PE
Signal Processing, PE
System design and programming: OOA, OOD, OOP, PE

5th Semester

This semester has the theme Biomedical Systems in the Health Sector and it will focus on biomedical systems and clinical work in the hospital departments. The project-part of the semester will be devoted to small “mini-projects” and stays at different hospital departments at Aalborg Hospital, e.g. department of cardiology, internal medicine, anaesthesiology and ICU, and clinical chemistry. The students will follow courses, given at the hospital, in hospital hygiene, ethics and theoretical and clinical internal medicine and surgery.

Mini Project Examples:

The mini projects will be combined with the stay at the different hospital departments.

Data Flow in a Hospital Department
Bio-sensors
Blood-gas MeasurementsCourses:

Internal medicine, theory and clinic
Surgery, theory and clinic
Physiology and Anatomy III
Hospital hygiene, organisation and etics
Microbiology
Medical Imaging Systems
Control theory
Biomechanics
Biocompabillity
Physiological modelling
Medical Informatics

5. 6th to 8th Semester

These three semesters in the graduate part of the BME-education are devoted to specialisation in three different areas: Medical Informatics, Sensors, Signals and Systems and Bio-mechanics. A number of courses will be common for all three specialities. Each specialisation will have a separate theme on each semester. For e.g. MI these themes are: Data acquisition and classification, Storage and distribution of information and Interpretation and presentation.

Following topics will be covered by courses:

Advanced Signal Processing
Biomaterials
Biomechanics
Bio-Statistics
Clinical Engineering and Safety
Decision Support Systems
Ethics
Entrepeneurship
Fuzzy Logic and Neural Network
Medical Imaging

Neurophysiology
Networks, TCP/IP, ISO/OSI
NMR, CAT, Ultrasound
Optics and optoelectronics
Regulations and Standardizations
Rehabilitation Technology
Research Planning
Sensory Physiology
Stochastics
Tissue Engineering

On the latter semesters many of the projects will be part of ongoing research projects and will provide the students with insight in scientific research planning and work.

6. 9th-10th Semesters

These two semesters will be devoted to the final project in the Biomedical Engineering curriculum.
A one-year master of science project from one of the research areas at SMI, MIBA, Inst. for Life Sciences, and Aalborg Hospital will give the final specialisation. The final projects are made by individual students or by two students together.
On 9th semester a possibility for an external project at collaborating foreign universities also exists.

7. Conclusion

A new five year curriculum in Biomedical Engineering (MSc) has been established at Aalborg University with start at September 1st 2000. With this programme we seek to meet the requirement for a larger number of BME-professionals with a master degree to the BME-industry and the health sector.
The curriculum reflects the multidisciplinary composition of Biomedical Engineering and it contains elements from the medical, engineering and natural sciences as well as humanities and the social sciences.
By establishing a full graduate curriculum in BME with intake directly from the high school level we believe that it will be possible to attract more students due to larger visibility of the programme as opposed to graduate programmes where students have to “pass” a traditional engineering study before reaching the BME-specialisation. As a positive side-effect we also hope that more women will seek this education compared to traditional engineering programmes.

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