EVICAB
European Virtual Campus
for Biomedical Engineering

WP2: Final report

Pilot Curriculum for Virtual Campus for Biomedical Engineering

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Report

REPORT TITLE
Pilot curriculum for virtual campus for biomedical engineering

WORK PACKAGE
2. Build up a common virtual pilot BME curriculum among partners

RESPONSIBLE(S)
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ABSTRACT

The aim of this WP was: (1) present a systematic procedure for creating a virtual curriculum; (2) establish a common Virtual Pilot BME Curriculum (VPBMEC) in the project based on the existing resources; (3) monitor implementation of the VPBMEC by all project partners; (4) evaluation of the VPBMEC.

The systematic procedure for creating a virtual curriculum is described in chapter "Procedure" containing: (1) systematic procedure for creating a virtual curriculum; (2) e-learning portal; (3) steering committee and coordinator; (4) quality assurance; (5) role of the participating institutions; (6) connections at the university level; (7) financing and sustainability.

Established common virtual pilot BME curriculum is presented in chapter "Core curriculum" including: (1) design principles of the VPBMEC and conformity of the program; (2) content of the VPBMEC.

Implementation monitoring of the VPBMEC by all project partners is observed through different outcomes given in chapter "Implementation" including: (1) participated students and transferred ECTS credits; (2) e-learning activities.

Evaluation of the VPBMEC describes shortly: (1) the online tests; (2) collected feedback.

Finally, a summary how the stated goals were achieved during the project are given.

Important is to stress that all WP-s are tightly interconnected and for more comprehensive description to other WP-s are referred.

KEYWORDS
Course curriculum, Implementation, Evaluation

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INTRODUCTION

Biomedical engineering is characterised by a multi-disciplinary, rapidly developing and extending nature, having a crucial impact on the quality of life, welfare and high-tech industry. It is hard to cover all aspects of BME in a curriculum provided by a single institute, especially in smaller countries or universities in low-population zones of larger countries. Often BME is represented as a part of other programmes, such as electrical engineering. The benefit from a unified virtual pilot BME curriculum covering as many institutions in the field of BME in EU will integrating small resources, improving the quality of learning, making the best practices and teaching resources available for larger community, improving the equality of European students and universities, creating new innovations by increasing the competence of employees and by transferring the know-how to new areas. Also the development and equality of rural regions is supported by e-learning by the transfer of knowledge from university centres to these rural areas.

The main idea of the European Virtual Campus for Biomedical Engineering (EVICAB) is to develop, build up and evaluate sustainable, dynamical solutions for virtual mobility and e-learning that, according to the Bologna process, (i) mutually support the harmonization of the European higher education programmes, (ii) improve the quality of and comparability between the programmes, and (iii) advance the post-graduate studies, qualification and certification. These practices are realised in the field of biomedical engineering and medical physics.

The aim of this WP was:
(1) present a systematic procedure for creating a virtual curriculum;
(2) establish a common Virtual Pilot BME Curriculum (VPBMEC) in the project based on the existing resources;
(3) monitor implementation of the VPBMEC by all project partners;
(4) evaluation of the VPBMEC.

The systematic procedure for creating a virtual curriculum is described in chapter "Procedure" containing:
(1) Systematic procedure for creating a virtual curriculum;
(2) e-learning portal;
(3) Steering committee and coordinator;
(4) Quality assurance;
(5) Role of the participating institutions;
(6) Connections at the university level;
(7) Financing and sustainability.

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PROCEDURE

Systematic procedure for creating a virtual curriculum

The systematic procedure for creating a virtual curriculum presents a framework for development of a sustainable Internet-based virtual BME curriculum, building on the existing expertise in the substance and e-learning technology and experience of partners, gathered in close long-term co-operation. The system should guarantee a sustainable learning environment and content, of which development is based on continuous dynamic peer and self evaluation and effective exploitation of information and computer technology. The systematic procedure for creating a virtual curriculum was created by the collaborative contribution from all partner institutions.

The important components of the systematic procedure for creating a virtual curriculum are:

- Core curriculum;
- e-learning portal;
- Steering committee;
- Quality assurance;
- Participating institutions;
- Connections at the university level;
- Financing and sustainability.

Core curriculum

In this context, according to the adopted definition from Wikipedia, "core curriculum" means a course of study consisting of a set of courses which is deemed central and usually made mandatory for all students of a school.

As a starting point for establishing a core curriculum was agreement that each project partner will provide at least one course to the virtual curriculum from their expertise. Next step is to include courses from other universities providing a sustainable Internet-based virtual BME curriculum building on the existing expertise in the substance and partly performed in the framework of **WP1** of this project. Motivation is based on win-win principle and is described in more detail in relation to sustainability of the virtual curriculum. The procedure of course submission is explained in more detail in **WP3**.

Selection and approval of the courses should be with respect to the minimum requirements of the BME programmes, established by the BIOMEDEA (Biomedical Engineering Preparing for the European Higher Education Area), and according to the Bologna process, more deeply handled later in this report in relation to the design principles of the common virtual pilot BME curriculum established in the current project.

In relation to the approval criteria here could be mentioned that BIOMEDEA describes guidelines for the core content for BME courses and curriculum, **WP1** describes general guidelines for virtual courses, **WP3** describes mechanism for selecting, and **WP4** describes general recommendations for e-courses.

EVICAB portal

EVICAB portal in the form of EVICAB virtual BME curriculum web portal is for: (1) course database - informing (and even advertising) content of the virtual BME curriculum with the core information and the links to the course web sites; (2) communication about the related

issues; (3) sharing and dissemination of experience and results gathered during the activities; (4) LMS (Learning Management System) - introducing the learning management and management of the virtual curriculum; (5) VLE (Virtual Learning Environment), introducing the virtual learning environment (e.g. Moodle).

The EVICAB web site will be opened and continuously maintained by a webmaster. The portal is a source for students, teachers, administrators, coordinator, steering group, etc. In communication sub-page links and recommendations about the electronic tools are proposed (e-mail, chat, video meetings and teleconferencing) to increase the cost-effectiveness and decrease the travelling.

Information provided about programmes and courses should fulfil certain defined minimum requirements (more explicitly given in **WP5**). There should be information available about:
- Core content,
- Learning outcome;
- Credits,
- Prerequisites,
- Target groups,
- Teaching material, (books, presentations, exercises)
- Laboratory works;
- Work load,
- Teaching and learning methods used,
- Examination;
- Special requirements or skills (programming, MATLAB…)
- Feedback system for follow-up;

Additional information may be available for students, teachers, instructors, etc.

At the same time the main tasks of the EVICAB in relation to EVICAB portal are:
- Content provider: EVICAB provides information about available e-courses within BME owned by universities, material, module for sharing, joint courses, accessibility of information and detailed plans and schedules for students.
- Service provider: information management about BME e-courses, contacts, teaching materials, methods, etc.
- Manager: developing, evaluating (QA), etc the curriculum.

Administration of the VC, Steering committee

In order to ensure high quality content, implementation, evaluation and development of the virtual BME curriculum a steering committee is needed.

EVICAB's Steering Committee is an institution that makes the final decision on actions made in the EVICAB. The role and activity of steering committee is directly linked to the EVICAB mission with the main aim to high quality content, implementation, evaluation and development of the virtual BME curriculum.

The responsibilities of the steering committee as proposed by the **WP3**, are: (1) external evaluation cycle: review the courses and accept-reject the courses for virtual BME curriculum; (2) internal evaluation cycle: a regular surveillance and follow-up for accepted EVICAB courses; (3) monitoring and updating of teaching and learning processes (aim of **WP4** within the project).
This ensures that the courses will be evaluated before they are implemented to the system but also during the execution of the course during the external and internal evaluation cycle.

For the evaluation, learning management system (LMS) is used by the Steering Committee described in more detail in the report by **WP3**. Evaluation data is gathered with a set of evaluation forms implemented to EVICAB LMS. The external evaluation cycle means that the chairman and the Steering Committee will receive the application for inclusion a course and make a conclusion whether the course is suitable for the EVICAB or not. The internal evaluation cycle consists of various evaluations and statements from the chairman and the Steering Committee. All courses in EVICAB will be evaluated regularly.

Steering Committee will consist of experts on different fields of education; i.e. pedagogical and technical. Personnel of the steering committee is made up of a chairman, one representative from each EVICAB institution, students representative(s) related to number of students in the EVICAB from a particular university. The chairman will monitor the realisation of the work tasks, following of deadlines, etc. Also, the chairman will compare the statistics and development related to previous year(s). The chairman will draw conclusion in co-operation with the steering group about the course. First time members of the Steering Committee will be chosen from existing EVICAB partner universities. Continuously additional members will be nominated from new coming EVICAB partner universities.

The feedback received from the different levels will be directed to the responsible teacher and to Steering Committee. The Steering Committee will monitor the actions taken based on the feedback.

To be able to evaluate the courses the Steering Committee will set the evaluation criteria and all the members of the corresponding course will be aware of these criteria. Once criteria are stated steering group will monitor the evaluation process and evaluation outcomes. The Steering Committee will monitor also the actions taken based on the evaluation results.

The steering group should meet at least two times per year (preferably using ICT-s).

Quality assurance

It is important to ensure that the structure and content of the curriculum are continuously up-to-date and of the highest possible quality. Otherwise the usability and attractiveness of the curriculum will deteriorate and it will gradually die out. To ensure the sustainability of the virtual BME curriculum, its quality must be continuously monitored and assessed. As a result of this monitoring, better new courses shall be included to the curriculum and lower quality and old fashioned ones will be deleted.

The model assuring the quality of virtual BME curriculum consists of two main evaluation cycles: (1) external evaluation cycle: review the courses and accept-reject the courses for virtual BME curriculum; (2) internal evaluation cycle: a regular surveillance and follow-up for accepted EVICAB courses. For the evaluation, learning management system (LMS) is used as described in work package 3. Additionally monitoring and updating of teaching and learning processes is performed with a starting point given by the **WP4**.

During the external evaluation cycle the chairman and the Steering Group will receive the applications and make conclusion whether the course is suitable for the EVICAB or not. Selection of the courses should be with respect to the minimum requirements of the BME programmes, established by the BIOMEDEA (Biomedical Engineering Preparing for the European Higher Education Area), and according to the Bologna process, and also considering the present status of the BME curriculum.

For the internal evaluation cycle the data as the source for the evaluation process is derived from different feedback forms. Especially the main users, students, will be able to evaluate the EVICAB from on different levels; educational-pedagogical issues, usability, functionality, learning, and management system. Even though a number of forms are required the whole process will be systematic and easy, and hence it will be quite self-evident action in addition to other educational tasks. Feedback form for students will be found from each course site. The form will be automatically added every time a new course is added to the system.

Based on the data Steering group and coordinator will make the decision about the course. The decision can include: (1) Re-election (course is approved as such for the next year); (2) Development (course is approved but some modification need to be done); (3) Suspension (course is not ready for next year and lot of modifications is needed); (4) Cancellation (Course is not approved. Course has to start the process from the first phase of approval process).

As an output, a method will be developed to dynamically improve and innovate the curriculum.

Role of the participating institutions in virtual BME curriculum

The main aim of the virtual BME curriculum is to extend a sustainable virtual campus to the international level based on the expertise of the co-operating participating institutions. This will integrate the synergy of European know-how to improve the teaching, learning and research activities and make the use of teaching resources more effective regionally and internationally. Participation the virtual BME curriculum is based on the win-win principle. The expected results can provide a wider transferable solution for virtual mobility activities among all European countries and universities and their students.
Among including courses from different universities providing a sustainable Internet-based virtual BME curriculum building on the existing expertise in the substance different partners can have different role as providing:
- competence knowledge about a particular substance;
- pedagogical knowledge;
- technical knowledge (e.g. e-learning techniques);
- administrative and management knowledge (e.g. acceptance of the students, administrate examinations, etc).

A very important role of the participating institutions is to make EVICAB portal really accessible and known for the students in order to reach maximal audience.

Moreover, monitoring the progress and evaluation of the teaching and learning activity is necessary. For this purpose a representative of the Steering Committee will collect the feedback from teachers, students and administrators in each partner institution. It gives a wide spectrum of views to the evaluation. This information will be transferred from each partner institute to the Steering Committee.

Personnel that should be active in each participating institution to ensure a smooth and high quality teaching and learning process includes: an EVICAB coordinator, a system administrator for technical support, responsible teachers and tutors in every course,.

Depending on the needs of the institution, it is possible to become both a tester and a developer of the curriculum or in addition to this, a content producer. Both roles obligate the

participants to share the results, feedback, suggestions and/or observations of testing, development and/or production of the material.

Student services provided by each partner institution like student administration and authentication are topic of work done in **WP5**.

Connections at the university level

Most beneficiary is the virtual BME curriculum for students and student groups for whom e-learning and the virtual campus will be an opportunity to complete their MSc degree in another European university after completing a BSc degree in their own university. They will get the most benefit in the form of improved participation and extended learning opportunities to complete their university diploma with new courses, which earlier not have been available, without physical enrolment at a foreign country/university. Also post-graduate students, especially those working in industry and public sector or in rural regions, benefit from the project through the improved long-life learning methods. To accomplishing this certain procedures are needed to: (1) accept, include and recognize EVICAB-courses into the local program; (2) admit students to the virtual BME curriculum and administrate the courses. One of the most important principle that is seen as a solution for the first mentioned procedure is that the virtual BME curriculum is a complement to existing BME programs - university owns the course provided to the virtual BME curriculum. As a result of this there is no need for an external accreditation of the virtual BME curriculum.

Students admittance into the virtual BME curriculum through the home universities can be done in several ways as for example by:
- Socrates agreements through the Erasmus Programme;
- Bilateral agreements between his/her university and the university recognizing the EVICAB course;
- Joint programs where universities agree which part of curriculum is accepted from the partner universities and which are a part of the virtual BME curriculum at the same time;
- Exchange of courses – based on other existing agreements to take courses from the other universities acting as EVICAB institution;
- Admitting students to the joint courses based on the existing courses– a part of courses from different teachers from different universities (so called "highlights").

Additionally, replacement of some lectures should be possible within a course and this should not need special agreements. More detailed description is given in WP5.

Finance and sustainability

Sustainability means a set of methods and models for running, maintaining, updating and further developing the virtual BME programme after the project has finished.

EVICAB as a service provider.
An important key to sustainability is that EVICAB offers to other institutions interested at several levels a service (information management) as access to the valuable and comprehensive database including:
- information over the existing BME e- courses, programs, etc.;
- contacts over institutions;
- e-learning and teaching methods.

The main principle should be that the virtual BME Campus will be open to all institutions both included and not included as the participating institutions, interested at several levels. The service (content and methods) will be free for all institutions-universities. Participation the virtual BME curriculum is based on the win-win principle. However, a service fee could be implemented as a (annual) donation or support by governmental and structural funds. Important aspect in the future could be co-operation and ties with other institutions, trade associations and representatives of employers, international organisations and higher education institutions, participation in co-operation programmes and student exchange programmes.

The components which should be considered to maintain sustainability of the virtual BME programme are:
- Administration, Steering Committee;
- Courses and course QA;
- Educational recourses and learning platforms;
- Student exchange.

Administration, Steering Committee.
Some amount of administrative work is needed to keep the virtual BME programme going including maintenance of EVICAB portal, update of information, some coordinating work, etc. This work requires qualified staff and those costs should be covered from the budget related to the virtual BME programme. Certainly the quality of work done by members of Steering Committee will benefit from some kind of reimbursement.

Courses and course QA.
Since a legal body, the home university, will own courses taking the responsibility for the courses, in order for them to follow national and international (Bologna compliant) regulations with a course code for follow up and identification and ECTS credit points recognized by the national authorities or the university educational boards, the quality assurance of the courses will be supported by the universities, and the EVICAB platform will serve merely as a portal to the true course application system. The contribution to the development of courses and the learning material should be supported by separate funds if necessary.

Educational recourses and learning platforms.
The pedagogical approach proposed in the EVICAB needs relatively few resources considering that the open educational recourses and learning platforms (e.g. Moodle) are available. At the same time each university may have separate educational recourses and learning platforms that can be used for the courses included into the virtual BME curriculum.

Student exchange.
All students interested and able to attend an proposed EVICAB course at another university should be encouraged to participate in an established educational exchange programme between the student home university and the university owing the specific course of interest. Such contracts should be established between EVICAB universities in order to facilitate the exchange but EVICAB should also foresee and encourage the creating of new contracts between educational providers. Free movers should be referred to the international relations office of their home universities in order to receive the needed help/advice of how to attend an EVICAB course.

The question concerning the funding has not found a clear and satisfactory answer yet. The collaborative and fruitful discussion on the EU level should be the best way to solve this issue as proposed also on the Finnish Chairmanship of the Nordic Council of the Ministers Theme Seminar Developing Joint Programmes and Degrees in Nordic and Baltic Countries took place in Tampere, Finland, 13 - 14 December 2007.

CORE CURRICULUM

DESIGN PRINCIPLES OF VPBMEC

A common virtual pilot BME curriculum was established in the project, starting gradually in the autumn term 2006. This is based on the **existing** resources and courses provided by the stakeholders and third parties based on WP1 as well as on the e-learning technologies and methods developed in WP4.

Guidelines for the accreditation of BME Programs in Europe

There is general agreement that existing criteria and guidelines for the accreditation of engineering programs in Europe, such as the EUR-ACE documents, do not cover the special needs of BME programs and that therefore specific guidelines should be agreed upon. Such guidelines should be based on the commonly accepted, general guidelines for engineering programs, and should add the necessary core competencies as well as specializations in Medical and Biological Engineering and Science.

They should also outline the basic competencies in engineering/science, biology and medicine and general competencies (soft skills) which are felt to be necessary requirements for a BME degree. The guidelines should satisfy the two purposes of specifying the criteria for accreditation and providing advice to those who want to start a new BME program, and thus should contain guidelines for curricula, too. Two different basic types of programs should be defined in the guidelines: research oriented and professionally oriented programs. In general, universities offer research oriented programs, whereas universities of applied science and polytechnic schools regularly offer professionally oriented programs.

Educational Objectives

There are two different basic types of programs with different educational objectives: research oriented and professionally oriented programs. The general goal of biomedical engineering education in one and two cycle professionally oriented programs is a scientifically based, application oriented study, that on the basis of broad knowledge of biomedical engineering and extensive competency of engineering methodology teaches and promotes the analytical, creative and design competencies for the development of concepts for solving engineering problems of a medical/clinical relevance, and for the development and improvement of biomedical systems.

For research oriented programs, the general goal is a scientifically based, fundamentals oriented study, that on the basis of broad biomedical engineering competencies, which must be profound in selected topics, teaches and develops the ability for basic and application oriented research in biomedical engineering and promotes analytical, creative and constructive skills for the development and improvement of complex biomedical systems and methods.

Both research and professionally oriented programs should add as learning outcomes the necessary skills for communication with the medical and biological community and the

knowledge of biomedical engineering ethics. Since a generally accepted code of biomedical engineering ethics is only slowly developing, medical ethics included in professional ethics is considered to be adequate.

Basic Structures and Categories

There are no predetermined curricula, nor specific requirements or percentages for individual courses in the different categories. With regard to accreditation, the outcome, i.e. the aptitude or the acquired skills of the graduates, is more important than the curriculum that may very well contain some specific local profile.

More important than adherence to the listed percentages is a reasonable concept for the curriculum. Therefore, the application for accreditation must contain a detailed description for the objectives of the program, its quality and compatibility as well as the professional qualification of its graduates. It should be explained how students can acquire the general professional competencies.

Program modules

The biomedical engineering topics and other modules are broken down into the following modules or categories:
•   Biomedical Engineering foundations (core topics)
•   Biomedical Engineering in-depth topics
•   Mathematics
•   Natural Sciences
•   Engineering
•   Medical and biological foundations
•   General and social competencies (soft skills)

Contents

Within these categories, research oriented programs should emphasize teaching of scientifically based foundations, foster analytical and creative competencies, teach the ability to develop and improve complex biomedical systems and methods, and teach the students to work in basic or application oriented research. The programs should also educate and train the students to become our future scientists.

Courses offered by professionally oriented programs should provide a scientifically based, application oriented study, that on the basis of broad knowledge of biomedical engineering and extensive competency of engineering methodology teaches and promotes the analytical, creative and design competencies for the development of concepts for solving biomedical engineering problems and for the development and improvement of biomedical systems.

Biomedical Engineering foundations (core topics)

•   Biomedical instrumentation and technology;
•   Physiological measurements;

- Biosignals, signal processing and interpretation;
- Medical imaging systems and image processing;
- Biomechanics;
- Biomaterials and biocompatibility;
- Clinical engineering;
- Healthcare telematics;
- Modeling and simulation;
- Rehabilitation engineering;
- Design and project management;
- Medical informatics;
- Cellular and tissue engineering;
- Laboratory and analytic techniques in medicine;
- Radiation therapy, therapy planning and dosimetry.

For clinical engineering programs, additional core topics are:
- Safety and quality assurance;
- Medical device directives;
- Legal aspects of design, manufacturing and application of medical equipment;
- Health technology assessment;
- Hygiene and sterilization;
- Radiation protection;
- Equipment management;
- Hospital technology management.

Selection and depth of these topics strongly depend on the specific program objectives. Dependent on the type of program, one or several of the core topics are mandatory. The detailed contents of the topics depend on the specific nature or options of the program.

Structure of programs

1. The regular duration of a Bachelor (first cycle) program is three years or 180 ECTS credits with an upper limit of 210 credits.
2. The regular duration of a Master (second cycle) program is two years or 120 ECTS credits. In consecutive two-cycle programs, the number of credits may be as low as 90 ECTS credits.
3. The regular duration of a two-cycle consecutive program is five years or 300 ECTS credits.
4. Periods for training, i.e. professional experience, and practical projects must be integrated into Bachelor programs. The total period should not be less than 10 ECTS credits.
Regulations for these periods are to be established and adequate guidance has to be provided by the educational institutions.
5. A Bachelor program normally integrates a thesis with a workload of 15 ECTS credits.
6. A Master program normally integrates a thesis with a workload of 30 ECTS credits.

CONTENT OF VPBMEC

For the core curriculum of the Virtual Provisional BioMedical Engineering Curriculum (VPBMEC) of the MSc education according to the agreement each project partner provided at least one e-course. In fact alltogether 10 e-courses with different level of e-learning facilities were provided. But providing of new courses for the EVICAB is continuously opened at https://www.moodle.fi/evicab/moodle/login/index.php.

Two high level e-courses were provided by 2 North-American universities.

An important resource has been the **International Master's Programme** (in BME) taught in English at the Ragnar Granit Institute (RGI), Tampere University of Technology, Finland (http://www.rgi.tut.fi/master/index.htm).

Bioelectromagnetism (http://www.rgi.tut.fi/edu/bem/index.htm) is the central topic of studies in this Programme. In addition, students can complete their studies with other biomedical engineering related topics provided by other institutes of the Tampere University of technology. These include biomaterial technology, biosensors, medical signal and image processing, and systems biology. The studies in Biomedical Engineering are supported by courses on electronics, electrical engineering, software engineering, signal processing and telecommunication.

On the **EVICAB's main portal** (http://www.evicab.eu) are presented four of the most relevant EVICAB courses. These courses are recognised in the university programs of several universities for their BME curriculae. Of course, they must recognised by the member universities of the EVICAB consortium, who have proposed them, but they are recognised also by several other member universities, and also by 3 universities, which are not the members of the EVICAB consortium (as shown on http://www.rgi.tut.fi/evicab/bme/credit.htm).

Already on this main page there are given the straight links to the lecture videos, lecture materials (in 2 cases the e-books) and exercises (mainly provided at http://www.rgi.tut.fi/evicab/bme/), and link for starting the Internet Examination, leading to the EVICAB's Web portal at http://www.moodle.fi/evicab/moodle/.

The **full list of provided e-courses** and one provisional e-course are presented in the Virtual Provisional BME Curriculum on the EVICAB's Web portal at http://www.moodle.fi/evicab/moodle/course/. On the EVICAB's main page the link to this page is given under the name Internet Education tool in Evicab Moodle.

This curriculum is presented in the form of a list, containing also courses, which are not widely recognised, but are assumed to be relevant for the MSc study in the field of BME.

The EVICAB web site was opened and is continuously maintained by a webmaster. The portal is a source for students, teachers, administrators, coordinator, steering group, etc.
(1) informing (and even advertising) content of the virtual BME curriculum;
(2) communication about the related issues;
(3) sharing and dissemination of experience and results gathered during the activities.

In communication sub-page links and recommendations about the electronic tools are proposed (e-mail, chat, video meetings and teleconferencing) to increase the cost-effectiveness and decrease the travelling.

EVICAB, WP2

EVICAB e-courses

EVICAB e-courses provided by the partner universities (in alphabetic order) were:

- Bioelectromagnetism, Tampere University of Technology, Finland
- Biomedical Electronics, Tallinn University of Technology, Estonia
- Biomedical Engineering and Medical Physics, Tallinn Univ. of Technology, Estonia
- Bio-optics, University of Linköping, Sweden
- Digital Image Processing, Brno University of Technology, Czech Rep.
- Digital Signal Processing, Brno University of Technology, Czech Rep.
- Electromagnetic Fields and waves, Tallinn University of Technology, Estonia
- Living Systems, University of Tartu, Estonia
- Medical Informatics Laboratory, Tampere University of Technology, Finland
- Ultrasound Medical Diagnostics: remote online labs, Kaunas Univ. of Technology, Lithuania
- Virtual Digital Signal Processing Laboratory, Kaunas University of Technology, Lithuania

EVICAB e-courses provided by other universities

- Biomedical Signal Analysis, University of Calgary, Canada
- Computational Modelling of Cardiovascular System, University of Utah, USA

In the following these courses are discussed in more details, as presented on the EVICAB's Moodle pages and on the homepages of the courses.

Bioelectromagnetism (BEM)

Teachers: Jaakko Malmivuo, professor
            Outi Väisänen, assistant prof.

Course provider: Ragnar Granit Institute   http://www.rgi.tut.fi
Tampere University of Technology, Finland

Topics
Nervous, sensory and muscle cells as bioelectric and biomagnetic sources, and their modelling.
Modelling of living tissues as volume conductors.
Theoretical analysis methods of bioelectric recordings.
Bioelectric and biomagnetic signals and their use in clinical diagnosis.
Electric and magnetic stimulation

Lectures:
The lectures are linked with the corresponding chapters of the study book on the Web http://butler.cc.tut.fi/~malmivuo/bem/bembook/.
Video recordings of the lectures can be found from Lecture Video Archive (section 2 on the EVICAB Moodle page of the course).

Queries:
A query can be found after every topic. These are given so that one can check how well the issues within each topic have been learnt.

Web Exam
Instructions and the Questionnaire for a Web examare given.

Course recognition

Tampere Univ. of Technology, Ragnar Granit Institute Prof. Jaakko Malmivuo	6 cr
Helsinki Univ. of Technology, Applied Electronics Laboratory Ass. Prof. Lauri Palva	4 cr
University of Barcelona, Dept. of Electronics Prof. Gabriel Gomila Lluc	? cr
Tallinn Univ. of Technology, Biomedical Engineering Center Prof. Ivo Fridolin	? cr
Czech Techn. Univ. in Prague, Fac. of Biomedical Engineering Prof. Peter Kneppo	4 cr

Content of the EVICAB Moodle page of the course
on http://www.moodle.fi/evicab/moodle/course/view.php?id=18

The contents is divided into 12 chapters with 28 subdivisions.
The queries for all 28 subdivisions, and some other questionnaires are present.
(for more details, please see Appendix 3)

Discussion Forum (General forum, and forums for all 12 chapters).

Lecture Video Archive on http://www.rgi.tut.fi/videos/BEM/

The whole course is covered with19 lectures, which were recorded at the Ragnar Granit Institute in autumn 2006.
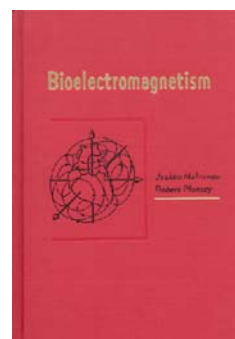Windows' RealPlayer **RealPlayer** is needed with a Plug-in for Camtasia.

Feedback Forms

EVICAB Preliminary Questionnaire Form - The first questionnaire is filled in the beginning of the course.
Course Feedback - Fill-in feedback form in the end of the course.

(for more details about this e-course, please see Appendix 3)

Biomedical Signal Analysis (CF101)

Teachers: **Rangaraj M. Rangayyan**, professor

Brief outline:
Introduction to the electrocardiogram, electroencephalogram, electromyogram, and other diagnostic signals.
Computer techniques for processing and analysis of biomedical signals.
Pattern classification and decision techniques for computer-aided diagnosis.
Case studies from current applications and research.

Prerequisite:
A course on Signals, Linear Systems, and Transforms (Laplace, Fourier, and z transforms).

Objectives:
- Learn about the genesis of biomedical signals, such as the action potential, EMG, ECG, EEG, and heart sound signals.
- Review basic concepts of signals, systems, and digital filters.
- Study the characteristics of biomedical signals: stationarity, periodicity, rhythm, wavelets, epochs, episodes, transients.
- Learn signal processing techniques for filtering, noise removal, cancellation of interference, and characterization of signals.
- Study techniques for the detection of events such as the QRS complex, heart sounds and murmurs, and the dicrotic notch.
- Learn about spectral analysis of biomedical signals.

**Background review and preparation:**
Students are advised to review a textbook on signals, linear systems, and transforms (please see Appendix 3). Students are also advised to familiarize yourself with MATLAB and the associated Signal Processing Toolbox.

Textbook:
Rangayyan R.M., "*Biomedical Signal Analysis - A Case-study Approach*", IEEE and Wiley, New York, NY, 2002. (Selected parts from the first six chapters.)
Table of Contents, Updates and Corrections to the textbook and other information is available.
Solutions to selected problems, lab exercises, biomedical signal data files, previous examinations, and additional material are posted on the website.
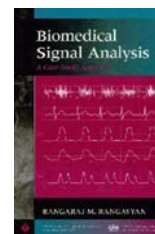
Course recognition
Tampere Univ. of Technology, Ragnar Granit Institute Prof. Jaakko Malmivuo   ? cr
Univ. of Calgary, Dept. of Electrical and Computer Eng, Prof. Ragnaraj M. Rangayyan   ? cr

The **pdf-files of the study materials** are available on the course provider's Internet page
See Index of /People/Ranga/enel563 www2.enel.ucalgary.ca/People/Ranga/enel563

Lecture Videos of Rangaraj M. Rangayyan *Biomedical Signal Analysis*

Recorded at the Ragnar Granit Institute in August 2007. 28 video recordings from 6 chapters (of 9) are available on http://www.rgi.tut.fi/evicab/bme/ranga/videos.htm.

Exercises
http://moodel.tut.fi/course/view.php?id=783 (login account is needed)

For more details about this e-course, please see Appendix 3.
www2.enel.ucalgary.ca/People/Ranga/enel563 is the site which is to be checked for updated information.

Bio-Optics (Bio-opt)

Teacher: Professor Göran Salerud

Course provider: Department of Biomedical Engineering
Linköpings universitet, Linköping, Sweden

Prerequisites and aim of the course can be found from the course homepage.

The EVICAB Moodle page of the course: http://www.moodle.fi/evicab/moodle/course/view.php?id=23

Lecture videos and notes
Videos of all 7 lectures and **Lecture notes** in 11 pdf-files.
(for more details, please see Appendix 3)

Course recognition

Tallinn Univ. of Technology, Biomedical Engineering Centre, Prof. Ivo Fridolin   ? cr
Linköping University, Inst. of Biomedical Engineering, Prof. Göran Salerud   5 cr

Study books

1. Vo-Dinh Tuan: Biomedical Photonics Handbook. CRC PRESS, 2003.
2. Valery Tuchin: Tissue optics: Light scattering methods and instrumentation for medical diagnosis. SPIE Press, 2000.
3. Akira Ishimaru**:** Wave propagation and scattering in random media. Vol 1. Academic Press 1978.
4. Craig F. Bohren and Donald R. Huffman: Absorption and scattering of light by small particles. Wiley Science paperback series, 1998.
5. B.E.A. Saleh and M.C. Teich: Fundamentals of Photonics. Wiley series in pure and applied optics, 1991.
6. Ashley J. Welch and Martin J.C. Gemert: Optical-Thermal Response of Laser-Irradiated Tissue. PlenumPress, New York, 1995.
7. Mishchenko M.I. , Travis L.D. and Lacis A.A.: Scattering, Absorption, and Emission of Light by Small Particles. NASA Goddard Institute for Space Studies, New York, 2004.
8. Benjamin Crowell: Optics. Click here.
9. Justin B. Peatross and Michael Ware: Physics of Light and Optics. Click here

Course Literature
File Archive (pdf-files of Reports & Theses, and Articles)
Materials on the WWW.

Biomedical Optics /Biomedicinsk Optik

Special course available to the students from Tallinn and Tartu
http://www.imt.liu.se/edu/courses/edutallin/

Course contents: Optical properties of biological tissue. Light transport in tissue. Therapeutic window. Light transport models. Measurement of tissue optical properties. Optical coherence tomography, multi-photon excitation, flourescens, etc.

Course literature Compendium with articles and book-chapters. Most material available at our file archive.

(for more details, please see Appendix 3)

Computational Modelling of Cardiovascular System (CMCF)

Teachers: Professor Frank Sachse, University of Utah
Assistant: Asta Kybartaite

Course provider: University of Utah, Utah, USA

Course description

The course will provide detailed insights in modeling approaches, which are applied to describe and reconstruct physical properties and physiology of the cardiovascular system. Students will be enabled to classify modeling approaches and select appropriate models as research and development tools. We will introduce and analyze mathematical models, which are used to quantify electrophysiology at level of single channels, cells, tissue up to whole organs. Models of cellular force development and tissue mechanics will be discussed. Numerical methods for solving of the underlying systems of equations will be addressed with regard to their efficient implementation.

Brief outline of the book *Computational Cardiology*:

This book is devoted to computer-based modeling in cardiology, by taking an educational point of view, and by summarizing knowledge from several, commonly considered delimited areas of cardiac research in a consistent way.

First, the foundations and numerical techniques from mathematics are provided, with a particular focus on the finite element and finite differences methods. Then, the theory of electric fields and continuum mechanics is introduced with respect to numerical calculations in anisotropic biological media. In addition to the presentation of digital image processing techniques, the following chapters deal with particular aspects of cardiac modeling: cardiac anatomy, cardiac electro physiology, cardiac mechanics, modeling of cardiac electro mechanics.

This book was written for researchers in modeling and cardiology, for clinical cardiologists, and for advanced students.

Sachse, Frank B. Computational Cardiology
Modeling of Anatomy, Electrophysiology, and Mechanics
Series: Lecture Notes in Computer Science , ol. 2966
2004, XVII, 322 p., softcover ISBN: 978-3-540-21907-1
Online version is available
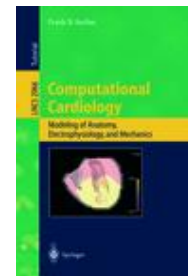
Keywords:
- biomedical computing
- biomedical image processing
- cardiac anatomy
- cardiac imaging
- cardiac mechanics
- computational cardiology
- computer-based modeling
- deformable objects
- electrophysiology
- mathematical modeling
- visualization

Course recognition

Tampere Univ. of Technology, Ragnar Granit Institute, Prof. Jaakko Malmivuo, 5 cr.

The EVICAB Moodle page of the course:
http://www.moodle.fi/evicab/moodle/course/view.php?id=22
including 8 lessons and 3 exercises provided with links to the **lecture slides/instructions**
for exercises, and **lecture videos**, Including the **iPod lectures** (mpeg-4 video)**.**
(for more details, please see Appendix 3)

Biomedical Engineering and Medical Physics (BEMPhys)

Teacher: Professor Kalju Meigas, kalju@cb.ttu.ee

Course provider: Biomedical Engineering Centre
Tallinn University of Technology
Ehitajate tee 5, 19086 Tallinn , Estonia
Homepage: http://www.cb.ttu.ee/

Course description.

Biomedical Engineering and Medical Physics is no longer an emerging discipline; it has become an important vital interdisciplinary field, including the design, development and utilization of materials, devices (such as pacemakers, lithotripsy, etc.) and techniques (such
as signal processing, artificial intelligence, etc.) for clinical research and use; and serve as a basis of the health care delivery team (clinical engineering, medical informatics, rehabilitation engineering, etc.) seeking new solutions for difficult heath care problems. To meet the needs of this diverse body of professionals, this course provides a basic core of knowledge in those fields.

Contents / Lecture Notes

1. Professional Societies
2. Biomedical Sensors
3. Physiological Signals
4. X-Ray Equipment
5. Ultrasound
6. Lasers in Medical Diagnostics.
7. Clinical Engineer: Safety, Standards and Regulations
8. Home Care and Rehabilitation

Books

1. Joseph D. Bronzino (Ed.). *The Biomedical Engineering HandBook.* Boca Raton: CRC Press LLC, 2000, Second Edition.
2. D. Jennings, A. Flint, B.C.H. Firton and L.D.M. Nokes. *Introduction to Medical Electronics Applications.* School of Engineering University of Wales, College of Cardiff, 1995.
3. Karen M. Mudry, Robert Plonsey, Joseph D. Bronzino. *Biomedical Imaging..* 2003.
4. James Moore, George Zouridakis. *Biomedical Technology and Devices Handbook.* 2004.

The EVICAB Moodle page of the course:

http://www.moodle.fi/evicab/moodle/course/view.php?id=9

Electromagnetic Fields and Waves (EFW)

Teacher: Professor Ivo Fridolin,

Course provider: Biomedical Engineering Centre http://www.cb.ttu.ee/,
Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn , Estonia

The EVICAB Moodle page of the course:
http://www.moodle.fi/evicab/moodle/course/view.php?id=8

Course description.

The main aim of this course is to understand and be able to use the principles of electromagnetism phenomena and apply this to electromagnetic fields and waves.

To understand the main parameters and mathematical expressions used to describe electromagnetic (EM) fields and waves.

To be able to understand basic mathematics for solving calculation and modelling exercises on elementary EM fields and waves.

Students are to be familiar with and understand the central topics of basic electromagnetism: Scalar and vector field, Electric field, Magnetic field, Material and Environment Characteristics like Linearity, Homogeneity and Isotropy, Maxwell's equations with a integral, differential and complex description, Wave equation, Uniform Plane EM waves in empty space, Uniform Plane EM waves in an unbounded conductive region, Classification of conductive media, Boundary conditions, Field types, The Poynting theorem and Electromagnetic Power, Sources of electromagnetic waves, Propagation of electromagnetic waves, Antenna basic, Electromagnetic compatibility.

Through the use of theory when introducing this material, students should to learn to understand how mathematics can simplify the description and treatment of complicated problems in physics.

Students should be able to
- analyse a problem described to them by applying basic laws and principles of
  electromagnetism, EM fields and waves.
- solve calculation exercises by applying basic laws and principles of electromagnetism,
  EM fields and waves.
- explain how phenomena in nature and everyday life can be explained qualitatively based
  on the basic laws and principles of electromagnetism, EM fields and waves.

The main audience of this course is supposed to be students in the field of biomedical engineering and therefore the physical phenomena of electromagnetism, EM fields and waves is connected into medical context (biological tissue, EM vs human interaction) in order to understand how the basic knowledge in EM fields and waves can be understood, used and developed for biomedical engineering technology.

The course includes also practical moments in the form of the laboratory works (diffraction, polarisation, and coaxial line).

This course should provide base for continuation on the more advanced course that studies effects of electromagnetic fields on biologic tissue.

Content

Scalar and vector field

Electric field

Magnetic field

Material and Environment Characteristics: Linearity, Homogeneity and Isotropy

Electromagnetic field

Maxwell equations

Electromagnetic waves

Uniform Plane EM waves in empty space

Uniform Plane EM waves in an unbounded conductive region

Classification of conductive media

Boundary conditions

Field types

The Poynting theorem and Electromagnetic Power

Sources of electromagnetic waves

Propagation of electromagnetic waves

Antenna basic

Electromagnetic compatibility

Bibliography

1. Ivo Fridolin. *Electromagnetic fields and waves for Biomedical Engineers*, Course material. Tallinn, 2007 (First edition).

2. Ramo S, Whinnery J.R.,Van Duzer T. *Fields and Waves in Communication Electronics*. John Wiley & Sons, Inc., Third ed. 1994.

3. *Engineering electromagnetic fields and waves*,
    John Wiley and Sons, Inc, Johnk, T. A. C. 1988.

4. Hinrikus H. *Elektrodünaamika (Electrodynamics)*, Tallinn, Estonia, 1975, in Estonian.

5. Л.Д. Гольдштейн, Н.В. Зернов. *Электромагнитные поля и волны*
    (Goldstein L.D., Zernov, N.V. *Electromagnetic fields and waves)*,
    Moscow, Soviet radio, 1971, in Russian..

6. Wayne M. Saslow. *Electricity, Magnetism, and Light*.
    ISBN: 978-0-12-619455-5
    http://www.sciencedirect.com/science/book/9780126194555

7. *Fundamentals of Engineering Electromagnetics*, Rajeev Bansal,
    http://www.engnetbase.com/ejournals/books/book_summary/toc.asp?id=4670

Biomedical Electronics (BioEl)

Course code or number: IEM0070 / BioEl   **Credits: 4**

Teachers: Toomas Parve, senior researcher,   Mart Min, professor.

Course provider: Tallinn University of Technology, Faculty of Information Technology, Dept. of Electronics Ehitayate Road 5, 19086 Tallinn, Estonia

The EVICAB Moodle page: http://www.moodle.fi/evicab/moodle/course/view.php?id=14

Course homepage (Internet) http:// www.elin.ttu.ee/mesel/Study/Subjects/0070BME/Index.htm

Objectives of the course
This course gives a wide spectrum of knowledge about the solutions of electronic units, systems and devices used in medical engineering practice and in biological research. Necessary refering to corresponding biophysical knowledge is given together with explanation of possible bionic prostheses and technical analogies.

Contents
− Introduction to the BioMedical Electronics
− Bioelectrical phenomena and signals, electrical properties of tissues.
− Electronic circuits for pick-up of the biopotentials.
− Electrodes and electronic bio-sensors and transducers.
− Measurement and diagnostic applications of Electrical Bio-Impedance.
− Electronic means for medical monitoring, data processing, data displaying, and medical diagnostics
− Bio-electronic stimulators, and electronic means in therapy
− Electronic prosthetic appliances
− Other electronics for the means of medical diagnostics and biometrics
− Bionics.
− Special topics of medical electronics
   Concepts of system design for biomedical applications.
   On-chip realisation of medical electronic devices (Mixed system and System-on-Chip (SoC) solutions, ASIC, FPGA/PL); CMOS circuit design building blocks;
   Electro-magnetic compatibility (the EMC) and galvanic isolation of the biomedical electronic devices;
   Electrical power supply of biomedical electronic devices.
   Norms and standards, and other regulations related to electronic equipment.
   Accuracy (errors) and calibration, testing and technical diagnostics

Study books:
− R. B. Northrop. *Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation*. - Boca Raton, Florida, USA: CRC Press, 2004 (The Biomedical Engineering Series).
− J. D. Bronzino (ed.). *Biomedical Engineering Handbook*. CRC Press & IEEE Press, 1995.
− M. Akay (ed.). *Wiley Encyclopedia of Biomedical Engineering*. John Wiley & Sons, Hoboken, New Jersey, USA, 2006. Vol.1 - 6.

(Incl. M.Min, R.W.Salo, T.Parve. Biomedical electronics. In Vol. 1, pp.500-514).
More bibliographic information is available on the course pages.

Laboratory works - the information is available on the Internet pages of the Course
http://www.elin.ttu.ee/mesel/Study/Subjects/0070BME/Laborat/index.htm

Living Systems (LS)

Teacher: Jüri Vedru, assoc. professor

Course provider: Institute of Experimental Physics and Technology, University of Tartu
BME group, Tähe 4-233 , 51010 Tartu, ESTONIA   e-mail: juri.vedru@ut.ee

Moodle page of the course: http://www.e-ope.ee/course/view.php?id=933
is available on the server of the Estonian e-University http://www.e-ope.ee/course/

Annotation

This propaedeutic course is devoted to physical and cybernetic aspects of the phenomenon of life. Fundamental physical laws – energy conservation and entropy growth – in living subjects, as non-equilibrium systems, are considered. Students are introduced with features of living systems as non-linear and self-regulating ones.

Notions of information, organisation and control are explained. Problems of evolution and consciousness are considered at the end of the course. Students can influence the topics by choosing the subjects of their seminar works.

This is a MSc level course for students of Biomedical Engineering and Medical Physics or similar specialisation.

Credits: 3 ECTS

PART 1 What Follows from Classical Thermodynamics
Lecture 1: Basics for Thermodynamics
Lecture 2: Energy and its Conservation
Lecture 3: The Second Law of Thermodynamics - the Entropy law
Lecture 4: Statistical Interpretation of Entropy
PART 2 Modern Trends in Thermodynamics and Synergetics
Lecture 1: n.a.
Lecture 2: n.a.
Lecture 3: n.a.
Lecture 4: n.a.
PART 3 Information and Control
Lecture 1: Information and communication theory
Lecture 2: Information and inverted communication
Lecture 3: Contol in living systems
PART 4 Biological Evolution
Lecture 1: Models of the Universe, Galaxies, Stars and the Solar System
Lecture 2: History of Ideas on Patterns of Evolution
Lecture 3: n.a.
Lecture 4: n.a.
PART 5 From Perception to Mind and Consciousness
Lecture 1: A short introduction to the philosophy of mind
Lecture 2: Consciousness

Literature is given by the Parts.

More information about the course

List of authors Jüri Vedru (Part 1) – Assoc. Professor (Docent), Institute of Experimental Physics,
Lembit Sossi (Part 2) – Lecturer, PhD, Institute of Theoretical Physics,
Jaan Pruulmann (Part 3) – PhD Student, MSc Dept. of Physics,

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Ivar Puura (Part 4) - Research Fellow, PhD, Institute of Geology,
Bruno Mölder (Part 5) - Research Fellow, MPhil, Dept. of Philosophy)

Lecture notes are provided.
Wiki Glossary of the Course is opened.

Digital Image Processing (DIP)

Course provider: Ústav biomedicínského inženýrství (Department of Biomedical Engineering)
Fakulta elektrotechniky a komunikačních technologií
Vysoké učení technické v Brně (Brno University of Technology)
Kolejní 4, 61200 Brno, Czech Republic

Tel: 541149541   Fax: 541149542   E-mail: ubmi@feec.vutbr.cz

Digital Signal Processing (DSP)

Course provider: Department of Biomedical Engineering
Faculty of Electrical Engineering and Communication
Brno University of Technology
Kolejní 4, 61200 Brno, Czech Republic

E-mail: ubmi@feec.vutbr.cz

Labs in Matlab/Simulink
- 1st virtual lab in Matlab/Simulink - Introduction to Matlab/Simulink
- 2nd virtual lab in Matlab/Simulink - Filtering of additive sum of two harmonic signals
- 3rd virtual lab in Matlab/Simulink - FIR and IIR bandstop filter design
- 4th virtual lab in Matlab/Simulink - Application of IIR filters to ECG signal filtering
- 5th virtual lab in Matlab/Simulink - Signal filtering using advanced Simulink block, frequency sampling method

Labs in J-DSP
- 1st virtual lab in J-DSP - Introduction, signal generation
- 2nd virtual lab in J-DSP - Filtering of additive sum of two harmonic signals

Available materials
Materials are available in pdf-format

Medical Informatics Laboratory (MIL)

EVICAB, WP2

Teachers: Lindroos Kari
           Viik Jari

Course provider: Medical informatics laboratory, Ragnar Granit Institute www.rgi.tut.fi
Tampere University of Technology, Finland.
P.O. Box 692, FIN-33101 Tampere, Finland
Phone: +358-3-3115 2524   Fax: +358-3-3115 2162

Ultrasound medical diagnostics: remote online labs (RemoteLab)

Teacher: Marozas Vaidotas,

Course provider: Biomedical engineering institute,
Kaunas University of Technology, Lithuania

Aim and objectives

This course of "Ultrasound medical diagnostics: remote online laboratory" is
dedicated for learning and gaining specific knowledge in principles of ultrasonic medical
diagnostics. The specialized knowledge on ultrasound transducers and their features, on
excitation of ultrasound waves, on wave interaction with media and tissue, and those
principles application in medical diagnostics and clinical solution is to be build during
course. Attendees of practical works gets portion of theoretical background, then
performs preparatory calculation, applies the theory in investigation of given problem
using virtual instruments and finally elaborates the discussion of experimental results and
creates the decisions in the conclusions of laboratory work report. The laboratory
practical works are prepared in problem based learning approach. There is proposed
template of laboratory work report, which can be considered as the guide trough
laboratory work.

Prerequisits
To study "Ultrasound medical diagnostics: remote online laboratory" course is required
background knowledge in electronic systems and signals, practical experience using
laboratory electronics equipment for experiments.

Contents
– Preliminary questionnaire
– Ultrasonic characterisation of tissue like material
– Investigation of motion using M scan echo pulse system
– Investigation of movement speed using continuous wave Doppler device

Structure of a laboratory work
1. Aim of investigation.
2. Objectives of investigation.
3. Theoretical basics applied.
4. Structure of experimental system (hardware and software).
5. Results of investigation.
6. Discussion and Conclusion

Virtual digital signal processing laboratory (VDSP Lab)

Course provider:
Biomedical engineering institute,
Kaunas university of technology,
Studentu str. 65-107, LT-51369, Kaunas, Lithuania
Tel. +370 37 407119   Fax. +370 37 407118

About the course
1. Introduction to biomedical signals
Motivation for processing of biomedical signals
**2. Primary signal processing methods**
3. Parameterization of biomedical signals

4. Nonstationary signal analysis
Objectives:
a) Know the mathematical principles of nonstationary signal
characterization methods in time-frequency domain: Heisenberg
uncertainty principle, short time Fourier transform, wavelet transform,
Wigner-Ville transform, Cochen class of time- frequency distributions;
b) Be able to select the right time- frequency characterization method
regarding the characteristics of the signal;
c) Have skills to develop nonstationary signal characterization and
segmentation algorithms using computer (in MATLAB).

- Lecture handout (pdf)
- Simulation exeperiments: Time- frequency analysis of
  nonstationary biomedical signals using spectrogram
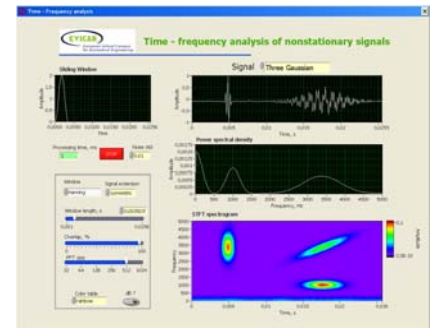
5. Modeling of biomedical signals and systems
Objectives:
a) Know the mathematical principles of linear and nonlinear modeling of
biomedical signals and systems: „surface" and phenomenological models,
system simulation and identification, parametric and non-parametric
models;
b) Be able to develop the strategy for biomedical signal and system
modeling;
c) Have skills to implement signals and systems models using computer
(in MATLAB).

6. Signal classification and diagnostic decisions
Objectives:
a) Know the mathematical principles of signal classification methods;
b) Be able to characterize the accuracy of diagnostic decisions of signal classifiers in terms of sensitivity,
specificity and ROC curves concepts;
c) Have skills to program multilayer perceptron using computer (in MATLAB), teach and verify its
performance.

Quiz.

Active learning using LabView based simulation experiments
In order to run LabView simulation files in exercises you have to install LabVIEW Run-time Engine.

LabVIEW Run-time Engine is free distributable package from National Instruments Inc. which installs all the necessary libraries to run the compiled LabView applications. You need to install this engine only once.

Please, follow this link to download the [LabVIEW Run-time Engine Version 8.2.1 for Windows 2000/Vista x64/Vista x86/XP](#).

IMPLEMENTATION

VPBMEC was applied successfully in different universities in the form of e-learning activities, on-line tests, internet examinations, and questionnaires for feedback.

Outcomes

e-learning activities

Altogether 13 e-courses (see http://www.moodle.fi/evicab/moodle/) have been included into the EVICAB curriculum by the moment. Still most of them are presently under construction and will be implemented during the next study term of the universities.

The following courses have been implemented as given in the Appendix 1.

Bioelectromagnetism. The course by the Tampere University of Technology, Ragnar Granit Institute. Teacher: Prof. Jaakko Malmivuo, assistant: MSc Outi Väisänen (see http://www.evicab.eu/ → BME Curriculum → BIOELECTROMAGNETISM).

Bio-optics. The course by the University of Linköping, Department of Biomedical Engineering. Teacher: Prof. Göran Salerud (see http://www.evicab.eu/ → BME Curriculum → BIO-OPTICS).

The *Bioelectromagnetism* course has been held 3 times under the EVICAB environment:

In 31.01. - 01.03. 2006 for students mainly of the Institute of Biomedical Engineering of the Tallinn Univerity of Technology, Estonia.

In 04.12. - 15.12. 2006 for students mainly of the Department. of Electronics of the University of Barcelona, Spain.

In 20. - 21. 04. 2007 for students mainly of the Applied Electronics Laboratory of the Helsinki University of Technology, Finland.

The course was recognized as a part of their programme by the Tallinn University of Technology and the University of Barcelona. The initiative of participation came from the informed departments, thus there were no problems with the registration onto and the recognition of the course.

The *Bio-optics* course has been held once:

In 06.10 - 07.10. 2006 for students of the Institute of Biomedical Engineering of the Tallinn University of Technology and of the Institute of Experimental Physics of the University of Tartu, both in Estonia.
The course was recognized as a part of their programme by the Tallinn University of Technology and the University of Tartu. The initiative of participation came from the

informed departments, thus there were no problems with the registration onto and the recognition of the course.

All the courses were mixed courses, composed of classroom lectures by the guest lecturer and following on-line learning. There were no problems in web-based modules. Certain difficulty was that organizing needed some practical arrangements related to time schedules etc.

For the *Bioelectromagnetism* course, student management took place in the EVICAB-Moodle environment (http://www.moodle.fi/evicab/moodle/), where the administrator created the user account for every student manually.

For the *Bio-optics* course, students were managed by ordinary administration of the students' universities.

By the present time, self-registration of the students to the EVICAB courses and their management still remain problems that need solving and testing afterwards.

Similar work must be done to break the barrier of recognition of the courses by the students' universities. Hitherto the tested way of the recognition is acceptance of the EVICAB courses by a students' university as courses belonging to the curriculum of themselves. It will need too many efforts from the students. This definitely requires cooperation between the universities participating in the EVICAB.

There is a barrier of recognition of the EVICAB courses in a students' university, but this barrier can be overcome on the grounds of cooperation between the universities participating in the EVICAB.

EVALUATION

This part of the WP2 Final Report describes shortly the online tests performed and feedback collected during the implementation of the VPBMEC.

Online tests

Online self-tests and online examination have been used, correspondingly, to enable students' self-evaluation of their understanding of the course and to give them grades for the course.

Self-tests

Self-testing is a usual method to enable the students recognize the level of their understanding of a course and this is naturally expected to be used in all the courses of the EVICAB.

A good exemplar of the self-testing is given in the *Bioelectromagnetism* course (see http://www.evicab.eu/ → BME Curriculum → BIOELECTROMAGNETISM → Exercises).

Generally, it can be concluded, that online self-testing of students does not present problems for nowadays information technologies (incl. the Moodle-based learning environment).

Online examination

Online examination is used to give to a student feedback about his/her level of mastering of the knowledge presented by the course and to assign him/her grades for the course. It is also a channel of getting reciprocal feedback to the teacher about the success of an e-course.

A good exemplar of the self-testing is given in the Bioelectromagnetism course (see http://www.evicab.eu/ → Internet Exam)

Actually, a problem remains: how to guarantee the true personality and to avoid cheating of the examined students. Still it needs participation of the students' university personnel in the examination.

In on-line examination there are applicable solutions with the participation of the students' university personnel in the examination. This definitely requires cooperation between the universities participating in the EVICAB. Still fully web-based examination techniques would be preferred but are missing.

Feedback

For the development of the EVICAB curriculum and each of the course syllabi, specially collected feedback from the students is inevitable. For all of the EVICAB courses collecting this kind of feedback is expected.

Exemplars of questionnaires for the anonymous feedback from the students can be found in http://www.moodle.fi/evicab/moodle/mod/feedback/index.php?id=18 .

For instance, the questionnaire about the *Bioelectromagnetism* course contains the following questions:
How useful were the lectures? What was the quality of the PowerPoint slides in your opinion? Did you find the internet book (the form of the internet material in the case) useful? Was the book easy to use? Did you find the exercises useful? Did you find the quizzes useful? Did you find the lecture videos useful? Was the internet exam easy to use?
The students had to evaluate these qualities in 5 point scale with 6th number (0) for indifferent answer.

The following questions should be answered in 3-point scale:
How was the internet exam? Was the internet exam easy to use? Which one do you prefer - classroom education or videolectures?

They also could supply textual comments: *Other comments on the internet material? How many hours did use do spend on the exercises? How many hours did you read the book? Other comments on the lectures?*

Final results of such feedback collected from the students passed the course in Barcelona and Helsinki (see above under **e-learning activities**) are the following:
Average examination grade for the students: 4.2 (maximum 5)
Average grade for teaching: 4.3
Course websites: 4.2
Number of active students: 54
Number of visitors in course website during the 6 months in EVICAB: 2149.

This example questionnaire shall be applied also for getting feedback about the other courses of the EVICAB. Thus, feedback about the content, presentation, tests and quizzes shall be collected.

Methods and instruments for getting feedback from the students for the EVICAB courses have been approved and ought to enable valid feedback.

SUMMARY

According to the work plan of WP2 the following outputs were achieved:
- Suggestions about the content of virtual curriculum were made;
- Preliminary agreement about the content was achieved;
- Consensus about the virtual curriculum and its content and providers was made;
- Agreement about the virtual campus, containing 5 virtual courses for testing was made;
- Announcements, advertisements and information for students were delivered through a WWW site (www.evicab.eu);
- Virtual campus web site was prepared;
- Course web sites in virtual learning environment Moodle were set up;
- Experience on activities of virtual curriculum was obtained as about 205 students participated in virtual campus and their ECTS credits transferred resulting about 827 course transactions.

APPENDICES

APPENDIX 1.

TABLE OF THE STUDENTS PARTICIPATED IN AND CREDIT POINTS GIVEN FOR THE EVICAB e-COURSES IN 2006-07

No	Course name	Teacher's name with title	Implementation dates	Where from were the students	Number of participated students	ECTS Credits	Total ECTS credits given	Which institution has managed the students	Your comments
1	Bioelectromagnetism	Prof. J. Malmivuo, Assist. O. Väisänen	31.01. - 01.03. 2006, 19.04-21.04.2007	Tallinn Univerity of Technology, Estonia	9	7.5	67.5	Students' university	Implemented partially, as a supplementary teaching instrument, Internet examination 7 students
	"	"	04.12. - 15.12. 2006	University of Barcelona, Spain	25		0	Students' university	
	"	"	20. - 21. 04. 2007	Helsinki University of Technology, Finland	25	4	100	Students' university	
	"	"	27.8.-24.11. 2007	Tampere University of Technology, Finland	18	6	108	Students' university	

2	Biomedical Electronics	Sen. res. T. Parve, Prof. M. Min	01.09.2006 - 26.01.2007	Tallinn University of Technology, Estonia	8	4	32	Students' university	Implemented partially, as a supplementary teaching instrument. Since the period 01.09.2007-21.12.2007 15 more students have participated (max 60 ECTS credits can be given before 26.01.2008)
3	Biomedical Engineering and Medical Physics	(Tallinn Univ. of Technol.), prof. K. Meigas	01.02-31.05.2006, 01.09-31.01.2006, 01.02-31.05.2007, 01.09-31.12.2007	Tallinn University of Technology	28	4.5	126	Students' university	Implemented partially, as a supplementary teaching instrument
4	Biomedical Signal Analysis	Prof. R.M. Rangayyan	28.8-1.9. 2007	Tampere University of Technology, Finland	13	8	104	Students' university	Students came from several univeristies of Finland
5	Bio-optics	Prof. G. Salerud	06.10 - 07.10. 2006, 01.02-31.05.2007	Tallinn University of Technology	18	4.5	81	Students' universities	Implemented partially, as a supplementary teaching instrument
	"	"	06.10 - 07.10. 2006	University of Tartu, Estonia	2	3	6	Students' universities	Implemented partially, as a supplementary teaching instrument
	"	"	06.10 - 07.10. 2006	Kaunas University of Technology	6	3	18	Students' universities	There were 6 students in KUT, Lithuania, participating in distance course.
6	Computational Modelling of Cardiovascular System	Prof. F. Sachse	07.03 - 09.03. 2007	Tampere University of Technology	4	5	20	Students' universities	Students came from several univeristies of Finland

7	Digital Image Processing	Prof . J. Jan	28.11 -29.11.2007	Tallinn University of Technology	7	6	42	Students' university	Implemented partially, as a supplementary teaching instrument
8	Electromagnetic Fields and Waves	Prof. I. Fridolin	1.09.-20.12.2007	Tallinn University of Technology, Estonia	18	5	90	Students' university	Implemented partially, as a supplementary teaching instrument
9	Living Systems	Assoc. Prof. J. Vedru and colleagues	1.10.-20.12.2007	University of Tartu, Estonia	4	3	12	Students' university	Implemented partially, as a supplementary teaching instrument
10	Ultrasound medical diagnostics: remote online labs	Dr. Rytis Jurkonis, KUT	01.09. - 31.12. 2006 01.09. - 31.12. 2007	Kaunas University of Technology	10	1	10	Students' university	Implemented partialy and used in the course "Ultrasound medical diagnostics"
11	Virtual digital signal processing laboratory	Doc. Vaidotas Marozas, KUT	01.02. - 31.06. 2006 01.02. - 31.06. 2007	Kaunas University of Technology	10	1	10	Students' university	Implemented partialy and used in the course "Digital signal processing of biomeical signals"