

# Learning Objects for the Virtual Campus of Biomedical Engineering

A. Kybartaitė, J. Nousiainen and J. Malmivuo, *Fellow, IEEE*

**Abstract**—Learning objects are fundamental elements of e-learning content creation and distribution. High quality and pedagogically valuable learning objects can lead to better results in education. In this paper we briefly present several learning objects developed and applied for EVICAB, European Virtual Campus for Biomedical Engineering. Thus, implemented objects may be applied for any other educational field.

**Index Terms**—Biomedical engineering, educational technology, learning objects, resource management

## I. INTRODUCTION

Better results in engineering education may come from innovative teaching techniques and effective instructional materials, which maximize opportunities for students learning in every lesson [1].

These are particularly important for relatively new and multidisciplinary field like biomedical engineering (BME), where educators have to consider how to introduce students to techniques applied in traditional engineering disciplines such as electrical, mechanical and chemical engineering and the biology based disciplines of life science and medicine [2]. Meanwhile students have to learn to apply classical engineering concepts in new ways and to an extent of biological systems not found in any other engineering discipline [3].

A traditional way of transferring knowledge effectively to students may fail despite lecturer's sound knowledge in the subject area. This occurs because often it is hard for students to take notes and listen with good comprehension simultaneously [1]. Therefore, quite often a lecture becomes one-way delivery of information.

Literature review provides a wide list of examples where innovative teaching techniques and effective instructional materials were created, developed and applied for BME. For example, Harris and Brophy [4] stated that effective instructions should be knowledge, student, assessment and community centered. The authors also considered that challenge-based instruction (CBI) could be an effective instructional model, where students apply their inquiry skills, explore multiple applications of the content and work with an instructors' guidance [4]. LaPlace et.al, [2] suggested that PBL is a

well-suited for students within the interdisciplinary field of BME. Giuffrida [5] stated that BME education requires hands on learning with cutting edge technology in order to train students to solve clinical problems in research and industry. Since real laboratories are not always available for students, learning with the aid of information communication technologies (ICT) may bridge the gap between theoretical and practical approaches. Trumbower and Enderle [6] contributed that virtual instruments imitate physical instruments and promote hands-on, real-world experiences, develop measurement skills, help to learn engineering theories and practical applications relevant for medicine and biology. Web 2.0 applications such as wikis, blogs and podcasts have been successfully adopted by health care related professionals and education services [7]. Bar et.al, [8] provided examples of instructions where numerous video-audio clips were given as background information for students learning in biomechanics.

These examples prove that traditional teaching techniques and instructional materials for delivering engineering education change into more timely and effective manner, e.g., becoming more personalized, flexible, portable, and on-demand. The starting point for innovative teaching techniques and effective instructional materials is creating learning objects.

With this paper we aim to review properties of learning objects and describe the ones we developed and applied for EVICAB, European Virtual Campus for Biomedical Engineering. EVICAB aims to develop, build up and evaluate sustainable, dynamic solution for virtual mobility and e-learning in the field of biomedical engineering [9].

## II. LEARNING OBJECTS

### A. Literature Review

Learning objects are fundamental elements for content creation and distribution [10]. Thus, the definition of learning object still causes confusion as different authors have diverse views [11].

IEEE Learning Technology Standard Committee defines learning object as "...any entity, digital or non digital, which can be re-used or referenced during technology supported learning [12]". An example of learning object can be multimedia content, instructional content, learning objectives, instructional software and software tools, persons, organizations, or events referenced during technology supported learning [12].

Sosteric and Hespermeier [13] argued that the definition for learning object should be narrowed to "...digital file (image, movie, etc.,) intended to be used for pedagogical purposes,

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Authors are with the Department of Biomedical Engineering, Tampere University of Technology, PL 692, 33101 Tampere FINLAND (e-mail: asta.kybartaitė@tut.fi).

which includes, either internally or via association, suggestions on the appropriate context within which to utilize the object”.

According McGreal [14] learning objects are sometimes defined as educational resources that can be employed in technology-supported learning. They can be modular units based on an electronic text, a simulation, a Web site, a .GIF graphic image, a QuickTime movie, a Java applet or any other resources that can be assembled together to form lessons or courses.

Miller et.al, [15] defined learning objects as “...usually a small digital or non-digital file (like text, images, audio and video) or module that when integrated with other learning objects make up course content. Learning objects are reusable resource that can be used in a variety of contexts, across disciplines and institutions. It is a resource that can be modified to suit the academic teaching style and method and further enhance the objectives of the course”.

*B. Levels of Development*

In this paper we are interested in learning objects for virtual campuses, where e-learning is a part of them.

The most common definition states that “e-learning is facilitated and supported through the use of information and communication technology (ICT)” (widely quoted without citation). e-Learning is made of interaction of number of components, i.e., courses, assessments, teaching materials, study materials, etc [15] (which can be defined as learning resources). This approach leads to the idea, that e-learning courses are created by combining reusable learning objects.

Therefore, three levels may be defined (Fig.1), i.e., 1) e-learning objects, 2) e-learning courses, and 3) virtual campus – e-learning program.

III. VIRTUAL CAMPUS

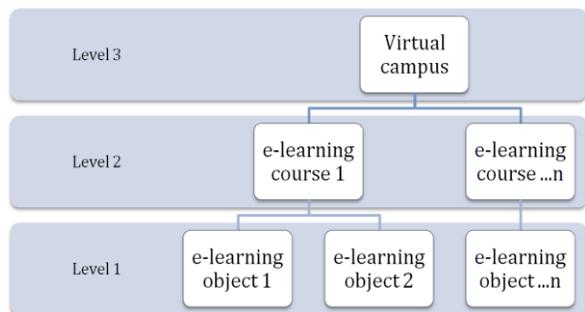


Fig. 1. Levels of development of virtual campus

*A. Learning Objects of the Virtual Campus*

We have created, developed and applied various learning objects for EVICAB. These include video lectures, e-book, virtual discussion system, online quizzes and exercises, lecture notes, animations, virtual models and simulations, Internet exam, lab works and links, virtual learning environment - Moodle and video conferencing approach. Preliminary metadata has been also created.

We consider these learning objects to be of the level 1. Several of them, i.e., video lectures and virtual learning environment can be considered of the level 2 when developing e-learning program. And the whole EVICAB is of the level 3.

Learning objects of the level 1 and 2 are discussed in the following chapters.

*Video Lectures*

Video as educational media can provide knowledge, which is difficult to achieve through text or verbally.

When developing video lectures we combined and synchronized three elements in one application: presentation slides, video and audio data. Presentation slides, as primary visual channel carried essential information, e.g., graphs, relevant pictures, samples of code, etc. Recorded live lectures were integrated as secondary visual channel and audio channel (Fig.2). Presentation slides were in .JPG files format (converted from .PPT or .PDF documents) or as .CAMREC files. Video and audio data were as .WMV files. The final format of video lectures was a Flash .FLV video format, which is popular on the web and can be easily played on every browser with standard PC/Mac.

Video lectures also include humor, personal examples, discussions, questions and gestures. Employing these techniques in teaching situations reduces complexity and provides sense of presence and includes more cues for understanding the matter [16]. Audio channel allows avoiding overloading of visual information and makes the learning process more effective [17].

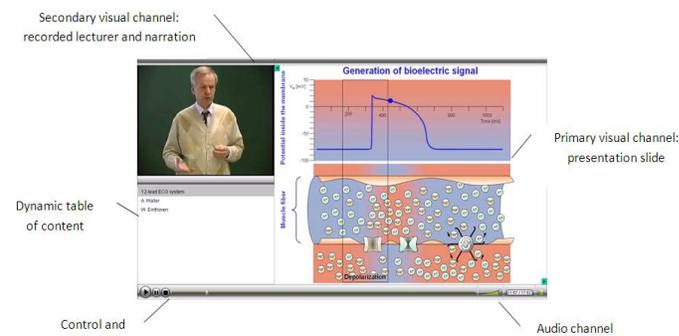


Fig. 2. Elements of video lectures (adopted from EVICAB)

Presentation slides, video and audio data were integrated so that presentation slides take 2/3, recorded live lectures take 1/6, and dynamic table of content takes 1/6 of the frame.

In order to make video lectures independent of one type of device, i.e., PC, and to make them accessible anytime and anywhere, files were also transformed to MP3, MPEG-4 and 3GP formats to be compatible with audio, video players, and mobile phones. We were mainly interested in iPods’ and media phones’ application in education. It became possible to access files with the open software, i.e., iTunes and QuickTime player, and then to upload them to personal gadgets.

*e-Book*

A free access digital book has been available for Bioelectromagnetism course. It includes the same content and follows the same structure as the originally published book [18]. The digital book in .HTM format can be read on the Internet, downloaded as a ZIP file to PC or printed chapter-by chapter by a high-quality printer (Fig. 3).

The content of the digital book comes in a textual media,

figures, tables and equations. It incorporates links to previous and next chapters, video lectures. The font size can be scaled to improve readability.

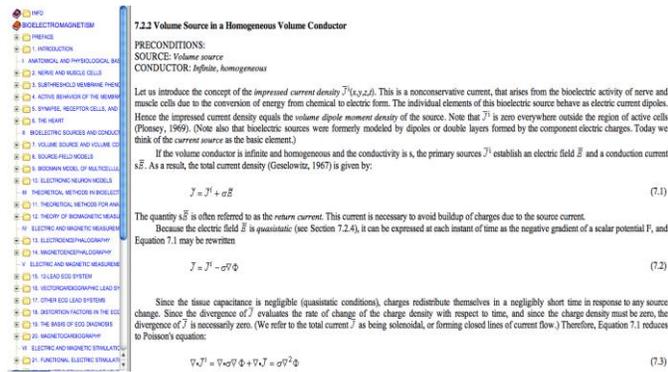


Fig. 3. Page of the e-book on the Internet

One of advantages of the digital book is that it allows knowledge to be accessible worldwide for everybody who is interested in the field; it supports e-learning.

*Virtual Interactivity System*

Classroom interactivity is a critical component of teaching and learning [19].

Since video lectures and e-book lack interactivity and possibility to ask questions or express opinion, we implemented communication and information rating system. WordPress blog tool and publishing platform [20] was adapted as asynchronous communication tool (Fig. 4). Users all over the world have possibility to leave their comments, messages and suggestions in the system. Rating system was added so that users could evaluate each lecture, which consists of several video records.

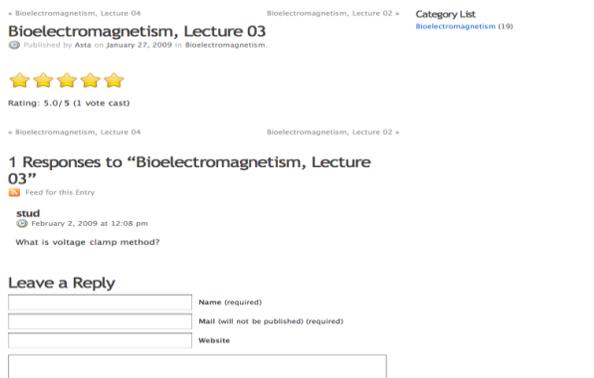


Fig. 4. Discussion system (blog) for virtual students of the course (adopted from EVICAB)

Another way to improve classroom interactivity can be by implementing wiki. It is a group collaboration software tool based on Web server technology [21]. Wiki allows building, sharing and managing knowledge for anyone (e.g., to read and update the content). There are many different wikis, called wiki clones, which can be accessed [22], and downloaded [23], [24] free of charged.

We consider that wiki can facilitate and enhance e-learning. As an example, we found related page devoted for

Bioelectromagnetism in collaborative online encyclopedia [25].

*Quizzes and exercises*

Online quizzes and individual exercises can replace related traditional classroom activities.

Online quizzes have been available for virtual students of Bioelectromagnetism course. They include multiple-choice questions based on the course content and provide immediate feedback – correct answers. Students can take quizzes over and over again until knowledge is accumulated. Quizzes allow reviewing the material and provide possibility to test one’s knowledge without lecturer’s interference.

Individual exercises are also available in virtual campus. They allow students to reflect on the material. In addition, students can work as a team and provide their solutions to an instructor for evaluation.

*Lecture notes*

Electronic lecture notes are a clear and concise medium provided openly to students via the course website [26].

We consider e-notes as .PPT presentations or summaries in .PDF, which are available for students to download to their PCs and/ or print. Electronic lecture notes include simple introductions, key concepts, theoretical foundation and practical examples. They provide an organizational framework, focus attention on the critical ideas and suggest cues for retrieval [26]. Students may annotate each slide; include comments and additional information, etc.

Electronic lecture notes are easily reusable learning objects which facilitate active learning by allowing students to be involved in a lecture [26].

*Animations*

Sometimes it can be difficulties to explain and understand various concepts, e.g., functional anatomy or clinical procedures. Animations can ease an explanatory and understanding process by making a story to come “alive”, e.g., showing how the heart contracts and relax, how action potential is conducted, how blood flows through the circulatory system, etc.

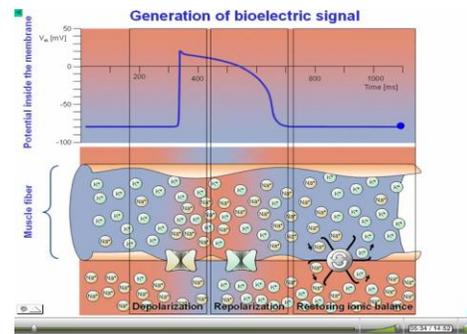


Fig. 5. Animation illustrating generation of bioelectric signal (adopted from video lectures of the course Bioelectromagnetism, EVICAB)

Several animations have been included in video lectures, in EVICAB (Fig. 5)

Animations on the web are becoming more popular because the software is no longer costly nor it is as complex or time

consuming to learn to use [27].

*Virtual Models and Simulations*

Computational modeling and simulations of physiological systems can be a practical and non-invasive method to study the functioning of living organisms.

Several physiological models and simulations were included when developing video lectures. An example is available in Fig. 6.

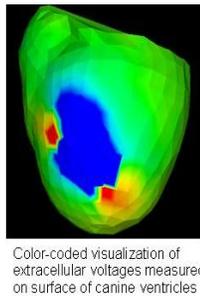


Fig. 6. Simulation – visualization of a human heart (adopted from video lectures of the course Computational Modeling of Cardiovascular Systems, EVICAB)

*Internet examination*

Internet examination is a new innovation in e-learning [28]. In EVICAB Internet examination is realized in the following way: the students attend the examination at the computer class and their identities are checked (depending on the instructions). When examination begins, the questions may be opened on the computer. All students may connect to the Internet and use all material available, including the e-book or textbook.

The examination primarily tests students’ understanding on the course material and ability to make conclusions on it. Therefore, the questions should be of the style: “ Why...? “ or “For what purpose...?” instead of “What is...” [28]. The Internet examination also makes it possible for the instructor to monitor the progress of the examination independently of the location where they are.

*Laboratory works (links)*

Deeper learning and longer retain of what has been learned can be supported by making experiments. Since real laboratories are not always available for students, interactive experiments using software tools can help students to grasp difficult theoretical concepts or develop certain skills.

A remote online laboratory has been developed for ultrasound medical diagnostics [29]; other examples are available though the tutorial links in EVICAB [9].

*Moodle*

Virtual learning environment (VLE) is a software system designed to assist teachers in managing educational courses for their students [30].

VLE Moodle [31] has been integrated as additional element in EVICAB. It has built-in enrolment system so only virtual users with provided passwords can access it.

The EVICAB Moodle [32] provides easy tools for teachers to create different activities for students e.g., material

presentation, instructions, questionnaires, etc.

*Video conferencing*

Video conferencing has a great potential for learning in Higher Education, i.e., creating greater opportunity for dialogue, which facilitates more effective learning than working in isolation [33].

We consider video conferencing as a potential mode of communication between instructors and learners or amongst learners in virtual environment; and especially for international communication. The instructor could inform certain time when she/he is available online and virtual students who have questions could contact.

According Rixon [33] students vastly prefer video conferencing to other forms of communication in distance education.

*B. Metadata of Learning Objects*

The key issue in using learning objects is possibility to identify them. Therefore descriptive learning objects’ metadata has to be created. Learning objects may be described by scale or size (e.g., course, digital asset), content (e.g., multimedia content, instructional content, software and hardware tools), and purpose or intent (e.g., instructional objects, collaborative objects, assessment objects).

The “Curriculum Page” as a preliminary metadata in EVICAB has been created. It lists all the available courses and provides links to all various materials within them (Fig. 7).

**Biomedical Engineering Curriculum**

BIOELECTROMAGNETISM							
Teacher	Course	Book	Video	iPod	Phone	Slide	Exercise
Jaakko Malmivuo: Bioelectromagnetism							
Frank Sachse: Computational Modelling of Cardiovascular System							
Risto Ilmoniemi: Transcranial Magnetic Stimulation							
BIOMECHANICS							
Teacher	Course	Book	Video	iPod	Phone	Slide	Exercise
Rami Korhonen: Biomechanical Modelling of Bone and Cartilage							
OPTICS							
Teacher	Course	Book	Video	iPod	Phone	Slide	Exercise
Goran Salerud: Biomedical Optics							
SIGNAL AND IMAGE ANALYSIS							
Teacher	Course	Book	Video	iPod	Phone	Slide	Exercise
Jiri Jan: Introduction to Biomedical Signal Analysis							
Rangaraj M. Rangayyan: Biomedical Signal Analysis							
Rangaraj M. Rangayyan: Biomedical Image Analysis							

Internet Education Tool in Evicab Moodle

Fig. 7. Biomedical Engineering Curriculum page (adopted from EVICAB)

IV. DISCUSSION

One of the main advantages of virtual education, including e-learning, is accessible education for all students; and not limited by time, place, and pace, etc. e-Learning objects should follow the same principle; they should be accessible with different tools, e.g., computers, iPods, media phones; available in different formats, e.g., digital or printed.

EVICAB includes different learning objects that can be used by students with various learning styles, e.g., auditory, visual,

active or reflective [34]. It is anticipated that when students learn in the way they prefer, they can become more interested, motivated and responsible for their learning process.

Future learning objects should motivate students and provide possibilities to test their knowledge, e.g., creating more intelligent and adaptable learning, like tests for students in the way that their level of understanding could be captured and analyzed by the automatic system, providing easier or more complicated questions.

In order to apply learning objects effectively, they should be designed considering at least following factors: relevance to a course, usability, cultural appropriateness, infrastructure support, redundancy of access, size of objects, possibility to integrate to a learning system [35].

Since it is relatively easy to implement various e-learning objects, it is important to measure if they have achieved the required outcomes. This can be tested through providing questionnaires to students and collecting their feedbacks. Positive answers indicate that learning objects have been designed and applied correctly; negative answers indicate that learning objects should be reconsidered. We have implemented this practice and evaluated students' attitudes towards learning objects for the virtual campus. Obtained results motivate to continue creating, developing and applying high quality and pedagogically valuable learning objects.

## V. CONCLUSIONS

At least 11 different learning objects have been implemented for the virtual campus of biomedical engineering, EVICAB. The same experience can be extended and applied for any other educational field.

Learning objects are not only fundamental elements of an e-learning course; but also educational institutions may establish new programs based on learning objects.

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