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Blended Teaching and Learning Solutions for Electrical Engineering Study Programs

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Introduction

This article presents the concept of using current pedagogical methods to meet the requirements for the Accreditation of EE Programs. In the multimedia and network environment, there are three teaching models which are giving priority of: traditional lecturing, independent learning, and group learning. Processes of: design, development, and implementation of interactive educational modules are presented, for the topic of electrical engineering and technology. This paper describes BTL methodologies and pedagogical approaches which use ICT in the field of Electrical and Computer EE (ECEE) program leading to international accreditation. In this paper, we review also recent ASEE (American Society for EE), IEEE (Institution of Electrical and Electronics Engineers), SEFI (European Society for EE) and IGIP (International Society for EE) papers to identify which pedagogical aspects of the instructional process have been published in the focus of this research area. Paper also reflects the experience of the Technical University "Gheorghe Asachi" from Iasi, Romania, with this approach.

Starting from Educational Objectives of EE, we analyzed how technical universities can use the web to teach and to learn applying a specific the ePedagogy for EE. We've been looking to apply the recent BTL research applied to engineering-specific study programs. Starting from the specificity of ECE online courses, some examples have been reviewed.

EE in Europe Recommend use of ePedagogy

The accreditation system for engineering training programs, EUR-ACE (EUROPEAN ACCREDITED ENGINEER), was proposed and approved in 2006. Between 2004 and 2010, the EC-DG EAC (Directorate-General for Education, Youth, Sport and Culture of the European Commission) developed EUR-ACE as part of projects, which take into account the diversity of Higher Technical Education in Europe.

The learning objectives set by EUR-ACE, defined in the Framework Standards, are in line with the European Qualifications Frameworks, apply to the 1st and 2nd grade levels, as well as the "integrated (long-term) programs" and can also be used by the polytechnic educational institutions in the countries that have not yet set up a national accreditation agency for engineering studies.

One of the main objectives of the accreditation of EE programs is to ensure transparency and to build TRUST, favoring the mobility of students and engineers. SEFI fully supports the development of the EUR-ACE system, based on cooperation and mutual recognition between existing national accreditation bodies; The EUR-ACE system has gained global visibility through contacts with Washington Accord, Sydney Accord and the entire International Engineering Alliance (IEA). SEFI recommends institutional members of higher education to use EUR-ACE certification for their program

Using the web to teach and to learn

Hybrid learning that is used creatively and efficiently can assist students by maintaining and improving the learning process. In a networked learning environment, the teacher transforms from reader to: consultant, guide and provider of training resources. The traditional teacher, who has total autonomy and total control over the teaching environment, is a provider of answers and content.

In the (BTL) system, the Teacher using a virtual teaching and control environment of the learning process must: be an expert in asking questions; be able to design experimental activities of the learning process for students; to establish only the initial structure for the activities of the students, encouraging the student's self-control in his training activity; to be a member of a teaching-learning team. BTL Professor presents learning topics with applications in various fields, highlighting important features and proposing activities that can be evaluated. The teacher is a student partner and takes into account the learning styles of the students.

The student's role in a networked learning environment changes. In traditional learning the student is a passive recipient of knowledge transmitted by the teacher and in general he must memorize the knowledge. In the BTL hybrid learning environment, the student becomes the builder of his own knowledge and a complex problem solver; analyzes the topics presented from several perspectives; asks his own questions and seeks appropriate answers;

Components of a website course

BTL Hybrid Teaching means offering the content of a course/discipline on an online platform and monitoring and controlling the learning activities performed by students to assimilate knowledge and gain practical skills. The components of a course distributed online on a platform are: the course diagram in weekly calendar format; correlated presentation of themes and objectives, didactic tasks and formative and summative assessments for each lesson, seminar, laboratory experiment or project stage, groups discuss/communicate through forums, emails and even chat; thus implementing a collaborative learning and training system validated finally by the instructor.

The information, provided to the students, regarding the course must contain: Course Title; semester; Weekly planning; Number of credits obtained by each student; Necessary knowledge gained by the student by promoting previous courses; Homework required; teaching materials that must be read and understood by each student; Planning of formative and summative evaluations (exact calendar dates with deadline for document delivery, including format); The way of appreciation and rating of the activities of each student (the time interval in which the instructor sends the student the assessment); compulsory bibliographic resources to be consulted offered by the virtual online library. The course contains information about the instructor (name, photo, email address, hours of consultation).

The study materials are multimedia: PowerPoint presentations; explanations and recommendations in audio or video format (regarding the concepts presented in the lesson); connections to teaching resources from websites (MOOC, OER courses); simulated laboratory exercises for the preparation of real laboratory experiences; online manuals.

Presentation of open educational resources

Open / free educational resources (OER) and MOOC courses can be used in designing BTL courses. MOOCs are courses with many students, which can improve the quality, access and equality in education and training.

The MOODLE platform have the characteristics of a MOOC course. MOOC is an online course designed for a large number of participants, which can be accessed by anyone who has an internet connection.

A MOOC course contains educational materials, facilitates student interactions and offers limited interactions with academic staff. There are provided study activities, tests to verify assimilated knowledge (including feedback), a study guide and an analytical program. Teaching laboratory procedures in the field of electrical engineering using a virtual laboratory, using a personal computer or other device connected to the internet, is the solution adopted by educational institutions for which maintaining an electrical engineering laboratory is not possible for various reasons.

Online laboratories in EE

The role of laboratory experiments is to develop the critical thinking of students working with real or virtual experimental resources. Students need to understand what kind of results they collect and analyze for each experiment. The student must be able to not only perform the correct experiment, but also to interpret the results correctly. Online laboratories are fundamental to the experiments carried out by students during the individual study. In the case of virtual laboratories operated from a distance, students studying engineering can develop their experimental skills and become familiar with the real phenomena. Software simulations that use the web are called "Virtual Labs" and use only software. "Remote laboratories" consist of real measuring equipment and devices and allow students to use real-world hardware through software.

The advantages of remote (and / or virtual) laboratories include: students' access to equipment; greater flexibility in the programming of laboratory experiments; a wider range of tasks or activities possible; increased opportunities for collaboration between students. In the case of laboratories accessed online, students can learn anytime and from anywhere they have Internet access. As in the case of real experiments, students can collaborate in the case of online laboratories. For the future engineer, teamwork with geographically dispersed members students practice communication and teamwork.

The student will follow with the help of simulations and video sequences the exemplification of theoretical concepts in order to deepen and understand the concepts better. There will be followed by a questionnaire with questions to which the student will receive additional information. Using the remote control panel the student will perform the experiment, visualizing and analyzing the experimental results. In this way students will understand and learn what the procedures for correcting unwanted evolutions of the experiment are.

This complex component can consist of several servers each performing several tasks / functions: presenting theoretical and practical information about the experiment; user authentication; reserving the execution of experiments.

Conclusions

We used the virtual learning environment to improve the quality of education by diversifying content and methods and promoting experimentation. The use of ICT ranges from "teacher-centered and face-to-face training" to "student-centered interactive learning environments". The use of mentoring (or coaching) is an extremely effective means of improving the assimilation and understanding of knowledge and the acquisition of practical skills by engineering students.

Mentoring is used to provide support for the student's personal development and to help him / her progress in career. The article provides resources to help educators, administrators and policymakers better apply ICT to the training programs of teachers and students involved in BTL.

Blended Teaching and Learning Solutions for Electrical Engineering Study Programs

Survey of A Project Proposal

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Abstract— The article presents a review of current pedagogical methods of designing study programs for education in the field of electric and computers engineering Using Blended Learning Resources. OER (Open Educational Resources) and MOOC (Massive Open Online Courses), Virtual Learning Environments (VLEs) are discussed. Experimental engineering skills and abilities can be developed by using remote labs and simulations. The development of critical thinking of engineer students takes place while students work with virtual resources, and students need to understand what kind of results they get for each experiment. Even if it addresses the same problems - by differentiating the simulation laboratories - it focuses on another field: not the ability to do this, but how you can do it. Online laboratories are also fundamental to the experiments the student performs in the individual study because they are specially designed for distance students who need to gain an introductory knowledge and familiarity with real-life phenomena. The instructional design model is based on the ADDIE model, which includes the phases of analysis, design, development, implementation, and evaluation. VLEs are used to make online interactions between Students and Teachers. Moodle (Modular Object-Oriented Dynamic Learning Environment) is known as an online course management system (CMS). Learning Process and Content Management Systems (LCMS), in this case, Moodle (an open source software platform for e-learning), provides instructors with the tools to create e-learning or Blended Teaching and Learning (BTL) course. The article provides resources and information to help educators, administrators, and decision-makers better apply ITC in Engineering Education (EE) programs. The resources were analyzed by the Faculty of Electrical Engineering ("Gh. Asachi" Technical University from Iași, Romania) with extensive experience in integrating ICT (information and communication technology) in the training programs of engineering teachers.

Keywords— *blended teaching and learning model for engineering education, electrical and computer engineering program, epedagogy*

I. INTRODUCTION

This article presents the concept of using current pedagogical methods to meet the requirements for the Accreditation of EE Programs. In the multimedia and network environment, there are three teaching models which are giving

priority of: traditional lecturing, independent learning, and group learning. Processes of: design, development, and implementation of interactive educational modules are presented, for the topic of electrical engineering and technology. This paper describes BTL methodologies and pedagogical approaches which use ICT in the field of Electrical and Computer EE (ECEE) program leading to international accreditation. In this paper, we review also recent ASEE (American Society for EE), IEEE (Institution of Electrical and Electronics Engineers), SEFI (European Society for EE) and IGIP (International Society for EE) papers to identify which pedagogical aspects of the instructional process have been published in the focus of this research area. Paper also reflects the experience of the Technical University "Gh. Asachi" from Iasi, Romania, with this approach. In order to reach the target of the proposed project: the use of new ICT in the training of engineers, the authors of the article consulted research papers published in SEFI, IGIP, IEEE, ASEE, EU journals, and conference proceedings. Here are briefly the topics to be considered and included in the general formulation of that project to modernize the education of computer and electrical engineers to meet the quality standards imposed by the above-mentioned organizations. The first topic relates to Accreditation of EE in Europe and worldwide [1]-[10]. The second subject is related to new modes of learning and teaching in EE [11]. Starting from Educational Objectives of EE [12], [13], we analyzed how technical universities can use the web to teach and to learn applying a specific the ePedagogy for EE [15]-[25]. We've been looking to apply the recent BTL research applied to engineering-specific study programs [26], [27]. Starting from the specificity of ECE online courses[28], [29], some examples have been reviewed [30]-[32]. Designing BTL engineering courses using Instructional Design principles was another subject [33]-[35]. It was discussed how to use LCMS, in particular the MOODLE platform for distributing BTL courses [36]-[38]. Much of the foundation of the project was dedicated to Online Laboratories, which are very important in the training of engineers [37]-[64]. OERs are very useful for Online EE [65]-[70]. Resources from MOOC courses can also be used [71]. Information from Romania [72]-[73] has been used to reflect the evolution of Virtual Learning in recent

years. In the context of using ICT in EE, the pedagogical education of Engineering Trainers must be improved [74]-[79].

II. THE ACCREDITATION OF EE IN EUROPE RECOMMEND USE OF EPEDAGOGY

The accreditation system for engineering training programs, EUR-ACE (EUROpean Accredited Engineer), was proposed and approved in 2006. It is based on SEFI documents from 2001 [1] - [10]. Between 2004 and 2010, the EC-DG EAC (Directorate-General for Education, Youth, Sport and Culture of the European Commission) developed EUR-ACE as part of projects, which take into account the diversity of Higher Technical Education in Europe. The learning objectives set by EUR-ACE, defined in the Framework Standards, are in line with the European Qualifications Frameworks, apply to the 1st and 2nd grade levels, as well as the "integrated (long-term) programs" and can also be used. by the polytechnic educational institutions in the countries that have not yet set up a national accreditation agency for engineering studies. One of the main objectives of the accreditation of EE programs is to ensure transparency and to build TRUST, favoring the mobility of students and engineers. SEFI fully supports the development of the EUR-ACE system, based on cooperation and mutual recognition between existing national accreditation bodies; The EUR-ACE system has gained global visibility through contacts with Washington Accord, Sydney Accord and the entire International Engineering Alliance (IEA). SEFI recommends institutional members of higher education to use EUR-ACE certification for their programs. Institutional members from countries that do not yet have an established EE accreditation procedure may request one of the EUR-ACE authorized agencies to accredit some of the EE Programs. SEFI wishes to ensure its strong support and involvement in the activities of the ENAEE [1].

III. USING THE WEB TO TEACH AND TO LEARN

Hybrid learning that is used creatively and efficiently can assist students by maintaining and improving the learning process [15] - [25]. In a networked learning environment, the teacher transforms from reader to: consultant, guide and provider of training resources. The traditional teacher, who has total autonomy and total control over the teaching environment, is a provider of answers and content.

In the Blended Teaching and Learning (BTL) system, the Teacher using a virtual teaching and control environment of the learning process must: be an expert in asking questions; be able to design experimental activities of the learning process for students; to establish only the initial structure for the activities of the students, encouraging the student's self-control in his training activity; to be a member of a teaching-learning team. BTL Professor presents learning topics with applications in various fields, highlighting important features and proposing activities that can be evaluated. The teacher is a student partner and takes into account the learning styles of the students. The student's role in a networked learning environment changes. In traditional learning the student is a passive recipient of knowledge transmitted by the teacher and in general he must memorize the knowledge. In the BTL

hybrid learning environment, the student becomes the builder of his own knowledge and a complex problem solver. In BTL the student: analyzes the topics presented from several perspectives; asks his own questions and seeks appropriate answers; activates as member of a group in collaborative activities; interacts with the training / study group of which he/she is part; works with tools similar to the professionals in the field of activity studied. The student is a self-motivated, autonomous manager, independent of his own learning process and controls his/her time allocated to study and training. The courses that also have content distributed on the web may be: Traditional course with web support as an additional resource, but does not oblige students to access materials or to participate in activities through the course website; Combined / hybrid web course is a face-to-face course that requires students to access materials and / or participate in activities through the course website by requiring students a certain number of contact hours through the course website.

IV. THE COMPONENTS OF A WEB-SUPPORTED COURSE WEBSITE

BTL Hybrid Teaching and Learning means offering the content of a course / discipline on an online platform and monitoring and controlling the learning activities performed by students to assimilate knowledge and gain practical skills [33]-[35]. The planning of the training activities within a BTL course results in the increase of the efficiency and quality of the learning and training processes both for all students enrolled in the course and for each individual student. The components of a course distributed online on a platform (virtual learning / training environment) are: the course diagram in weekly calendar format; correlated presentation of themes and objectives, didactic tasks and formative and summative assessments for each lesson, seminar, laboratory experiment and / or project stage. The rigorous planning of the didactic activities aims to create a virtual learning community (virtual class) in which the students divided into groups discuss / communicate through forums, emails and even chat; thus implementing a collaborative learning and training system validated finally by the instructor and / or tutor. It is intended that the training components and the content of the discipline / course correspond to the standards, objectives, tasks and evaluations of the curriculum. The information, provided to the students, regarding the course must contain: Course Title; semester; Weekly planning; Number of credits obtained by each student; Necessary knowledge gained by the student by promoting previous courses; Homework required; teaching materials that must be read and understood by each student; Planning of formative and summative evaluations (exact calendar dates with deadline for document delivery, including format); The way of appreciation and rating of the activities of each student (the time interval in which the instructor sends the student the assessment); compulsory bibliographic resources to be consulted offered by the virtual online library. The course contains information about the instructor (name, photo, email address, hours of consultation). Indications regarding the navigation mode in the course content are specified (equipment, hardware, navigator and installation of the necessary auxiliary software programs,

digital skills necessary for navigation). It specifies how the student can obtain assistance from the Online Platform Administrator. Homework (written papers, compulsory consultations of bibliographic references, participation in discussion forums, carrying out simulations, analysis of case studies) are designed so as to take into account the different learning styles of the students, to be interactive and obligatory. students to interact with each other and with the instructor / tutor through forums and emails. Students learn by solving problems, applying the concepts studied to a practical situation. Students can consult either additional documents or answers to frequently asked questions related to the subject studied. The study materials are multimedia: PowerPoint presentations; explanations and recommendations in audio or video format (regarding the concepts presented in the lesson); connections to teaching resources from websites (MOOC, OER courses); simulated laboratory exercises for the preparation of real laboratory experiences; online manuals. Every Student has his/her own personal page. Formative and summative assessments of each student's activities include: online or protected testing; standardized tests; projects; demonstrations; presentations; case studies; statistics of evaluation results.

V. GENERAL PRESENTATION OF OPEN EDUCATIONAL RESOURCES (OERS) AND MOOCS

Open / free educational resources (OER) and MOOC courses [65] - [70] can be used in designing BTL courses. MOOCs are courses with many students, which can improve the quality, access and equality in education and training. MOOCs can be implemented in formal, informal and non-formal learning. The project presented in this article uses the MOODLE platform and the distributed courses may also have the characteristics of a MOOC course [71]. MOOC is an online course designed for a large number of participants, which can be accessed by anyone who has an internet connection, does not require students a pre-arranged level of previous educational preparation for enrollment and participation and offers a complete experience being a free online course . A MOOC course contains educational materials, facilitates student interactions and offers limited interactions with academic staff. There are provided study activities, tests to verify assimilated knowledge (including feedback), a study guide and an analytical program. Teaching laboratory procedures in the field of electrical engineering using a virtual laboratory, using a personal computer or other device connected to the internet, is the solution adopted by educational institutions for which maintaining an electrical engineering laboratory is not possible for various reasons (for example the high cost of the analyzed equipment and of the measuring and control equipment). Simulations of laboratory experiments similar to real experiments constitute the resources of the virtual laboratory. For example, the electrical circuit design lab offers the possibility to experiment with particular circuits, with the option of adjusting the parameter values and observing the results of these changes. Interactive illustrations use Graphical User Interface (GUI) allows the user to interpret and understand the interdependence between related concepts.

VI. ONLINE LABORATORIES IN EE

The role of laboratory experiments is to develop the critical thinking of students working with real or virtual experimental resources. Students need to understand what kind of results they collect and analyze for each experiment. The student must be able to not only perform the correct experiment, but also to interpret the results correctly. Online laboratories [37] - [64] are fundamental to the experiments carried out by students during the individual study. In the case of virtual laboratories operated from a distance, students studying engineering can develop their experimental skills and become familiar with the real phenomena. Software simulations that use the web are called "Virtual Labs" and use only software. "Remote laboratories" consist of real measuring equipment and devices and allow students to use real-world hardware through software. ABET (Accreditation Council for Engineering and Technology) requires students studying engineering to obtain "the ability to design and conduct experiments" and "the ability to use modern engineering techniques, skills and tools." The EUR-ACE (European Accredited Engineer) criteria require that students have: "The ability to select and use equipment, tools and methods appropriate to a field of activity", as well as "An understanding of the techniques and methods applicable to a particular technical area / technological knowledge and knowledge of their limitations". Many engineering study programs now incorporate remote (and / or virtual) laboratories either to reduce costs; either for the shared use by several institutions of the equipment; either for pedagogical reasons. The advantages of remote (and / or virtual) laboratories include: students' access to equipment; greater flexibility in the programming of laboratory experiments; a wider range of tasks or activities possible; increased opportunities for collaboration between students. In the case of laboratories accessed online, students can learn anytime and from anywhere they have Internet access. As in the case of real experiments, students can collaborate in the case of online laboratories. By considering the future engineer as a teamwork member, with geographically dispersed fellows, students practice communication. We will present the concept of conducting a virtual experiment (the didactic scenario of a virtual experiment, or at a distance). First the student will have to read an introductory teaching material that presents the subject / topic, the purpose, objective and theory behind the experiment and to understand the applications of the phenomenon in various technological fields. The student will then take an online test to assess their level of knowledge and understanding of the stages of the experiment (procedure, prerequisites, hardware and software details for each stage of the experiment, the procedural details of how to use the remote control panel effectively).). The student will follow with the help of simulations and video sequences the exemplification of theoretical concepts in order to deepen and understand the concepts better. There will be followed by a questionnaire with questions to which the student will receive additional information. Using the remote control panel the student will perform the experiment, visualizing and analyzing the experimental results. In this way students will understand and learn what the procedures for correcting unwanted evolutions of the experiment are. To further deepen the

cognitive understanding, each student will receive additional tasks and will be evaluated after the execution of each operation on understanding the experimental phenomenon. The student should also study the suggested references for further information.

The components required for a remote-controlled laboratory, which allow the execution of experiments by students distributed over a wide geographical area, are presented as follows. The essential element is the experiment itself carried out using a functional set of equipment. Measurement and control devices of the sizes to be analyzed are also required. The results obtained as a result of conducting the experiment are analyzed and interpreted using a graphical interface with which auxiliary software programs are accessed. The control and monitoring of measuring devices and equipment is the responsibility of a laboratory server. The connection between students at a distance and the laboratory server made using the Internet is a dedicated server that can be a complex system of management of learning and learning content (LCMS) that manages both the users and the allocation of time for conducting experiments. . This complex component can consist of several servers each performing several tasks / functions: presenting theoretical and practical information about the experiment; user authentication; reserving the execution of experiments. The functionalities can be accessed through a web portal, acting as the first page for the experiments established by an institution or an inter-institutional consortium, offering access to a group of remote experiments. It is necessary to include a server through which the remote student can obtain visual and audio feedback of the state of the experiment. Audio, video and chat communications between users are also required. Client workstations are also needed to ensure remote users connect to the experiment and associated resources. Some remote labs will need to have specific plug-ins or allow the download and installation of client programs to gain access. suitable for the experiment (such as when using platforms that use LabView, MultiSim, etc.).

VII. CONCLUSION

In this project we wanted to create an interactive learning environment in which the students finally get skills to solve practical problems. The adopted ICT technologies improve the model of independent / autonomous learning in the ECEE study programs. We used the virtual learning environment to improve the quality of education by diversifying content and methods and promoting experimentation. The use of ICT ranges from "teacher-centered and face-to-face training" to "student-centered interactive learning environments". The use of mentoring (or coaching) is an extremely effective means of improving the assimilation and understanding of knowledge and the acquisition of practical skills by engineering students. Mentoring is used to provide support for the student's personal development and to help him / her progress in career. The article provides resources to help educators, administrators and policymakers better apply ICT to the training programs of teachers and students involved in BTL. The resources were developed by the Department for Teacher Education, with extensive experience in integrating ICT into teacher training programs. The concepts of engineering education promoted by

IGIP, and ASEE, are very favorable to the extension of the use of ICT in the Electrical Engineers Education Programs [33]. It is recommended to implement a mixed model of teaching and learning (a balanced approach between e-learning and face-to-face learning; between formal and informal learning). The skills and expertise of the engineer trained in the 21st century: critical thinking, complex problem solving, interactive collaboration, etc. Teaching the scientific, technical and technological knowledge must be accompanied by the training of skills that will allow the future engineer to solve correctly and efficiently the real problems in the technical field in which he is working. Also the future engineer will have to learn on the job (lifelong learning, using distance education).

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