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**Implement Online Laboratories in Electrical and Computer Engineering Education
using Virtual Learning Environments**

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Abstract: *The article presents a review of current e-pedagogical methods of designing study programs for education in the field of electric and computers engineering. 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. These on-line experiments can be carried out in various engineering fields, including Electrical and Computer Engineering. The instructional design model is based on the ADDIE model, which includes the phases of analysis, design, development, implementation, and evaluation. Virtual Learning Environments (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 Learning course. The article provides resources and information to help educators, administrators, and decision-makers better apply ITC in engineering education programs. The resources were analyzed by the Faculty of Electrical Engineering ("Gh. Asachi" Technical University of Iași, Romania) in collaboration with Menoufia University, Egypt with extensive experience in integrating ICT in the training programs of engineering teachers.*

Keywords: *Virtual and Remote Laboratories; Virtual Learning Environment; Blended learning model for engineering education; ePedagogy; Electrical and Computer Engineering Program.*

I. INTRODUCTION

This study presents the current e-pedagogical methods to develop a Project Design for Electrical and Computer Engineering Education Study Programs including online engineering laboratories.

II. VIRTUAL AND REMOTE LABORATORIES IN ENGINEERING EDUCATION

Essential experimental skills of engineer students can be developed with remote labs and simulations [1]-[5]. Developing critical thinking while students work with virtual resources is very important and students need to understand what kind of results they collect and analyze for each experiment. It is important for the student to be able not only to perform the experiment correctly but also to interpret the results correctly [6]. Online laboratories [7, 8] are fundamental to the experiments performed by students during the individual study. Thus, remote students can acquire introductory experiences and become familiar with real life phenomena. These on-line experiments can be conceived in various fields of engineering study. Software simulations that use the web are called "Virtual Labs" and use only the software. "Remote labs" consist of real hardware and allow people to use real-world hardware equipment through software. Because lab experiments and tools are becoming more and more sophisticated and expensive to acquire and keep functioning by universities, remote laboratories are becoming increasingly used. Remote labs are a practical alternative solution for students through which students can conduct online experiments regardless of time and space. Compared to traditional laboratory practice experiments, remote labs offer students a flexible learning mode that does not depend on time and place, access to a large number of experiments distributed over an extended geographic area and a reduction in operating costs. Remote laboratories, as collaborative educational strategies, are becoming more widespread, offering great opportunities for students to interact while studying they are selling a common goal.

| | | | | | | | |
|---|---------------|-------------------|--|--------------------|-------------------|-------------------|-----------------|
| Online Laboratory: <ul style="list-style-type: none"> • access URL • title • description • language • experiment • release Date • architecture • lab Status • access Information • costs • technical Data • documentation • tutorial • owner • administrator • creator | Remote | Laboratory | Experiment: <ul style="list-style-type: none"> • title • description • language • scientific Field • educational Level • difficulty Level • typical Learning Time • online Lab • type of Experiment • duration • creator | Observation | Controlled | Experiment | Adaptive |
|---|---------------|-------------------|--|--------------------|-------------------|-------------------|-----------------|

release Date: a fixed date on which a product is due to become available for the public to see or use
lab Status: importance that educational program give it

Figure no. 1. The Features of Online Laboratories

Figure 1 shows the features of an online lab. An online lab is an environment that allows a person to perform experiments and/or simulations using the Internet. Online laboratories contain software-based simulations or experiments that use real hardware. An online laboratory can be divided into three types of laboratories: 1. Remote laboratory; 2. Virtual lab; 3. Hybrid Laboratory (an online lab that combines real-world hardware experiments with software simulations). An online lab may contain one or more experiments in various fields of science and engineering.

An experiment is defined as the smallest unit of an online lab and allows for virtual or real-world experiments to observe the behaviour and outputs of a technological system under study. An experiment can be ranked according to the interactivity between the experiment and the experimentator as follows: 1) Observation Experiment for which the parameters of the experiment

under observation and the experimental environment are fixed (unmodified); 2) Fixed Experiment environment is fixed, but experiment parameters can be remotely changed, and one or more remote measurement tools may be controlled; 3) Adaptive Experiment for which the parameters, as well as the experiment environment, can be remotely changed. For example, a circuit configuration can be changed.

2.1 Remote and virtual laboratories

1. Simulations are imitations of operating systems through time, via computers [9, 10]. Simulations Labs represent a process on the basis of a model that is cheaper, faster, less risky and more affordable than the real process. Simulation Laboratories are primarily used for: a. Pre-lab experience to give students some idea of what they will encounter in an actual experiment; b. Substitute for physical lab exercises; c. Substitution, when the system studied is dangerous, expensive or large, and not practical for a typical educational laboratory. Simulation-based labs on the Internet which use software can be classified into two groups: a. Processing on each client: simulators of real-lab tools/experiments can be run on students' computers; b. Processing on a server: the simulator is run on a server and is accessed by students remotely through the web. The interface is a www browser.

2. JAVA-applets. Classical simulations contain certain elements of laboratory experiments and are available on the Web (online) or are available as JAVA-Applets (or accessible with plug-ins) (Cyber Labs).

3. Virtual laboratories are: a) Science laboratories which simulate a virtual technology system on the computer screen; b) is an online laboratory which provides software simulations or applications and exploits the potential offered by modern media technology key features: technical interaction, and direct and plausible manipulation of objects and parameters.

4. Virtual Reality Labs (VRLs) are computer-based and highly interactive. The user becomes a participant in a "virtually real" world, in a three-dimensional artificial optical environment. These workshops have a complex interface that includes real-time three-dimensional simulations and uses different sensory channels.

5. Remote Laboratories Controlled by Distance (otherwise known as online labs or workbenches) include real experiments conducted from a distance with the use of telecommunications (accept commands via the Internet [11]), while the user uses this technology from another location [12]. Most of the virtual laboratory software consists of computing applications running on the local user's computer, for speed and security reasons [13]. The control of real hardware and the realization of real measurements is possible for Remote Laboratories.

2.2 Remote Labs used in Engineering Education Programmes

ABET (Engineering and Technology Accreditation Board) includes in the results of a study program that Engineers will have the "ability to design and conduct experiments" and "ability to use engineering, engineering and engineering tools." The Criterion of the EUR-ACE (European Accredited Engineer) program calls for future engineering students to obtain the completion of their studies: "Ability to select and use appropriate equipment, tools and methods" and "An understanding of the applicable techniques and methods and also which are the limits of these processes. "

Many Engineering programs currently include remote (and / or virtual) laboratories for either: saving money; expand the use of limited resources or share equipment with another educational institution; or for pedagogical reasons. Depending on how laboratory experimental work takes place, these benefits may include: increasing student access to equipment (workload and student time); greater flexibility in programming laboratory work; a wider range of possible activities; increased collaboration opportunities between students. If laboratories are accessed online, students can (potentially) be involved in learning an experiment anytime and anywhere they have access to the Internet, unlike practical activities based on when campus buildings are open and staff members are available. Finally, there may be increased student collaboration opportunities when laboratories are accessed online, while eliminating the same constraints on the location of traditional working groups. For a tomorrow's engineer, working in a team whose members are scattered around the country (or around the globe) can be a habitual thing and provides students with practical skills to get useful skills in this working environment (communication and teamwork, e.g).

III. VIRTUAL AND REMOTE LABORATORIES ARCHITECTURE

Collaborative Accessibility Platform (VL Platform) to Support Distributed Virtual Laboratories [14] has a multi-tier architecture, based on moodle LCMS, that not only supports technological variations, but also allows for collaborative development, publishing in various online and prints formats, security, audit, and access controls. The system also provides the standard functions of a Learning and Content Management System in ways that can accommodate effective development and use of virtual and remote labs.

VL Platform may reside in the cloud, while remote equipment will be located at various geographically distributed labs behind institute firewalls. It maintains the technology-independent data of multi-institutional labs along with the metadata of parts of labs that are dependent on proprietary software technology or remote equipment in the cloud. Simulations that require proprietary software and remote equipment are maintained at local institutional servers. Thus, labs from different institutes may add existing simulations or remote labs to the system using customizable templates and protocols for remote labs. The platform also requires secure user access to remote equipment, thus ensuring the safety of expensive equipment. Lab owners may reuse components such as simulations, animations, videos, and assessments from other labs to create new components. The instructor can create groups, add students, assign learning modules, give assignments, monitor student usage and evaluate student performance.

VL Platform offers rich content management and collaborative authoring environment, with versioning of all changes along with automatic logging of data and related data analytics. Configurable templates offer a similar look and feel regardless of the source's technological constraints while allowing further customization by the developing institute. In addition, the system supports a simultaneous deployment of multilingual labs and uses a modular format for text storage that lowers the cost of translation. The platform supports content versioning and allows collaborative lab developers to revise, create and manage versions, while also allowing restoration to previous versions. The templates separate the content, the visuals, and the structure, allowing the final output to be defined based on the device type or publishing to media types such as web applications or print materials.

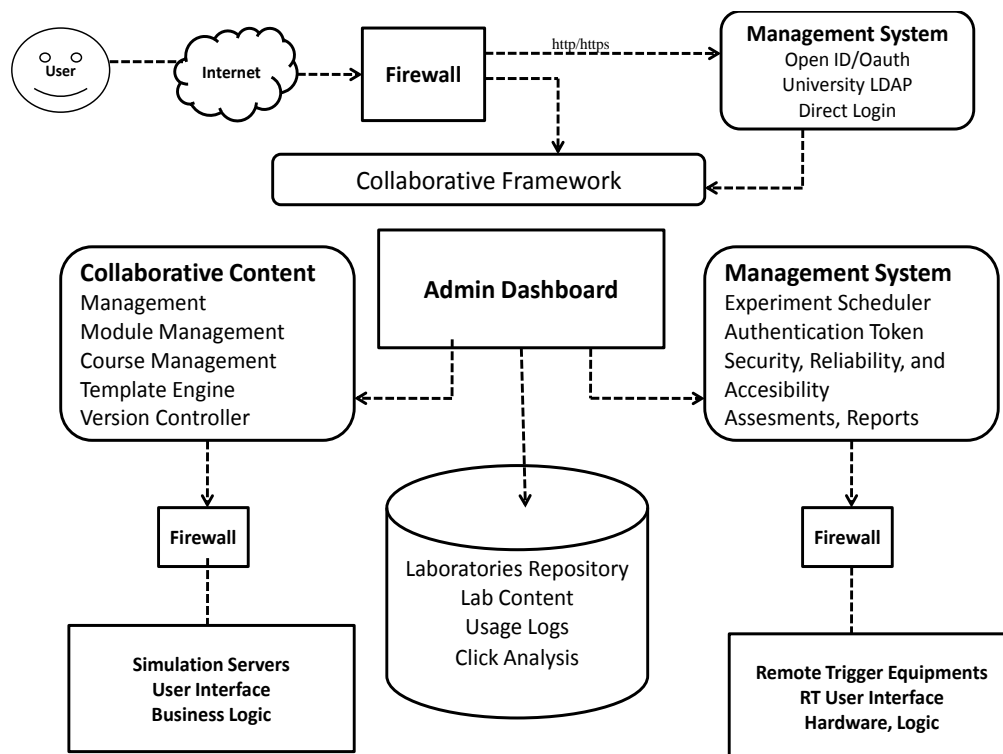


Figure no. 2. Collaborative Accessibility Platform/Frameork for Virtual Labs

The VL Platform (figure 2) provides a flexible work structure for users: developers, educators and students. No matter how the laboratories are engineered, the Platform offers pedagogical facilities to developers of laboratory work and provides structure for the learning environment. The learning environment is made up of screens and / or tables associated with various aspects of pedagogy, such as conceptual background and theory, procedures, video demonstrations, animations, exact mathematical simulations, and online access to remote equipment, as well as assessment tools learning. In this way, students can achieve the conceptual, procedural, and experimental abilities. Finally, Students are able to conclude on findings and reports as a result of their laboratory experiments.

| Analysis | Design | Development | Implementation | Evaluation |
|---|---|---|--|--|
| <ul style="list-style-type: none"> ▪Designer will detect -Knowledge and skills of the learner -Important goals that need to be established -Who is the target audience ▪Designer can also determine -Environment -Delivery of learning objectives -Time frame of project completion | <ul style="list-style-type: none"> ▪Design the structure of the course -Coordinate your objectives -Identify contents and strategies based on behavioral results -Analyze information Create prototype The designer implements visual design -Graphic design -Interface -Media selection | <ul style="list-style-type: none"> ▪Produce the actual learning criteria -Develop course materials -Add assignments -Create quizzes and assessments -Review and revise course objectives -Do a pilot test for a final review | <ul style="list-style-type: none"> ▪Training procedure is developed for facilitators and learners This will cover: -Curriculum -Outcome -Method of delivery -Procedures for testing | <ul style="list-style-type: none"> ▪Formative Evaluation -This part of the evaluation is presented in every phase of the ADDIE model. ▪Summative Evaluation -Opportunity to receive feedback from the learner. -If necessary, revisions are made at this point. |
| <p>Identification of learning objectives, goals, audience, delivery options, and timeline of project was the main focus during the initial analysis phase.</p> | <p>The second phase dealt with the design of the learning platform, experiment planning, contents to publish, media selection, arrangement of various formats of the contents and prototyping by means of Instructional Objectives.</p> | <p>Next, lab developers designed the experiments and performed continuous testing, validation, and debugging for the labs during the development phase.</p> | <p>Ensuring the proper placement of contents, tools, and media as well as the procedure for training educators and students were carried out in the implementation phase.</p> | <p>Formative Evaluation was conducted for each individual stage of the process, and the resulting feedback information was immediately integrated into process revisions for that stage. The Summative Evaluation was performed by collecting feedback from users and incorporating their suggestions.</p> |

Figure no. 3. The ADDIE model for instructional design

Lab developers may tailor both the order and the presentation style to suit various teaching styles as well as diverse student needs.

Instructional Design Model. The design of the VL Platform is based on the ADDIE model. ADDIE is a flexible model with structured guidance for design and provides collaboration at every level. The ADDIE model (figure 3) is a project management tool for creating successful instructional design plans. The ADDIE Model consists of 5 phases: Analysis, Design, Development, Implementation, and Evaluation. Identification of learning objectives, goals, audience, delivery options, and timeline of project was the main focus during the initial analysis phase. The second phase dealt with the design of the learning platform, experiment planning, contents to publish, media selection, arrangement of various formats of the contents and prototyping by means of Instructional Objectives. Next, lab developers designed the experiments and performed continuous testing, validation, and debugging for the labs during the development phase. Ensuring the proper placement of contents, tools, and media as well as the procedure for training educators and students were carried out in the implementation phase. During the evaluation phase, both formative and summative evaluations of the lab were carried out. A formative evaluation was conducted for each individual stage of the process, and the resulting feedback information was immediately integrated into process revisions for that stage. The summative evaluation was performed by collecting feedback from users and incorporating their suggestions.

Draft Standard for Networked Smart Learning Objects for Online Laboratories. This standard [20], [21] defines methods for storing, retrieving, and accessing online laboratories as smart and interactive learning objects (figure 4). The figure 5 illustrates the implementation levels of online labs as smart learning objects which are considered hereafter for standardization.

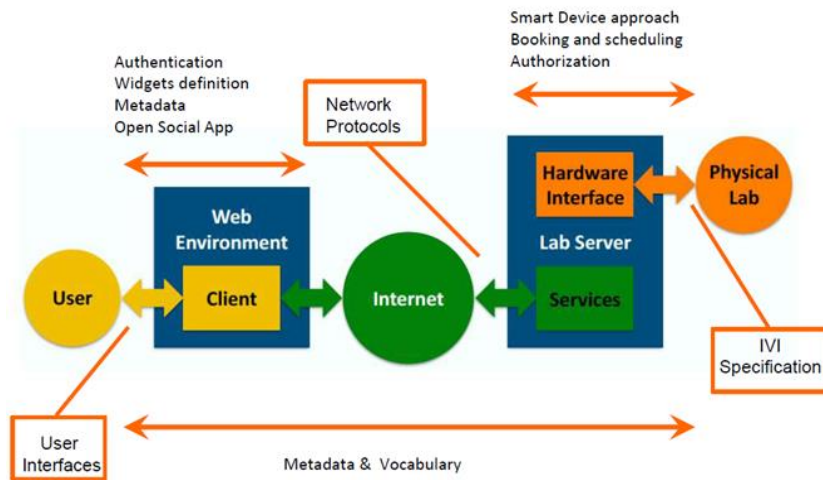


Figure no. 4. Online laboratories: context

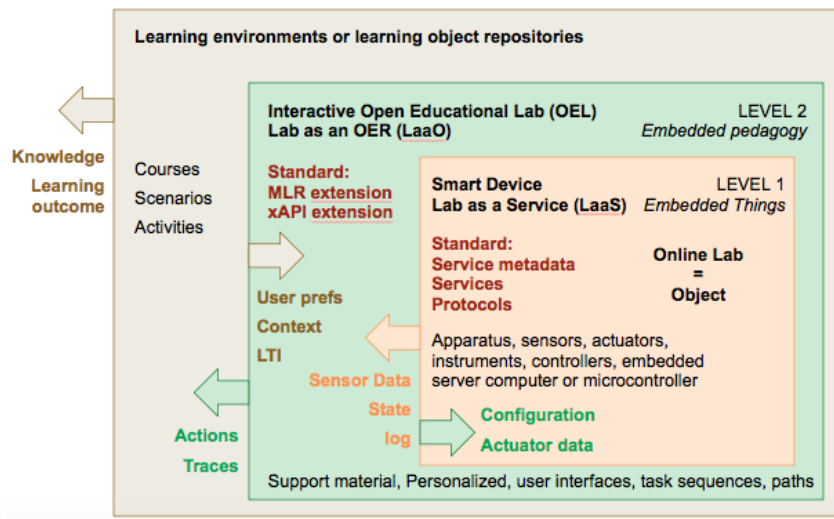


Figure no. 5. Conceptual layers and normative information

The first level standardized an online lab as a service (LaaS) which can be personalized at the second level. The second level standardize an online lab as an Open Educational Resource (LaaO) which can be integrated into learning environments or hosted in learning object repositories.

IV. EXAMPLES OF ONLINE LABS

A. Science, Technology, Engineering and Mathematics (STEM) in Europe. Studies on Education Policies and Practices in Europe funded by the European Commission have shown that in European education systems in Europe: STEM studies have a low attractiveness and the labour market in the STEM-related sectors is not satisfied. The Scientix Moodle program [15] was designed as a platform for peer learning for an exchange of best practices between STEM teachers throughout the European Union. The latest courses on the Moodle platform have been developed by teachers from different countries who shared their experiences of using different tools and teachers in classrooms. Courses are self-paced and can be accessed by anyone at any time, and users do not need to create a Moodle account to study. Created by European Schoolnet, the Future Classroom Lab (FCL) has six

learning areas; visitors can explore key elements in delivering 21st century learning: student and teacher skills and roles, learning styles, learning environment design, current and emerging technology in education, the socio-economic requirements and expectations affecting education [16]

B. Labs Virtual India: Learn, Simulate, Practice, Self Evaluate. The virtual laboratories [17] - [21] are a project initiated by the Ministry of Human Resources Development (MHRD), the Government of India, under the coordination of the National Mission for Information and Communication Technology Education (NMEICT) (figure 6).

Objectives: 1. Providing remote access to laboratories in different disciplines of science and engineering; 2. Encourage students to experiment by stimulating their curiosity and helping them learn basic and advanced concepts through remote experiments; 3. Provide a complete learning management system around virtual labs where students can benefit from the various learning tools, including additional web resources, video lectures, animated demonstrations and self-evaluation; 4. Distribute costly equipment and resources that are otherwise available to a limited number of users due to time and geographical distance constraints.

4.SIMULATOR Verification of Norton Theorem.

Verification of Norton's Theorem

1.THEORY

2.PROCEDURE

3.OPERATING ENVIRONMENT

4.SIMULATOR

5. QUIZ

6.REFERENCE

Figure no. 6. Verification of Norton Theorem Simulator

Characteristics: 1. Virtual laboratories provide students with the result of an experiment by: ▪ Modelling the physical phenomenon with a set of equations and performing simulations to obtain the result of a particular experiment and providing an approximate version of the "real experiment"; ▪ Provide measured data for virtual laboratory experiments corresponding to data previously obtained by measurements on a real system; ▪ Performing a real-time experiment in a remote laboratory and providing students with the help of the computer interface the control of the remote laboratory experiment; 2. Virtual laboratories can be more effective and more realistic if they offer students more communication channels, such as audio and video streaming as they accompany an experienced phenomenon, and the operation of real equipment. In this laboratory, students will get to explore and learn various concepts regarding analogue electrical signals, networks and measurement of various electrical components. The experiments are developed on open source web based platforms, so that the student doesn't need to download or install any third party application. In each experiment, the student first get to learn the theories well and then perform the experiment to enhance their knowledge.

V. CONCLUSIONS

The article provides resources to help engineering teacher educators, administrators and policymakers better apply ICTs to engineering education programmes. The resources were developed by Departments for Teachers Education with extensive experience in the integration of ICTs into engineering teacher preparation programmes.

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