



Remote Laboratory for Secondary School Physics Curriculum

Olga Dziabenko, Olatz Alzola Colinas, Javier Garcia-Zubia

DeustoTech, University of Deusto, P. Andrés Urdaneta School

Faculty of Engineering, University of Deusto (Spain)

olga.dziabenko@deusto.es, olatz.alzola@colegiourdaneta.com, zubia@deusto.es

Abstract

This paper describes the current influence of the remote laboratory on practical learning aspects of secondary sector of education. The key challenges faced by the teaching of science include insufficient hands-on laboratory usage in classrooms. The main objective of the paper is to present learning approach of usage VISIR - Open Lab Platform for teaching Ohm's Law in Physics curriculum of secondary school. The activity was organized on the basis of P. Andrés Urdaneta School with support of the remote lab WebLab-Deusto. Educators can benefit from different teaching methods (collaborative, inquiry-, and project-based learning) integrated in WebLab-Deusto.

Electrical experiments are common at schools and universities. Usually students execute experiments in the frame of traditional hands-on laboratories. However, the laboratory equipment is expensive and its maintenance is complicated. The remote laboratory reduces the costs significantly, makes lab experiments available almost at any time and everywhere, personalizing the learning pathways. The existing remote laboratories are more or less copies of hands-on ones. Virtual Instrument Systems in Reality (VISIR) Open Lab Platform is a remote laboratory created by Blekinge Institute of technology (BTH) for designing, wiring, and measurement of electric circuits. This main feature of VISIR allows to build a scenario of performing basic DC and low frequency AC circuits experiments related to Ohm's and Kirchhoff's laws. Moreover, the students will become familiar with instruments, components, manuals, data sheets, circuit wiring, and other laboratory work.

In the paper the remote experiments executed by students will be presented. Finally, the preliminary result of integrating of remote experiments for study in Urdaneta School will be discussed.

1. Introduction

During last two decades the information technology has been changed the education excessively causing modernizing. ICT revolution contributed as well into structural shifts in the economy. Today the need of industry in unskilled labor is reducing while the need and effective demands for highly educated, capable of adapting and using complex modern technologies employees are increasing. At the same time the percentage of drop off students in science, technology, engineering and mathematics (STEM) is very high - 30% for the science education and 50% for the engineering. What knowledge and how the students should obtain in order to keep their motivation and engagement? Indeed the first encouragement students get in the school through the class instructions, practical assignments, laboratory work, and extra curriculum activity. A teacher is a core of knowledge mechanics. Because of that teachers should have access to high quality and real-life-based resources to support student's curiosity with up-to-date research and developments in STEM, with multimedia interactive instruments including an experimental laboratory. The experimenting influences students' innovation and creativity. It is no secret that laboratory equipment is expensive and its maintenance is complicated. The remote laboratory can reduce the costs significantly, makes lab experiments available almost at any time and everywhere, personalizing the learning pathways [1], [2].

Observing the tendency of decrease in the interest in STEM studies and understanding the demand for well-educated individuals for the contemporary society, several EU researchers decided to consolidate their efforts to reconsider new strategies in the STEM educational field. The OLAREX – Open Learning Approach with Remote Experiment project was developed for this purposes.

2. OLAREX

The project OLAREX has been funded with support from the Lifelong Learning Programme (KA3 - ICT) from European Union. The main goal of the project is to innovatively implement ICT-based learning materials, remote experiments, and e-didactic methods into formal and non-formal lifelong learning settings. It will enhance and modernize science, technology, engineering and mathematics (STEM) curricula, foster student creativity and motivation, and develop professional skills and insights about the impact of evolving technologies.

As a first step consortium conducted a Europe-wide e-survey for all secondary school sector actors and enterprises in order to understand ICT competence needs and remote laboratory demands in contemporary STEM [3]. As a result of this study the online training programme for secondary school teachers in six consortium countries: Austria, Bulgaria, Hungary, Lithuania, Poland and Spain, was developed. The themes of all education products - courses and modules - were chosen based on the study reports of each participating country, and personal interviews and discussions with secondary school representatives. The programme consists of five training courses using ICT-based learning materials, remote laboratories, and e-learning method (Fig.1).

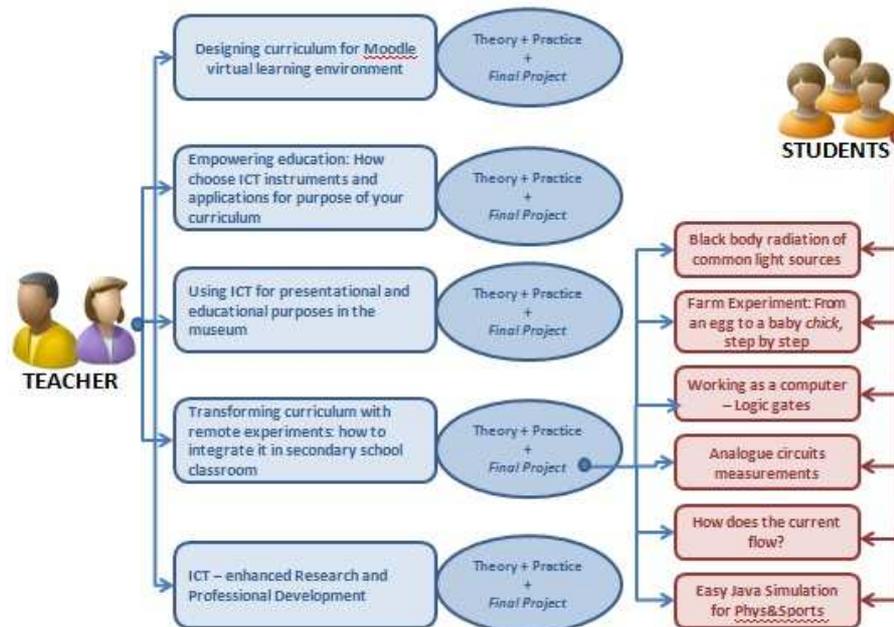


Figure 1: Structure of the Online Training in frame of the OLAREX project

One of five courses “Transforming curriculum with remote experiments: how to integrate it in secondary school classroom” supports with six e-didactic learning modules. Each learning module offers practically-oriented approaches presenting didactical materials and examples for remote experiments and its work explanations.

In the module “How does the current flow? Ohm’s Law“, the Virtual Instrument Systems in Reality (VISIR) Open Lab Platform is suggested to be used. This external remote laboratory is integrated in a frame of WebLab-Deusto as a tool for practice work for teaching electrical or electronic circuits, for instance, Ohm’s Law.

3. VISIR Open Lab Platform

Electrical experiments are common at schools and universities. Usually students execute experiments in the frame of traditional hands-on laboratories. The existing remote laboratories are more or less replicas of hands-on ones. Virtual Instrument Systems in Reality (VISIR) Open Lab Platform is a remote laboratory created by Blekinge Institute of technology (BTH) for designing, wiring and measurement of electronic circuits. A student designs circuits using virtual instruments and wires on the interface of the devices-gadgets such as: Smartphone, tablet, iPad, and PC. Then, VISIR Open Lab Platform converts the student’s design into a real wired circuit and sends the measurement results to the interface of the student device. Thus, VISIR Open Lab Platform is a real electronic lab environment which can be accessed at any time and from anywhere over an internet [4].

There are three main scenarios for practical learning using VISIR Open Lab Platform [5], however we will only present the usage of the VISIR by secondary school students. They can use VISIR Open Lab Platform for performing basic DC and low frequency AC circuit experiments related to Ohm’s and Kirchhoff’s laws. Moreover, the students will become familiar with instruments, components, manuals, data sheets, circuit wiring, and other laboratory work [6].

The main part of VISIR Open Lab Platform architecture is online workbench (Fig.2) that is similar to



hands-on laboratories at any school. Workbench for electrical experiments contains power sources, measuring instruments and a solderless breadboard (Fig.2). A virtual instructor protects the online workbench from student's harmful errors and damages during experiments.

The VISIR Open Lab Platform provides a virtual component box and virtual breadboard for controlling the switching matrix and for "wiring" circuits remotely with the mouse pointer. Users select components using the button "+" from the library of components and put them into the component box.

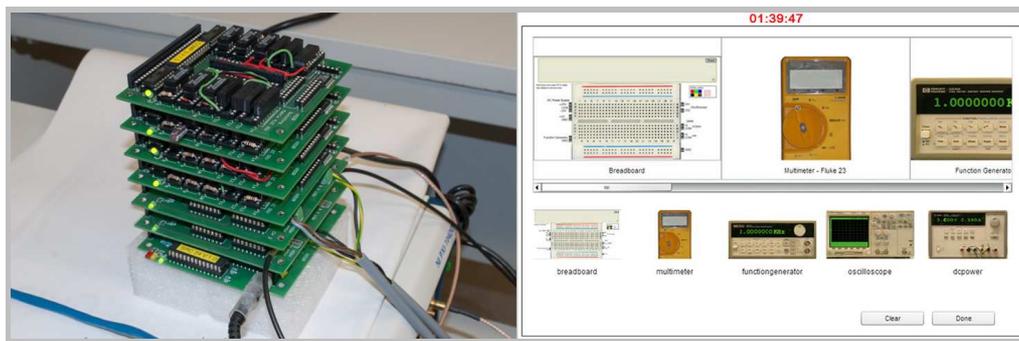


Figure 2: The online VISIR workbench at WebLab - Deusto, University of Deusto.

The VISIR Open Lab Platform offers virtual front panels of the desktop instruments and the multimeter in image format (Fig.2). Adobe Flash animations enable students to turn the knobs and buttons, and make settings using the mouse pointer. In order to avoid misunderstanding and provide immersion of the remote experiment, the virtual panel is an exact virtual copy of devices which students use at hands-on laboratories. In order to build holistic immersion of the experiment sessions of the remote activity should be organized as a hands-on laboratory - one workbench per student or student's team [7]. Each remote student or student's team creates the experiment using laboratory interface and sends a message containing a description of the desired circuit and the instrument settings to the VISIR workbench (server). The experiment result or an error message is returned to the requesting client computer after performing the procedure. The student should wait in queue to execute the experiment in case of server occupation.

4. Ohm's Law Learning Module

The provided module is a didactic support module for implementing the remote experiments in a classroom. Teachers can use its structure as a whole element without any changes. They can apply some parts such as exercises, experiments, problems, or only ideas of topics for student's final projects. Average learning time for the module is around 20 hours: 10 hours of theory, 5 hours of execution of exercises, tests, experiments, and one final small project (5 hours of work) are included in the module. The learning module covers following topics: electrical current, Ohm's law for direct and alternative current, electrical resistance, capacitors, signal generators, digital circuits and measurements within the VISIR. Each module unit provides both theoretical and practical approaches including a problem solving by simulations and using remote experiments.

Designing real experiments confirming the hypotheses, building a practice to work with laboratory materials and equipment, and using the VISIR remote laboratory to carry out a research of the nature of direct and alternating current and digital circuits are the main learning outcomes that were achieved by learner having successfully implemented all module tasks and assignments.

5. Results of implementation in school

The laboratory practice with remote experiments was taking place during two weeks in March 2013. Forty eight students from two classes of Urdaneta high school (Loiu, Bizkaia, Spain) [8] participated in it. A group of Urdaneta high school teachers in STEM areas have volunteered time within their busy schedules, to design and implement one curriculum topic – Ohm's Law, which requires the laboratory practice, learning, and understanding of the technology [9].

The activity is divided into three parts. In the first part a teacher presents WebLab-Deusto remote laboratory: how to login in the remote laboratory, how to work with library of the components, how wire



before the actual activity will start; share their final project with friends and discuss it during lessons; obtain understanding of research cycle from hypothesis statement until analysis of the results, discussion, conclusion and report writing. However the remote laboratory needs holistic understanding of the difference between computer simulation and real experiments provided with Internet. There is no doubt that the fast without any interruption Internet is required. Several sessions were needed in order students can recognize that it needs time (just several seconds) to send signals to server, complete the experiment and get it back on the screen of their computer, tablet or Smartphone. Namely, this misunderstanding was a reason of student's disappointment on the first stage of work with VISIR at high school level. We decided in the next semester to improve the strategy of introduction of remote laboratory in secondary school classroom.

6. Conclusion

Since 2005 the Faculty of Engineering of the University of Deusto has provided WebLab-Deusto - a remote laboratory for technical curricula. WebLab-Deusto is focused on the development of an infrastructure that enables students to access hardware of experiments located at the University over the Internet. Today's WebLab-Deusto 4.0M1 is a robust platform that uses web standards suitable for mainstream web browsers and is adapted to mobile devices. It can be downloaded and deployed to serve new remote experiments in different environments and operating systems. The general features of the system are a secure and scalable design, using SSI in the communication, checking experiment in the management layers, and tracking down the use of the system and the messages sent by students. The system also supports different authentication schemes such as a regular database, LDAP, supported external students OpenID. It is extensible enough to be integrated into a number of platforms such as Facebook, LRN and LMS, e.g. Moodle, and to integrate external experiments such as VISIR.

In this paper we discussed the aspect of integration of remote laboratories into the secondary school curriculum using WebLab-Deusto. Thanks to contemporary communication instruments, common resources including remote experiments are available for students worldwide. That is a great solution to eliminate the challenges and meet the demands of growing globalization in STEM education.

Our future work can be presented in three aspects: to provide this teaching approach to several EU countries, providing teachers online technical and content support; to improve introductory and visionary activity for remote laboratories in secondary school to allow a holistic immersion to the topic; to personalize the web interface of the remote laboratories and experiments. This year we have got the first results of using the remote experiment in the secondary school physics instruction. The 72% of successfully performed exercises and laboratory work students show that this tool is valuable supplementary instrument in the education of school sector. As well it has solid potential to encourage students' interest in STEM subjects, to enhance and modernize STEM curricula, foster student creativity and motivation, and develop professional skills and insights about the impact of evolving technologies.

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