Integration of an e-learning Platform and a Remote Laboratory for the Experimental Training at Distance in Engineering Education

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Abstract— Nowadays, it is more common to use both systems, a Learning Management System (LMS) and a remote laboratory, independently. However, we understand it is highly convenient for the students to have access and perform real experimental practices in remote laboratories from a LMS. This integration of both educational resources constitutes one objective of a project developed by a joint venture company-university: a technology company (“e-ducativa”) and a public university (UNR). The project is based on the addition to the “Virtual Campus LMS”, developed by “e-ducativa”, of a function that allows the access and control, via Internet, to the “Remote Laboratory of Electronic Physics” located in the university headquarters. Technology is basically a self-communication protocol that allows exchanging data in a standardized way between the LMS software and the device control connected to the remote equipment. The project includes the implementation of an interface that allows the users of the e-learning platform to have access to it and to future developments of remote laboratories. In this paper the authors describe the technical implementation of the project and provide educational criteria in order to integrate the new development into the electronic engineering curriculum.

Index Terms—remote lab, LMS, e-learning, online engineering

I. INTRODUCTION

The advances in knowledge, methods and techniques associated to the field of information and communication technologies (ICT) are allowing significant changes in the educational practice. The applications are a lot and they allow increasing the capacity in ranges of distance communication, to guide the student in his decisions through techniques of artificial intelligence, and to develop efficient and trustful mechanisms of asynchronous communication among others [1].

In this context, the Learning Management Systems (LMS) widely spread among the educational institutions, are highlighted. They are allies in the development of distance education through the Internet, and help to the management of information, the availability and distribution of multimedia didactic materials, the collaborative development of learning activities, and the personalization of learning strategies, the bi and multidirectional communication (synchronous and asynchronous) without taking into account the place of residence.

However, these systems, as they are known today, become limited when they have to provide distance education in the field of scientific-technologic disciplines with an experimental base. On this matter, it is true that through the use of the LMS systems it is possible to do certain practical activities (exercises, exams, and on line handing in of projects). Yet, it is also true that purely practical activities of such technical fields, as Engineering, do not find in LMS an overall solution. This problem is solved by the remote laboratories [2].

In the Facultad de Ciencias Exactas, Ingeniería y Agrimensura of the Universidad Nacional de Rosario (UNR) we developed a Remote Laboratory of Electronic Physics [3] [4]. It is possible to enter the site http://labremf4a.fceia.unr.edu.ar/ with a username and password. This laboratory has been and is still used in training courses for professors at different levels, in subjects of post graduate careers and updating courses dealing with the incorporation of ICT at technological university level and as an extra didactic resource [5] [6] [7] for the teaching of the main properties of the basic electronic devices in the subject Physics IV, Electronic Engineering, UNR. On the other hand, independently, in such a subject we are using the e-ducativa e-learning platform.

But we understand it is highly convenient for the student to have access and perform real experimental practices in remote laboratories from the system LMS. The latter is used to have access to the learning materials, communicate among students and professors and perform and send learning activities.

Out of this, we have started a project to integrate both systems. Such a project is being developed by this work’s authors as a technologic link between the company e-ducativa and the Facultad de Ciencias Exactas, Ingeniería y Agrimensura of the UNR.

On this subject, there are relatively recent antecedents of remote laboratories integration with e-learning platforms. In particular, in Ibero-America we can mention, among others, the works [2] and [8]; in all cases, they are self-made developments of remote laboratories in universities with the Moodle platform, open code. In our case, it is an LMS privately owned. E-ducativa is a company devoted to the e-learning processes that was started in Rosario, Argentina and it has expanded to nine countries. In Argentina, it gives technologic support to the
Campus Virtual of the Teacher Training Institute of the National Ministry of Education, (http://campus.infd.edu.ar/aula/acceso.cgi), among others.

The company has developed products and services implemented as modular and additional systems to provide a solution for the needs of each institution, trying to support the growth of the e-learning projects with gradual cost rising. In this case in particular, for e-ducativa, this development stands as a recent implementation that fits with the LMS in modules.

II. DESCRIPTION

Basically, the implementation of the remote laboratory in the e-ducativa LMS requires three main components: a) the LMS or the system of knowledge administration; b) the remote laboratory which includes both the laboratory itself and the software and hardware that allow distance management; and c) an interface between the LMS and the Remote Laboratory that had to be fully developed.

A. The Remote Laboratory: Applications and Functions

The direct access to the Remote Laboratory of Electronic Physics is performed with no need to install a plug-in or any additional application to the web browser. This characteristic makes it powerful enough to be accessible from any PC with few requirements. Also, from a Cyber or a mobile phone, the student can access and carry out experiments using a user’s name and password.

![Figure 1. New interface to access the Remote Laboratory](image1)

The detailed description of the structure of this Remote Laboratory has been reported in previous publications [3] [4] [7]. At present, it is possible to make the following experiments:

- P-N junction diode under forward bias.
- P-N junction diode under reverse bias.
- Zener diode under both forward and reverse bias in only one step.
- Germanium bipolar junction transistor in active mode and in reverse operation mode.
- Silicon bipolar junction transistor in active mode and in reverse operation mode.
- Uni-junction transistor.
- Field effect transistor.
- Phototransistor.
- Infrared light emitting diode.

The results of the different experiments are presented in the shape of graphs and tables. Each table can be exported as File XLS (Excel) and each graph as image file PNG. The screen of results can modify the scale of the graphs so as to be able to see better the peculiarities of the resulting curves.

![Figure 2. Screen of results of a test with a bipolar junction transistor](image2)

The most important features of the remote laboratory are:

- The independence of the access platform (compatible with different explorers such as Mozilla, Internet Explorer, Opera)
- Simple, intuitive and easy-to-use interface
- Access only to registered users
- Admission to more than one user through a buffer. In other words, if more than one student wants to do a test through the remote lab at the same time, the system enables only one of them while the others wait. Once the first test is over, the system enables the second and so on.
- Recovery by each user of its previous tests. During the experiment, information is kept in the database server of the lab so the student can get it back and see the results of the experiment.
- Data export to Excel spreadsheet for its subsequent analysis and treatment.

The syllabus units that included the students’ use of the remote laboratory were the ones related with P-N junction diodes and bipolar junction transistors. Students have to deal with these topics before working with the remote laboratory. The first issue is essential to understand the behavior of the different semiconductor diodes and for an informed study of the physical processes that explain the behavior of nearly all the semiconductor devices. The second issue requires the understanding of the electronic processes that turn out when more complex structures, involving junctions in interaction as in the bipolar transistors, appear.

The integration of the remote laboratory into the syllabus was carried out through two different activities of open-ended and ill-structured problems.

This way we have tried to promote, in the student’s cognitive structure, the link between the physical concepts which supports the electronic behavior of the devices with the characteristic curves obtained through test [6].
B. The e-ducativa LMS: Characteristics and Functions

The e-ducativa LMS integrates information services, news, messaging, Chat, discussion forums, software repository, wikis, surveys, videoconferences, evaluations, marks, updated professors and students’ data, schedule of events, among others. From a technical point of view, the e-ducativa LMS is developed in PERL and HTML languages and uses MySQL database systems. The main characteristics are:

- Intranet/Internet Multi-platform
- Multi systems: Windows, Linux, Unix, Solaris
- Multi language: English, Spanish, Italian, Portuguese.
- Managing and administering system of students, tutors, courses and on line evaluations.
- Compatible SCORM

From the managing perspective, the LMS allows:

- Automatic configuration to give services to six different types of groups: teaching, at distance, course, postgraduate, working group, investigation.
- Manually shape as far as six different users’ profiles, defining from the profile name to the permissions: students, assistants, tutors, heads, coordinators, guests.
- Ask for a variety of follow up and statistics reports, including an overall control of the material read and sections visited.
- Import files with users’ groups.
- Manage pedagogic resources, announcements, surveys, messaging, discussion forums and chat, with a variety of tools to edit and manage courses as well as evaluations.

Regarding the management, design, treatment and didactic development of contents and learning activities, the LMS has:

- A content editor with intuitive and simple interface.
- The possibility to develop the same content among multiple authors.
- The possibility to individual or group assignment of material, practical work and activities.
- Student’s self-check of his performance in a course (detailed control of pending and read material)
- The possibility to report the marks of finished assignments with private access for the student and complete access for the professor.

Regarding the communicative functions, the LMS offers:

- The possibility to do surveys among different groups of students
- The management of news and innovations with the possibility to attach images and links to external websites.
- Updating instructions to the user about activities to be done any time he accesses the platform.
- Sending corporate mails to all users in a group, in different groups or to users in one or more groups.
- Management of a schedule of events.

- Personal e-mail addresses or through the POP3 account.
- Communication among members / users of the virtual classroom and control of personal data uploaded by each student.
- Management system for discussion forums and chat rooms with the possibility to private chat and online registering.
- Embedded net meeting that allows sharing the board.
- The possibility to video chatting between two users.

C. The characteristics of the implementation

To integrate the LMS with the Remote Laboratory, we did the following:

- Unification of authentication: both systems have separate authentication. They were unified entering from the LMS for the users who are doing courses on LMS.
- Security: as a security system, we used the Recrypt Cypher version 4 (RC4) encrypted method and the Message-Digest Algorithm 5 (MD5) to check the validity of data sent from and to the platform.
- Re – design of Remote Laboratory interface: It was made according to the design provided by the platform. CSS and HTML5 templates were used. We checked its correct operation in all modern browsers at hand both for PC and mobile devices.
- User management: From the platform side, the users are the students and professors who use the LMS. The laboratory has a register of the ID that installed the platform and a password mutually agreed and linked to the same ID.
- Content management: The contents of the remote laboratory are managed by the system Remote Laboratory.

The way to integrate both systems is shown in the following diagram (Figure.3)
III. OPERATION OF THE INTEGRATION

The resource Remote Laboratory is integrated in modules into the LMS as an activity. The user, who can create an activity to use the Remote Laboratory, is the professor. He is also responsible for managing the contents of the subject program or course in the virtual classroom (Figure 4). So as to use the remote laboratory for an activity, it is necessary to ask for it, ticking on the option: “Handed in through the remote laboratory”. For the students’ view, the created activity is checked as shown (Figure 5).

Once the student has done the activity, the professor sends it back. It may be approved or failed. For example, he may ask the student to do the experiment and the report again. In this case, the student will see what is shown in Figure 6.

The student presses the button “open remote laboratory” and a new window appears corresponding to the main menu of the remote laboratory. Once into the remote laboratory, the students may ask to do a new test or to see the results of a previous one (Figure 7).

Out of that, a screen Result will come out and it will show data in graphs and tables (Figure 8). So as to let the data “travel” to the LMS, the student has to press the button “Export to the virtual classroom”, from the same screen. Then, a new window is opened (Figure 9). In this window, the student writes the test report and sends it to the professor for correction pressing the button “send”.

With the student’s report and the results of the test, the system generates a report of the activity in a file format with a pdf extension. Such report will appear to the professor as shown in Figure 10.

IV. FINAL CONSIDERATIONS

This integration was started on the basis of a research Project which started a couple of years ago with the LMS of the National University of Distance Education (UNED), from Spain, with Moodle implementation [8]. That time, we just asked for the possibility to have access from the LMS directly to the laboratory. The user’s verification is internally performed in the remote laboratory being simple for the final user. Departing from that idea, we worked to integrate our laboratory with the e-ducativa LMS, improving it by adding encryptions for security reasons. On the other hand, we also implemented the return of the tests to the same LMS. This same scheme...
or protocol can be implemented in the future to any other LMS (such as Moodle).

This joint venture company-university has helped to the promotion and use of the research, and the improvement of any individual development. We have been thinking about extending its use to a larger number of institutions based on the concept of scalability. The aim of using such an experience within the system should only require dedication adjusted to the characteristics of the experience.

REFERENCES


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