

VISIR: Experiences and Challenges

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Abstract—It is of crucial importance the integration of practical sessions in engineering curricula owing to their significant role in understanding engineering concepts and scientific phenomena. However, the lack of practical sessions due to the high costs of the equipment and the unavailability of instructors has caused a significant declination in experimentation in engineering education. Remote laboratories have tackled this issues providing online reusable and shared workbenches unconstrained by neither geographical nor time considerations. Thereby, they have extremely proliferated among universities and integrated into engineering curricula over the last decade. This contribution compiles diverse experiences based on the deployment of the remote laboratory, Virtual Instrument Systems in Reality (VISIR), on the practices of undergraduate engineering grades at various universities within the VISIR community. It aims to show the impact of its usage on engineering education concerning the assessments of students and teachers as well. In addition, the paper address the next challenges and future works carried out at several universities within the VISIR community.

Index Terms—Engineering Education, Remote Labs, VISIR

I. INTRODUCTION

Virtual Instrument Systems in Reality (VISIR) is a remote laboratory for designing, wiring and measurement of electronic circuits. Virtual Instrument Systems in Reality (VISIR) is a remote laboratory for designing, wiring and measurement of electronic circuits. The project was launched by the end of 2006 by the Signal Processing Department ASB at Blekinge Institute of technology (BTH) in Sweden together with National Instruments in USA (as a supplier of instruments) and Axiom EduTECH in Sweden (as a supplier of education, technical software, and engineering services for noise and vibration analysis). The project was financially supported by BTH and the Swedish Governmental Agency for Innovation Systems (VINNOVA). An identical simulation of the real equipment and instruments appears on the student PC-screen that makes him familiar with the real instrument models and types. The student starts to adjust the instruments and wires his circuit with his PC-mouse. Then, VISIR converts the student's design to a real wired circuit and sends to him, on his PC-screen, the measurement results. Thus, VISIR creates a real electronic lab environment to the student which can be accessed at any time and from anywhere as long as the student have a PC connected to internet. [1]-[2]-[3].

So far, six universities have already implemented VISIR after Blekinge Institute of Technology (BTH) [2]; Carinthia University of Applied Sciences and FH Campus Wien University of Applied Sciences, both in Austria, Polytechnic Institute of Porto (ISEP) in Portugal, University of Deusto and Spanish University for Distance Education (UNED), both in Spain, Indian Institute of Technology Madras (IIT-M) in India. Whereas, the following Universities have shown their interest in participating in this project but they have not implemented it yet; University of Genoa in Italy, Princess Sumaya University for Technology in Jordan, Gunadarma University in Indonesia, Institute for the Development of New Technologies (NINOVA) in Portugal, College of the North Atlantica in Qatar, and others.

This paper discusses the experience of University of Deusto, Spanish University for Distance Education (UNED) and Polytechnic Institute of Porto (ISEP) in applying VISIR in the undergraduate engineering practices showing results and assessments gathered from students as well as teachers during the academic courses. On the other hand, it provides new results of case studies about applying computer-based technologies in the practices of undergraduate engineering education.

The paper is divided into five main sections, the first section gives an overview on the usage and the implementation of VISIR in academic courses, it gives a general summarized overview on its installation, however, it is focused on the administration and the accessibility features provided by the web interface, which facilitate the remote connection between the teacher, the students and the laboratory. The second, third and fourth sections discuss the role of VISIR deployment in the undergraduate engineering practices at University of Deusto, ISEP and UNED respectively. The fifth and the last section address the conclusion and the further and future efforts being done on VISIR by those universities and others within the VISIR community.

II. USAGE AND IMPLEMENTATION

All the installation procedures of VISIR can be consulted in the manual "VISIR Installation and Start-Up Guide" [4] or in the installation web site [5]. However a brief description about the system is going to be addressed. As depicted in figure 1, VISIR platform mainly consists of 4 parts:

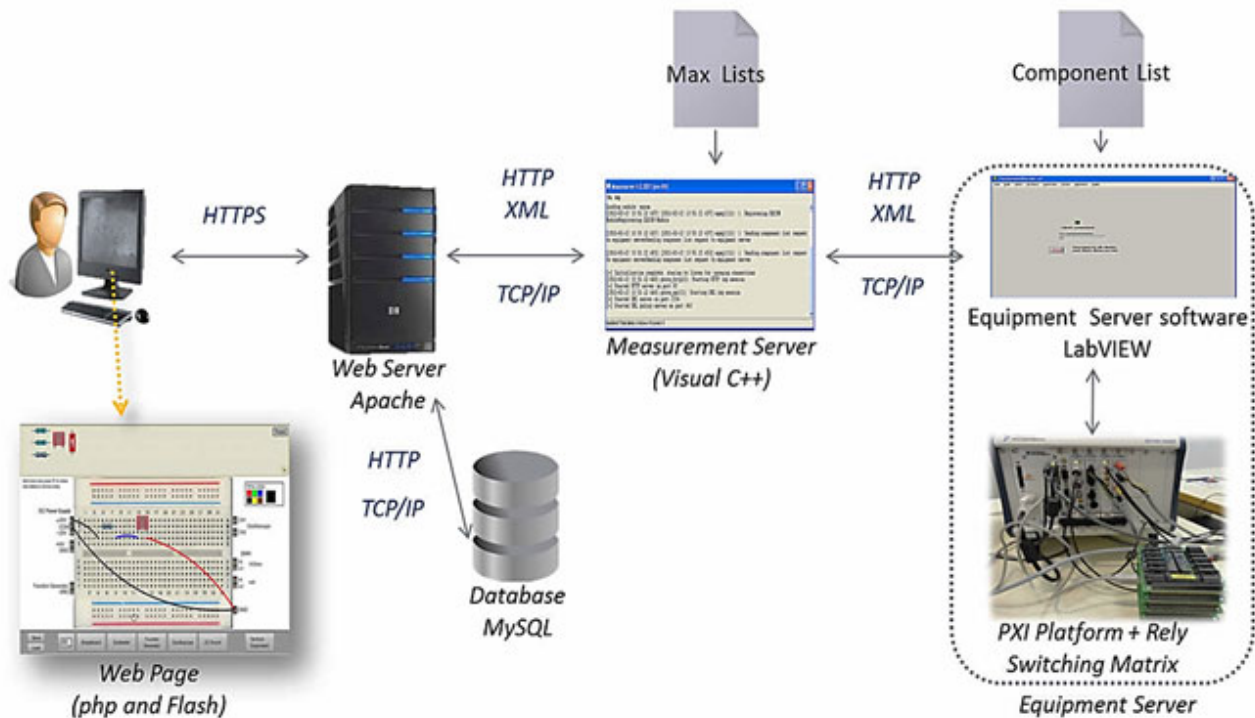


Figure 1. VISIR platform

- **Equipment Server:** It comprises all the lab equipment; the PXI platform connected to the relay switching matrix, both are controlled with a server written in LabVIEW. It receives the commands from the measurement server over TCP/IP to be executed on the real instruments. The commands are sent in form of XML-based protocol (experiment protocol) on HTTP. A “component list” file is inserted to the equipment server to define the components installed on the matrix.
- **Measurement Server:** It is a server written in Visual C++ for Microsoft. It acts as a virtual instructor that controls the commands passing from the web interface (and received over TCP/IP) to the equipment server.

That is, in order to prevent hazard circuit designs and protect the instruments. It is programmed by “max list” files which contains the maximum component values and instruments adjustments for each experiment.

- **Web Server:** It is the server that hosts the VISIR web interface. The web interface is written for Apache server against MySQL Database.
- **Web Interface:** It is the web site of VISIR (written in PHP) with the experiment client integrated inside (written in Flash). The student accesses to the web site through the secured protocol https, after getting authenticated, he/she begins to design his/her circuit in the experiment client. This design is sent to the measurement server to be verified then to the equipment server to be converted into a real wired circuit and the measurement results appear through the virtual instruments on the user PC-screen.

VISIR has its own Learning Management System (LMS) as a web interface in which the lab contents are arranged and through which they are accessed. However,

other universities are working on integrating it into their own LMS (see Conclusion and Future Works). The LMS of VISIR contains many access and administration features such as, Registration, Log-in, Booking, account types, etc. The availability of the lab contents depends on the user account type. Each user account type has its own features, privileges and limits. Next, the characteristics and properties of each account type are going to be discussed.

A. Administrator account

It is the account of the lab organizer and distributor. VISIR can have one or more administrator account. The administrator account has the following privileges:

- Design the lab web pages contents through the WIKI markup syntax.
- Upload files, videos, manuals, etc. this can be done by uploading them to the webservice (apache) and link them to the PHP code of the Page.
- Create, update and delete courses indicating the start and the end date of the course, the maximum users and seats.
- Assign teacher and instructor accounts for each course.
- Modify or remove any user account.
- In any course, administrator account can switch to “teacher view” and consequently, could have on that course all the teacher privileges which are going to be discussed afterwards.

B. Teacher account

The teacher account is created by the administrator and linked to a certain course and it has the following privileges within that course:

- Add and remove experiments. This is done by choosing the allowed components to appear to the student in each experiment.
- Add, remove and modify student accounts.
- Make teacher scheduled reservation: Teacher reserves a number of seats within an interval of time so that he/she could put his/her students in groups and assign an instructor to each group. These seats are seen to the student with the teacher's name. Accordingly, the student chooses his group and reserves seat.
- Teacher can switch to "student view" to make sure of the contents seen by student.

C. Student/Instructor account

It is created by the teacher and linked to a certain course. It is only permitted to access experiments that are created by the teacher within that course. The student likewise can make a scheduled reservation separately or reserve a seat belonged to a scheduled reservation of a teacher.

D. Guest account

It is a public limited trial account created by the administrator and doesn't require registration. It could be accessed by anybody to try a certain available experiments prepared by the teacher assigned to that account.

The well-structured Web interface of VISIR allows it to be easily and directly deployed in the academic courses. Next, University of Deusto, ISEP and UNED are going to share their experience in deploying VISIR in the undergraduate engineering practices respectively.

III. VISIR AT UNIVERSITY OF DEUSTO

VISIR is being used in the Faculty of Engineering of the University of Deusto since 2007 in different Engineering degrees: Telecommunication, Computer Science, Industrial Technologies and Electronics. The subjects related with VISIR at this moment are: Digital Electronics, Computer Technology, Analog Electronics, Circuits and Physics.

It is used in different situations and for different objectives: (i) The teacher uses VISIR at the classroom to remark the theoretical results, (ii) The student uses VISIR before going to the lab to have more confidence learning, (iii) The students use VISIR as a substitute of the real lab because of the unavailability of the real one. For instance, In Figure 2, the teacher shows the relation between the input and output of an RC circuit at different frequencies and capacitor to allow the student to understand the concept before he/she tries to prove it in a mathematical model.

At University of Deusto, a survey was realized on the students that had used VISIR (see Table 1). The survey follows the likert scale standard and it is divided into three parts: Usefulness, Usability and Sense of Reality/Immersion. The survey results have been obtained combining the original one developed four years ago and the actual surveys. Figure 3 shows the average survey results with regarding to each course. While Table II lists the description of each course indicating the subject name and the academic year. As shown in Figure 3, the survey results were acceptable. In general terms, we can conclude that VISIR was accepted among the students as a useful

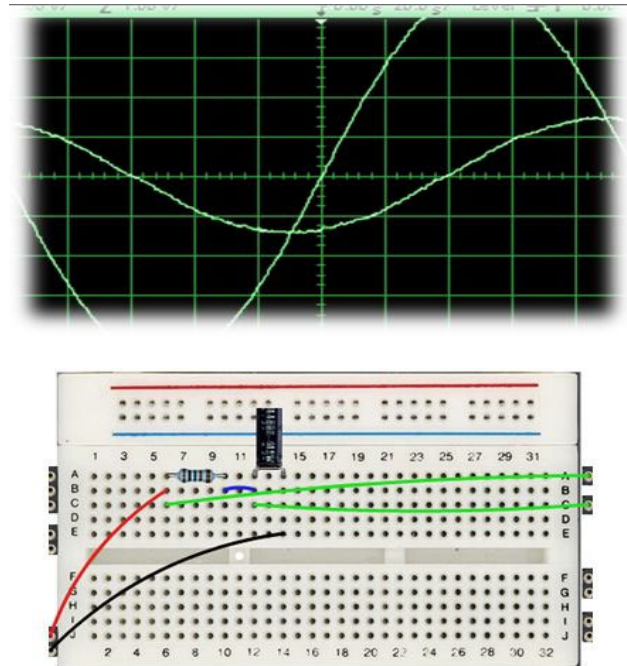


Figure 2. RC Circuit with VISIR

TABLE I.
SURVEY AT UNIVERSITY OF DEUSTO

B1. Usefulness

- Q1. VISIR helps me in the subject: concepts, practical exercises, projects, etc.
- Q3. It is a good idea to extend VISIR to all the students
- Q11. I would like to use VISIR in others subjects
- Q12. I am satisfied with VISIR
- Q17. I have been motivated by VISIR to learn more about the subject

B2. Sense of Reality/Immersion

- Q2. Using the VISIR, I felt that it is real and not a simulation
- Q6. I would like to have a Webcam to see something at VISIR: a clock, a device, a screen, etc.
- Q10. Being far from the VISIR, I have felt myself to be in control of it

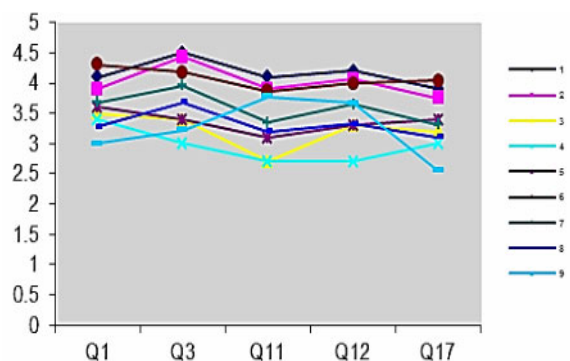
B3. Usability

- Q4. I have enjoyed using the VISIR
- Q5. VISIR is easy to use
- Q7. The different devices (power supply, multi-meter, oscilloscope, etc.) are easy to use.
- Q8. I don't have problems with the assigned time
- Q9. The devices implemented in VISIR are well selected

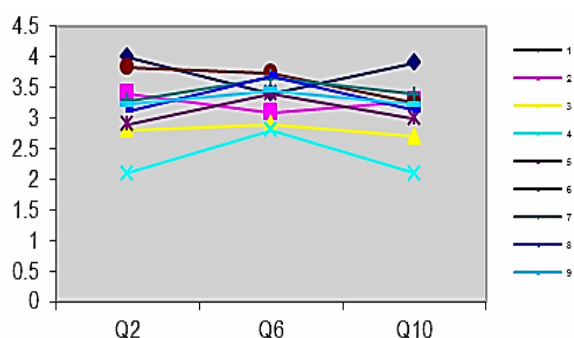
TABLE II.
COURSE DESCRIPTION

Course	Subject	Year
1	Computers Technology	08-09
2	Digital Electronics	08-09
3	Computers Technology	08-09
4	Computers Technology	08-09
5	Computers Technology	09-10
6	Digital Electronics	10-11
7	Digital Electronics	10-11
8	Digital Electronics	10-11
9	Circuits	10-11

Usefulness



Immersion



Usability

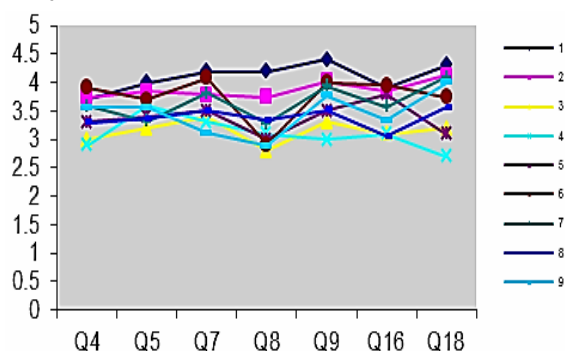


Figure 3. Survey results at University of Deusto

tool for practical sessions. However we consider VISIR as a support tool, not a total substitution to the real labs. The students that had used it gained more self-confidence when they started using the real lab, even though, their first time was through a remote lab.

IV. VISIR AT ISEP

The School of Engineering at ISEP installed VISIR in July 2010 and started applying it on the Applied Physics course of the Computer Science Engineering degree with 561 students enrolled. The course has duration of 12 weeks. The 561 students enrolled were divided in two groups. Group A, with a total of 288 students, corresponds to those students who are performing hands-on lab work during some of the laboratory classes, while group B, with 273 students who already had a lab work from previous years but didn't get approved, and they are developing a comparative analysis with values taken from the remote system and hypothetical ones, realized by group A, in those same classes. Table III describes the course lab topics during the first 6 weeks, i.e., from September, 27th to November, 1st.

TABLE III.
LABORATORY CLASSES PLAN FOR TOPIC ON ELECTRICITY

Weeks	Organization of topic electricity for lab classes	
	Group A	Group B
Week 1 27/9	Introduction to VISIR. Taking measurements in the remote system for a DC experiment described in the lab guide.	
Week 2 4/10	Real DC circuit mounting and performing measurements. 24h to hand-over the group lab report.	Comparative DC analysis with values from previous class and components nominal values.
Week 3 11/10	Introduction to VISIR. Taking measurements in the remote system for an AC experiment described in the lab guide.	
Week 4 18/10	Real AC circuit mounting and performing measurements. 24h to hand-over the group lab report.	Comparative AC analysis with values from previous class and components nominal values.
Week 5 25/10	Individual lab report related to one of the two experiments done.	Teachers use VISIR to demonstrate the previous AC circuit as a passive filter.
Week 6 1/11	1st partial examination related to this topic. (a)	

TABLE IV.
STUDENTS' PERCEPTION QUESTIONNAIRE RESULTS

Questions	Using a Likert scale 1 (minimum) - 5 (maximum)	Results	
		Average	Standard Deviation
Q1	Did VISIR help you on: a) concepts and problem solving? b) Handling the equipment? c) Mounting the circuits?	3.40 3.57 3.84	1.07 1.22 1.20
Q2	Did VISIR motivate you to the learning objectives?	2.77	1.26
Q3	a) Provided usage information was sufficient? b) Was VISIR operating in stable conditions?	2.61 3.66	1.10 1.26
Q4	Would you like to have similar systems for other course subjects?	3.34	1.44

ISEP has realized a preliminary assessment which reflects the students and teachers perceptions during the first 6 weeks of the course. According to the teachers, only some students had their personal computers with them, this minimized their capability of personally working with it, but they had a more spectator view of what their colleagues were doing. In general terms, students of group A showed more laboratory competences in assembling the circuits' components and indeed a much lower percentage of burning multi-meter fuses was found (nearly half of the one encountered in previous years). In other words, it was more beneficial using it simultaneously with the traditional laboratory. However, teachers do agreed that it improved the student's knowledge towards the subject.

Students were asked to fill in an online questionnaire that meant to assess their satisfaction and their perception of learning outcomes using VISIR. This questionnaire was done anonymously, accessing a Google page in the class, at the end of the course. This was not mandatory, yet 185 students choose to share their opinion, which represents a sample of 33%. As can be seen in Table IV, students agree that VISIR was most helpful in developing laboratory competences. Even though, they did not feel that it helped with their motivation. However a great percentage would

like to extend its usage to other subjects, showing their palatability towards the system. These results also indicate that the system has not shown many irregularities, but students felt that a formal tutorial could have been helpful.

Now VISIR is being used at ISEP in 6 different courses offered by 6 different engineering degrees. The teachers responsible for each course are following slightly different evaluation methods, so we expect to assess the impact of VISIR in the learning/teaching process, by carefully examining the students results obtained at the end of these courses [6].

V. VISIR AT UNED

During the last academic years, the students of the subject “Electronic Circuits and components”, a first year subject of the Technical Industrial Engineering career, now in extinction, used VISIR installed at University of Deusto. This was possible thanks to an agreement between both universities. The objective was to evaluate the capacity of VISIR for providing online remote labs to the students. About 40 students have been using VISIR of Deusto during 2 entire days each year without any kind of problems. Moreover, VISIR was capable of realizing complex circuits within the practices of the subject such as:

- Half-wave Rectifier with and without filter.
- Regulator with zener diode.
- Inverter and non-inverter operational amplifier.
- Operational amplifier as a driver.
- Common emitter BJT.
- Common collector BJT.

The results were very satisfactory. The students could realize their practical tasks without any time delay problems (at real-time). They could repeat their experiments varying the values, all the time they needed during the 2 days. Many of them revealed that they would like to use this system for other subjects. The average results of a Google survey that was carried out among the students of that subject that had used it is seen in Table V. we deduced that they enjoyed the experience and it produced a higher motivation of learning among the students.

Therefore, the Electrical and Computer Engineering Department at UNED decided to install its own VISIR for our own electronic practices. The department installed VISIR in December of 2010. The equipment is now fully functional and the described labs are now scheduled as a mandatory pre-laboratory work for students of the new subject, “Foundations on Electronic Engineering”, of the third academic course of the new Electronic Engineering Grade of Bologna. They will use VISIR to take a first approach to the instrument and the typical ways of work in a real Electronics laboratory. Afterwards they will repeat the same practices in the real laboratory at the department. Hopefully, this procedure will allow the students to gain more efficient experimentation skills during their first electronics practices. On the other hand, the department is working on the expansion of VISIR deployment on the practices of engineering grades subjects to include more number of student and more complex circuits [7]-[8].

VI. CHALLENGES AND FUTURE WORKS

VISIR software is an open source to catalyze other institutions and researchers to study it and work on it development. Thus, various universities within the VISIR

community are working on the development and integration of VISIR to enhance and enrich experimentation in engineering distance education. Among these efforts we can address:

Grid Laboratory: Mounting electronic circuits and components on the relay switching matrix is limited owing to the limited number of nodes and component boards. However the project founders proposed an excellent solution. It aims to connect all VISIR systems installed at all the universities and institutions within the community to create a grid laboratory shared and accessed by all the participants as shown in Figure 4. This would allow to make the most of VISIR and to expand its application range. Every university could install certain circuits and

utilize other type of circuits installed at other university and vice versa [2].

VISIR-LXI: University of Deusto is developing a new LXI-based VISIR system, Figure 5, in which all the instruments are replaced with IVI drivers instruments (instead of NI) and LXI compliant. The connection between the server and the instruments is through a standard Ethernet connection, and IP addresses are used to identify each instrument. The Proprietary relay switching matrix of VISIR is replaced with a commercial one consisting of two dual 4X16 matrixes 34932A. The aim is to reduce the cost of the PXI instruments and the proprietary relay switching matrix and increase the system flexibility. Moreover, this architecture will permit the system integration into WebLab-Deusto architecture, which would make it easily integrated to an LMS [9].

Integration with iLab: The iLab Shared Architecture (ISA) developed by the Massachusetts Institute of Technology (MIT) allows access to various online laboratories at distinct institutions through a single web interface that handles all the common services provided by online laboratories (authentication, scheduling, security, etc.). The architecture is based on using web services to communicate with non-homogenous lab systems. The System Engineering Department at Carinthia University of Applied Science together with BTH are working on the integration VISIR into ISA framework to provide users form iLabs Community the possibility of deploying and using VISIR in their ISA framework and to take the advantages of the services ovided by ISA. This integration allows sharing of VISIR with a high load capacity in an efficient way [10] [11].

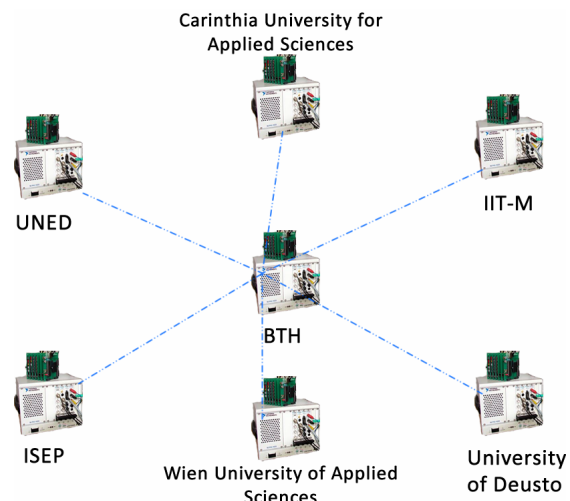


Figure 4. VISIR Grid Laboratory



Figure 5. VISIR-LXI

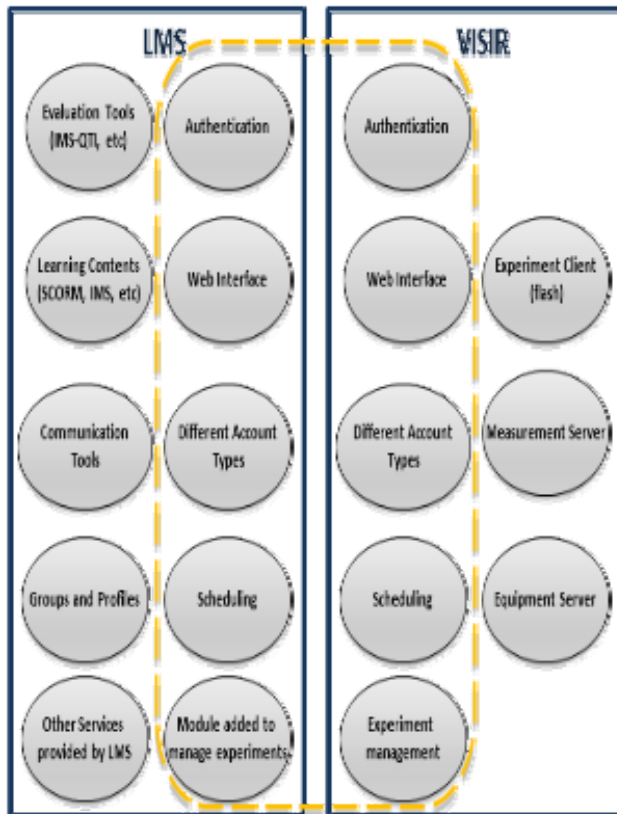


Figure 6. VISIR Integration with LMS

Integration with LMS: The Electrical and computer engineering department at UNED is researching into the integration of the services provided by the VISIR interface with those provided by LMS. By this way, users could access to VISIR through the LMS with a single sign-on and every account type in the LMS (teacher, student, administrator, etc.) would have the same privileges of its equivalent account type in VISIR interface. This would allow the utilization of the provided LMS services besides the lab work to create a rich integrated online educational platform, Figure 6. The objective is to integrate it in its own LMS based on DotLRN (ALF) [12] [13].

VII. CONCLUSION

In this contribution, different scenarios of experiences with VISIR have been presented. VISIR allowed students from distinct universities to develop their lab knowledge either by using it individually or combining it with real labs. The overall experience among those universities was positive. The participant universities within the VISIR

communities have realized significant efforts in order to enhance learning technologies either by improving VISIR capabilities or by integrating it with a full learning platform in order to facilitate its adoption in the learning process and thus, augment learning outcomes in online electronics practical sessions.

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