

Application and User Perceptions of Using the WebLab-Deusto-PLD in Technical Education

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Abstract – The paper shows the results of an integration of the remote laboratory WebLab-Deusto-PLD at the “Programmable Logic” course of the Faculty of Engineering of the University of Deusto (Spain). Presented herein is a technical overview of the laboratory, a description of access to it, and an analysis of the user experience derived from conducted surveys since 2004. The surveys’ analysis shows a correlation between two advantages of the remote experimentation: efficiency/usefulness and immersion/control. The prospective work includes an improving the WebLab-Deusto usability, an extension of the capabilities of the overall system and further its implementation in curricula.

Index Terms – Programmable Logic, remote laboratories, students’ evaluation, survey.

INTRODUCTION

A remote laboratory is a tool, which provides to students an access to real experiments through Internet. Nowadays remote labs are becoming a powerful didactic instrument in an engineering education. The Labshare project survey [1] shows that remote labs offer superior features in terms of flexibility, utilization, space saving, and safety issues. The executive, academic and technical staff members from all the Australian universities offering undergraduate engineering programs participated in this survey. The participants concluded that remote labs have the potential of achieving learning outcomes equally as good as hands-on labs although more studies and trials were required.

The increasing interest in this field has led to establishing of a consortium for remotely accessible laboratories for educational use - Global Online Laboratory Consortium (GOLC¹).

At the beginning we describe briefly the WebLab-Deusto implemented in the curriculum of the Faculty of Engineering of the University of Deusto. Then we introduce the “Programmable Logic” course concept and general procedures which should be done by the students in order to accomplish the assignments of the course. The survey and its results is analyzed at the SURVEY part of the paper. In the

following section the accesses of students are discussed and contrasted to the provided evaluation. Finally, the conclusions and future work are outlined.

WEBLAB-DEUSTO PLATFORM

The WebLab-Deusto is an Open Source² platform. It can be easily deployed to offer different remote experiments. It is important to distinguish between the platform that manages a number of remote experiments (rigs) and the domain-dependent remote experiments (i.e. “electronics remote laboratory”). MIT iLabs, LabShare Sahara and WebLab-Deusto [<http://www.weblab.deusto.es>] are good examples of the rigs while VISIR [4] [4] is a good example of the domain-dependent remote experiments.

Since February 2005, WebLab-Deusto is being used in production through different versions in the University of Deusto. Until September 2007, WebLab-Deusto was a domain-dependent experiment platform: WebLab-Deusto 1, and AJAX and web service based WebLab-Deusto 2. WebLab-Deusto 3.0 manages different remote experiments, focusing on the software challenges [4] and providing libraries for a wide range of development frameworks to make the development easy.

Today's WebLab-Deusto 4.0M1 is a robust platform that uses web standards suitable for mainstream web browsers, and adapts to mobile devices. It can be downloaded and deployed to serve new remote experiments in different environments and operating systems. The effort has been put to provide a secure and scalable design, using SSL in the communication and untrusting experiment developers in the management layers, and to track of 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 in a number of platforms such as Facebook, .LRN and Moodle, and to integrate external experiments such as VISIR.

In order to support a usage of hundreds of students, administration tools have been developed, which come out of the box with the available packages of WebLab-Deusto.

¹ <http://www.online-lab.org/>

² <http://code.google.com/p/weblabdeusto/>

At this moment in the classroom WebLab-Deusto is used with different experiments: WebLab-Deusto-CPLD, WebLab-Deusto-FPGA, WebLab-Deusto-PIC, WebLab-Deusto-GPIB, WebLab-Deusto-Logic, WebLab-DEUSTO-Microbot, VISIR, and LXI-VISIR. Furthermore the platform already supports new schemas based on Virtual Machines that will be used in the near future at the University. Figure 1 shows the weblab.deusto.es page which includes demos, mobile lab, Facebook integration, and different options offered to students by WebLab-Deusto.

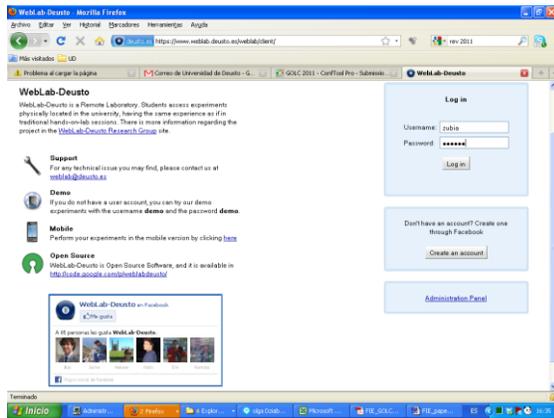


FIGURE 1
WEBLAB-DEUSTO MAIN PAGE AND EXPERIMENTS

SUBJECT AND REMOTE EXPERIMENT

The University of Deusto is using the experiment WebLab-Deusto-CPLD for course “Programmable Logic”. This subject is offered for the third-year students of Electronics and Control Engineering Degree.

The course includes VHDL - VHSIC hardware description language which is used in electronic design automation to describe digital and mixed-signal systems such as field-programmable gate arrays and integrated circuits, and CPLD - complex programmable logic device. The objective of the course is to teach to design with microcontrollers and assembler or C programming languages. The course is based on the Project Based Learning (PBL) approach offering to the students the labs assignments and projects as main activities.

The students learn to program in VHDL, and to develop, implement and test the designs in an educational board in traditional laboratory. Weekly student’s assignment is to program, and to implement a design. Student decides how and on which equipment – remote or traditional labs - she will execute the assignment. The remote laboratory is not a replacement rather a complement of the traditional lab to promote the autonomous and significant learning, and to support students.

In order to accomplish the assignment student writes the VHDL code (Figure 2), simulates it (Figure 3) and obtains a binary file.

```

53 process(inicio, clk)
54 begin
55   if inicio='1' then
56     cont_base<="1000000000";--"0000000000";
57   elsif clk='1' and clk'event then
58     if cont_base=999 then
59       cont_base<="1000000000";--"0000000000";
60     else
61       cont_base<=cont_base+1;
62     end if;
63   end if;
64 end process;
65

```

FIGURE 2
VHDL CODE FOR DESIGNING

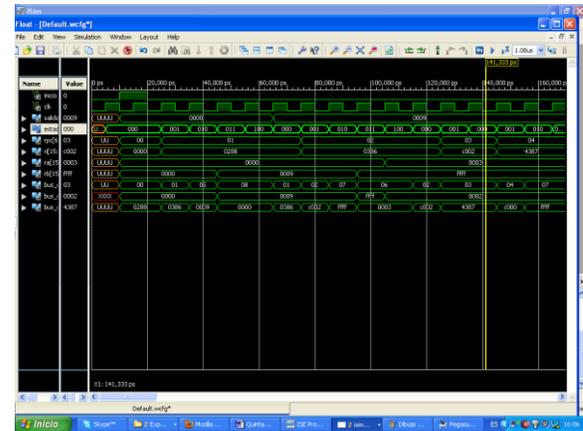


FIGURE 3
SIMULATION OF A VHDL CODE

Student accesses the WebLab-Deusto - a demo is available - using the university authorization validated through LDAP. Once logged-in she uploads the generated binary file. From this moment student has a control of the board during 200 seconds. The board consists of 10 switches, 4 buttons, 1 clock, 6 LEDs, and 4 seven-segments. Then she tests the design using these inputs and sees an evolution of the system through the WebCam (see Figure 4)

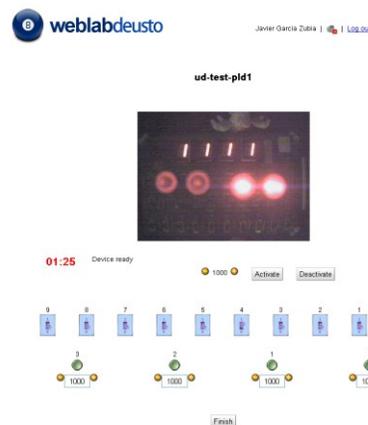


FIGURE 4
WEBLAB-DEUSTO-PLD INTERFACE

If the program is running properly, student records the results on video. Finally student uploads the program and the video into Moodle - LMS system of the University of

Deusto. The use of WebLab-Deusto is an optional tool to complete the assignment.

Administration of the access to the WebLab occurs based on a priority queue. The platform automatically shows to the student availability and position in the queue, and gives the control of the experiment when student's turn arrives.

SURVEY

Since the beginning of the WebLab-Deusto integration in the curricula the research and development team collects and analyzes the student feedback in order to improve the platform. Although the Faculty of Engineering provides the traditional lab experiments for students, contemporary technical education enhances by the remote experiments that modernize the teaching with research and collaborative components [5].

At the end of each course we perform a survey to the students. Survey includes 18 questions Q1-Q18:

- Q1. WebLab helps me in the course: concept, exercises, projects, etc
- Q2. Using the WebLab, I felt that it is real and not a simulation
- Q3. It is a good idea to extend this WebLab to all the students
- Q4. I have enjoyed using the WebLab
- Q5. WebLab is easy to use
- Q6. The quality of the WebCam is good
- Q7. The different I/O devices (switches, buttons, etc.) are easy to use
- Q8. I don't have problems with the assigned time
- Q9. The I/O devices implemented are well selected
- Q10. Being far from the WebLab, I have felt myself to be in control of it
- Q11. I would like to use the WebLab in others courses
- Q12. I am satisfied with the WebLab
- Q16. The user's manuals are good and clear.
- Q17. I have been motivated by the WebLab to learn more about the subject
- Q18. The WebLab is a high quality software (access, management, availability, etc.)

The students provide answers to the survey questions in the number format where "5" points to the complete

agreement of the responder with the sentence, and "1" points to the complete disagreement. For the analysis the questions of the survey are grouped in three blocks: Usefulness - Q1,3,11,12,17, Usability - Q4,7,8,9,16,18, and Sense of Immersion Q6-10. At 2008-2009 we added the questions Q2, Q4, Q16-Q18 to adapt our survey to the [6] and [7]. Questions 13-15 we will not discuss at this paper.

247 students participated at surveys during last six courses (Fig.5-9). 75% of them answered on all questions of the survey. This is the largest data of feedback of using remote labs students in Spain.

TABLE I. SUMMARY OF THE SURVEYS: AVERAGE VALUES

	04/05	05/06	06/07	07/08	08/09	09/10
Usefulness						
Q1	4,6	3,8	3,8	4,2	4,5	4,7
Q3	4,7	4,2	4,3	4,2	4,4	4,8
Q11	4,3	3,9	3,8	3,9	4,1	3,6
Q12	4,7	3,7	3,9	4,1	4,4	4,5
Q17	-	-	-	-	4,3	3,1
Immersion						
Q2	-	-	-	-	4,3	4,3
Q6	3,2	2,8	2,7	2,8	3,4	3,9
Q10	4,1	3,6	3,6	3,8	4,3	4,1
Usability						
Q4					3,8	3,4
Q5	4,4	3,9	4,3	4,4	4,3	4,6
Q7	3,8	3	3,7	3,6	4	4,2
Q8	3,7	3,1	3,7	3,7	3,6	3,4
Q9	3,8	3,4	3,7	4	4,3	4
Q16	-	-	-	-	4,4	4,4
Q18	-	-	-	-	4,4	4,5

TABLE II. STUDENTS, SURVEYS & ACCESSES

	04/05	05/06	06/07	07/08	08/09	09/10
Students	13	58	37	36	71	32
Surveys	10	40	33	33	48	25
Accesses	1.706	632	1.012	3.180	3.453	1.600

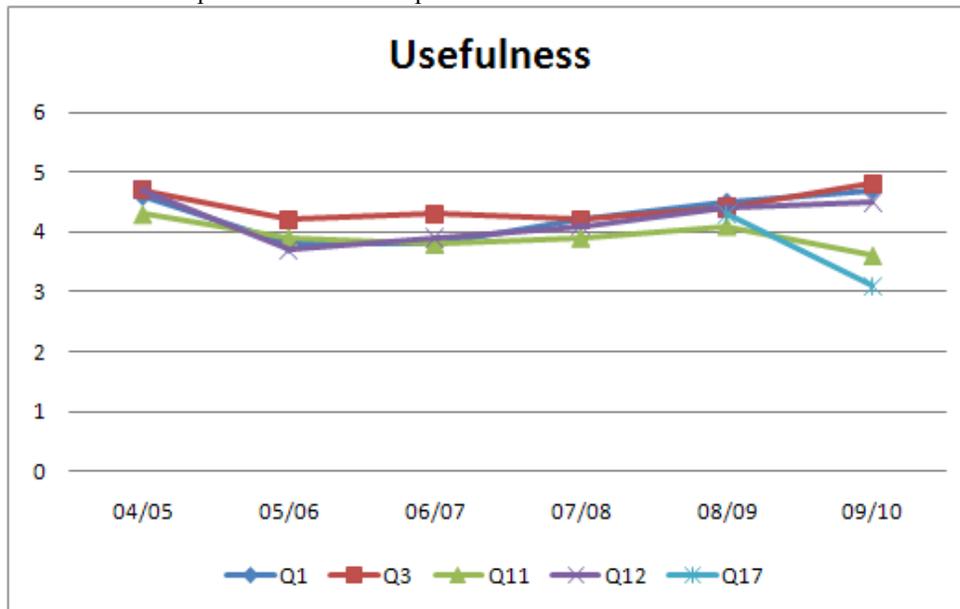


FIGURE 5. USSEFULNESS



FIGURE 6. IMMERSION

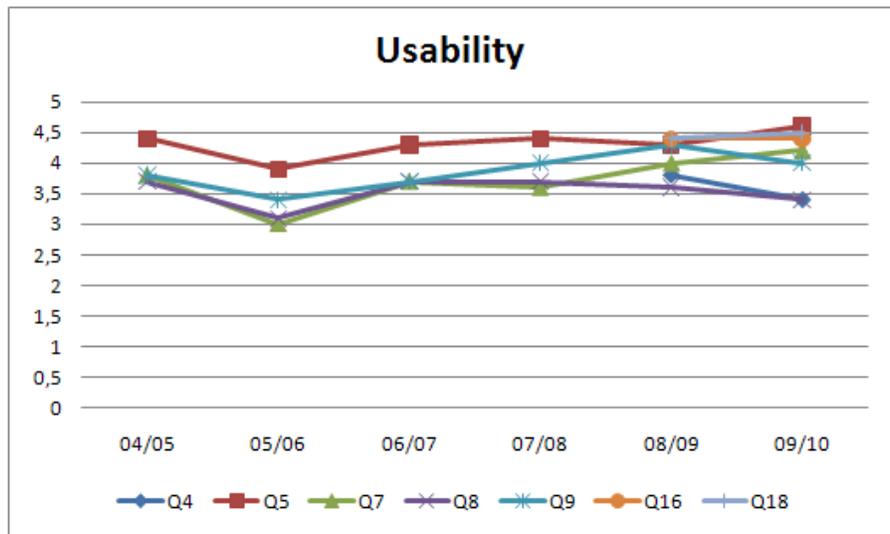


FIGURE 7. USABILITY

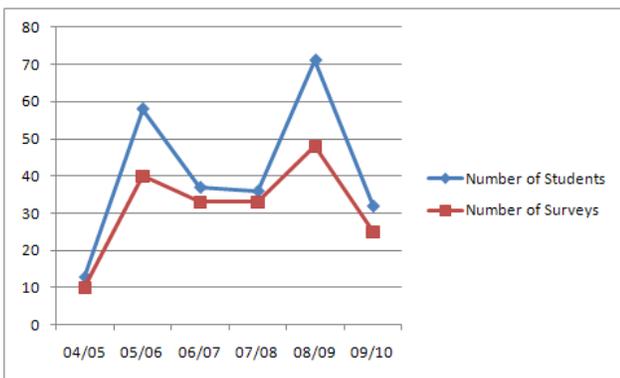


FIGURE 8. STUDENTS & SURVEYS

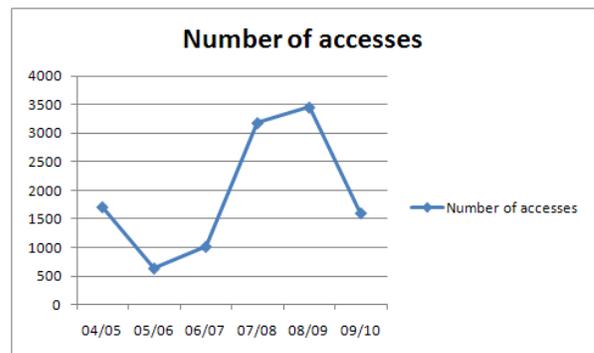


FIGURE 9. NUMBER OF ACCESSES

Analyzing the Tables I-II and the Figures 5 – 9 we obtained the following results:

- In general terms the students think that the WebLab-Deusto-PLD is useful learning tool. According the Q1 the its attractiveness is 4,7 out of 5.

- The students recommend applying the WebLab (Q11) for the “Programmable Logic” course. They think also that other courses of the Faculty of Engineering will benefit from the integration of the WebLab in their curriculum.
- The students agree that the WebLab is easy to use (Q5). The average value for all years is higher than 4.
- Although the I/O devices are well selected (Q9), the students meet some problem to use them (Q7). The network impact can be a reason of it.
- The students are dissatisfied with the performance of the webcam (Q6). The improving of light system of the experiments caused to increasing their evaluation from 2,8 in the survey of 2008 till 3.9 in the 2010 survey.
- Based on the response on the Q10 and Q2 the sense of control and the sense of immersion are significant for the remote labs. [6]
- The well designed and written manual helps and supports the students to understand and experiment with the WebLab-Deusto(Q16).
- The students have a good impression of the software of the platform (Q18).
- The accesses number depends on the students enrolled at course and their preference to use traditional or remote labs.

The sense of immersion is related to the usefulness of the Web-Lab-Deusto system. Therefore, in order to improve the Web-Lab-Deusto the immersion of the user must be augmented. This is in the line with a conclusion of J.E.Corter *at al.* who indicates that “as much immersive is a remote experiment much better will be for the user” [6].

ACCESSES OF THE STUDENTS

In the course 2010-2011 23 students are enrolled in the course “Programmable Logic”. The semester will finish in May, but in middle term we can already analyze the student’s activity at the WebLab-Deusto-PLD.

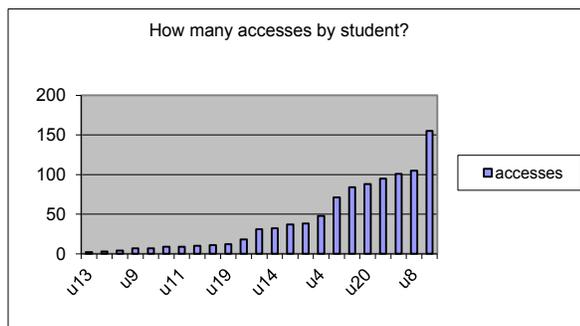


FIGURE 12
NUMBER OF ACCESSES PER STUDENT

For this period the students accessed the WebLab over 1000 times. Figure 12 shows that 5 students were very active and done more than half of the accesses. One of them accessed the remote experiment 155 times.

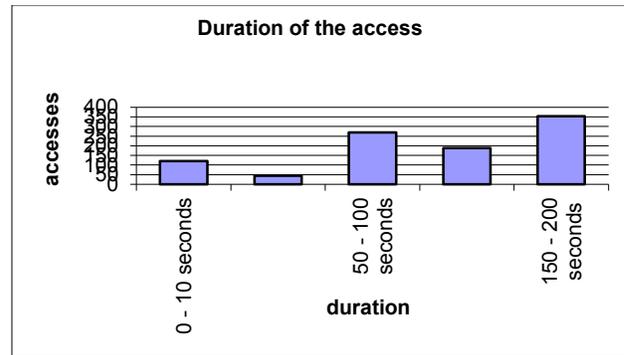


FIGURE 13
DURATION OF THE ACCESSES

In Figure 13 we can see that usually, the students utilize the full time of sessions. If student recognize that the design is not running properly she interrupt it (50-100 seconds). More than 100 sessions is less than 10 seconds; it means that students failed these connections.

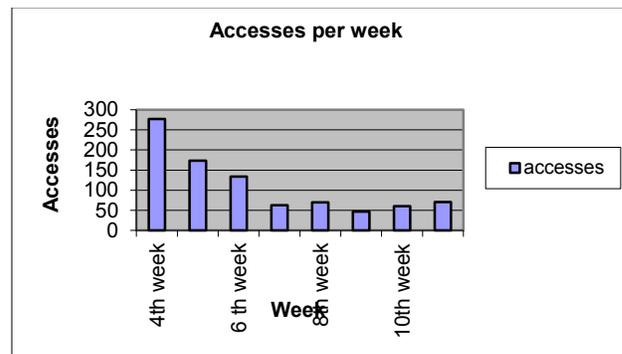


FIGURE 14
NUMBER OF ACCESSES PER WEEK

The Figure 14 shows the number of accesses per week. Since at the beginning of the course the students have many short assignments and experiments the access number is high. While at the end of the course they have one final project that required more programming job than testing the design. This structure of the curriculum explains low level of the entry to the Web-Lab on the last weeks of the course.

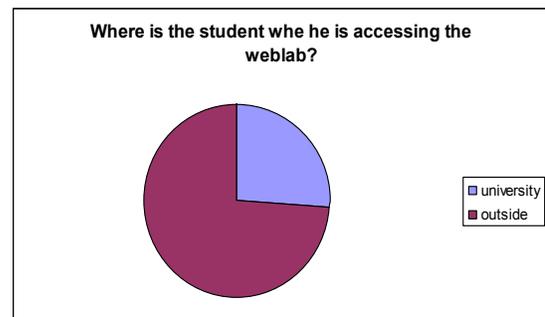


FIGURE 15
ACCESS POINT

75% of sessions are made outside the campus of the University of Deusto (see Figure 15).

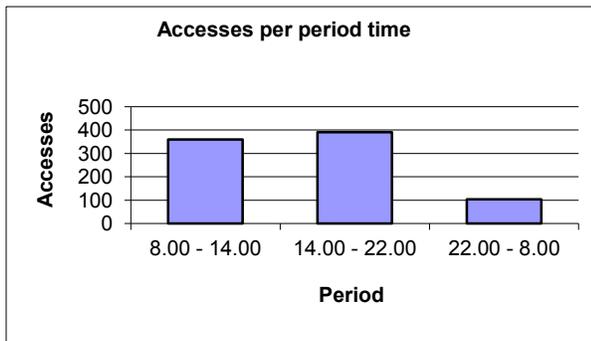


FIGURE 16
ACCESSES PER TIME PERIOD

The majority of the accesses are made in the afternoon-night (Figure 16), when the students are not in the classroom. If the university laboratories are unavailable for use and the student needs to finish her assignment, she connects the WebLab-Deusto actively.

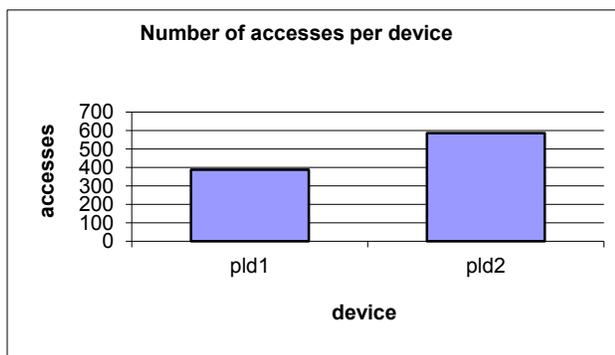


FIGURE 17
ACCESSES PER DEVICE

The load is balanced between the two copies of the same experiment (Figure 17).

CONCLUSIONS AND FUTURE WORK

In this paper we present the results of survey of the evaluation of the remote experiment for CPLD implemented for the course “Programmable Logic” using the WebLab-Deusto of the Faculty of Engineering of the University of Deusto (Spain). The survey held during last six years. The research shows that Web-Lab-Deusto is a functional and useful learning instrument. The analysis of the results confirms the correlation between the remote experiment usefulness and the student sense of immersion/control. However this correlation is not strong. The best knowledge and skills at the subject students get from combination of experiments at traditional and remote laboratories.

The future research and development with the WebLab-Deusto will be focused on an integrating it for more engineering courses, disciplines and degrees, and engaging the teachers and educators for using remote experiments in

their curriculum. The technical improvement of the video quality and the time period will bring the enhancement of the Web-Lab-Deusto usability overall. Finally, deeper statistical analysis of the student evaluation of the remote experiments and platform is significant for understanding the students learning needs, and for further development and enrichment of the platform.

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