

Acceptance, Usability and Usefulness of WebLab-Deusto from the Students Point of View

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Abstract—In the engineering curriculum, remote labs are becoming a popular learning tool. The advantages of these laboratories and the different deployments have been analyzed many times, but in this paper we want to show the results of the students' opinion about WebLab-Deusto as a learning tool. This work is focused on the subjects Programmable Logic (PL) in the third year of Electronics Engineering and in Electronics Design (ED) of the fifth year of the same degree. The paper presents the results of the surveys done by students since 2004. This survey consists of fifteen questions and its main objective is to measure the acceptance, usability and usefulness of the remote laboratory developed at University of Deusto from the students point of view.

Index Terms—Remote Labs, e-Learning, Students' surveys

I. INTRODUCTION

Using a remote laboratory – called WebLab, iLab, eLab, etc. – the students can complete a practical exercise or experiment in the same way as they were placed in a real laboratory. They can access to the remote lab from their houses or from anywhere with an Internet connection. A WebLab gives the students total control over the experiment: they can control its logic, they can wire/connect components and active inputs and show the outputs. Usually a client-server architecture is used.

Since 2000, a huge number of remote laboratories have been designed, implemented and set up over the world. Papers and books about remote labs focus on their advantages/disadvantages [1], state of art [2], technologies [3], didactic [4], etc. have been also published. Those papers, books, and articles show us the interdisciplinary quality of this research area. Most of those works are focused on the technology and a few articles are focused on the didactic utility of the remote labs as a didactic tool.

The present work analyzes the student's opinion about the acceptance, quality, usability and usefulness of the WebLab-Deusto. All the aspects related to the academic performance, students' marks, and so on, are not considered.

The section 2 describes the academic scenario of this work, and section 3 explains the survey that the students must full fill when they finish their work with Weblab-Deusto. Section 4 analyzes the results of the subject Programmable Logic from 2004 until 2008. Section 5 describes the results of the subject Electronic Design during from 2005 until 2008. Section 6 compares the two previous sections and section 7 studies in depth the results of the subject Electronic Design during the academic year 2007/08. The conclusions are presented in section 8.

II. SCENARIO

The Faculty of Engineering of the University of Deusto designed and implemented the first remote lab in the year 2002/03. During the year 2003/04 WebLab-Deusto was accessible for the students and since years 2004/05 y 2005/06 surveys about WebLab-Deusto-PLD and WebLab-Deusto-FPGA are available, respectively. WebLab-Deusto-PLD is used in the subject Programmable Logic (5 ECTS) during the second semester, in the third year of Electronics Engineering. WebLab-Deusto-FPGA is used in the subject Electronic Design (6 ECTS) during the first semester, in the fifth year of the same degree. In both subjects, the scenarios are similar:

- The student reads the outline of the practice and programs the solution using VHDL. Then, she/he simulates the program to test if it runs well.
- Files .jed or .bit are generated. These files contain the logic of the practice.
- The student connects to remote lab using the web site <http://weblab.deusto.es>. After logging/authentication he/she can download the .jed or .bit file into the programmable device through internet. (Figure 1).
- The system assigns 200 seconds to the student, he/she can activate the inputs by clicking at the switches and buttons located on the web site. The outputs (LEDs and 7 segments displays) are shown in the Weblab-DEUSTO site using a webcam. (Figure 2).



Figure 1. WebLab-DEUSTO

TABLE I.
RESULTS OF THE SURVEYS PROPOSED TO THE STUDENTS. YEARS 2004/08

	PL 04/05	DE 05/06	PL 05/06	DE 06/07	PL 06/07	DE 07/08	PL 07/08
Acceptance and Usefulness of WebLab-DEUSTO							
1. Has WebLab helped you with the subject?	4,6	4,1	3,8	3,84	3,75	3,5	4,2
2. Did you feel that you were in a better position by having been in the WebLab group?	4,7	3,9	3,9	3,74	3,7	3,8	
12. What is your global satisfaction with WebLab?	4,7	3,9	3,7	3,72	4	3,7	4,1
3. Do you think it is a good idea if this WebLab experiment is extended to all the students?	4,7	4,6	4,2	4,13	4,1	4,2	4,2
11. Would you like to use WebLab in other subjects?	4,3	4	3,9	3,8	4,1	3,7	3,9
Usability of WebLab-DEUSTO							
4. How many prototypes do you think are needed to support 50 students?		4,4	3,7	2,54	3,3	2,3	3,4
5. Is it easy to use?	4,4	4,4	3,9	3,67	3,9	4,1	4,4
6. How is the quality of the WebCam?	3,2	2,4	2,7	2,95	2,5	3,2	2,8
7. Did you feel at ease managing the inputs?	3,7	3,1	3	3,51	3,1	3,4	3,6
9. What do you think about the inputs/outputs implemented?	3,8	3,2	3,4	3,41	3,5	3,7	4,0
8. What do you think about the time assigned to each connection?	3,7	2,7	3,1	3,23	2,4	3,8	3,7
10. Being far from the prototype, Have you felt yourself to be in control?	4,1	3,7	3,6	3,64	3,7	3,7	3,9
Problems with WebLab-DEUSTO							
14. How many times was the server down?		3,1	2,2	2,46	2,1	2,7	3,3
13. How long did you wait for using it?		2,5	2,1	2,49	2	2,6	3,9
15. Do you know anybody who uses a WebLab in other University?	0	0	0	0	0	0	0

- The student has 200 seconds to work with the WebLab to confirm if the practice she/he has implemented is correct. It is enough in general, but if the student needs more time, he/she must to access again to the WebLab. The system manages the students' queue.
- The student analyzes the results and then she/he finishes the practical exercise. He/she can repeat the process all the times that she/he wants.
- In the subject Programmable Logic the students use the real lab and the remote lab, but in Electronics Design they use only the remote lab.
- If a student wants to access the WebLab and it is occupied, then the system will queue him. When the WebLab is free, the system will give the control to the first student in the queue, and so on.

From a technological point of view, the WebLab-DEUSTO has been implemented using web 2.0 technologies (AJAX, SOAP, etc.) and its architecture presents the following general characteristics:

- Users management - it uses the students' credentials officially provided by the University of Deusto; manages the access queue to the remote experiments; provides usage statistics; etc.
- Security and communication – neither the university nor the students are required to open other ports apart from the usual :80 port, used for the HTTP protocol. The university and the client security options are also not affected. The communications among the several modules implementing WebLab-DEUSTO are based on standard secure protocols.
- Universality – WebLab-DEUSTO can be accessed from any OS, with any web browser, and does not require any plug-in.
- Adaptability – the implemented architecture supports the seamless integration of new remote experiments due to its modular nature.

III. SURVEY AND METHODOLOGY

The survey consists on fifteen questions and it is filled by the students at the end of the semester. Table I shows the results of the survey from 2004 to 2008 for the subjects Programmable Logic (PL) and Electronics Design (ED). The minimum value is 1 and the maximum is 5: 1 is "I totally disagree" and 5 is "I totally agree". The answers of the questions 4, 13-15 are quantities.

At the beginning, the questions were in order from 1 to 15, but in the presented table, they are grouped in Acceptance and Usefulness of the WebLab, Usability of the WebLab and Problems in the WebLab. Questions 4 and 15 are not used for further analysis.

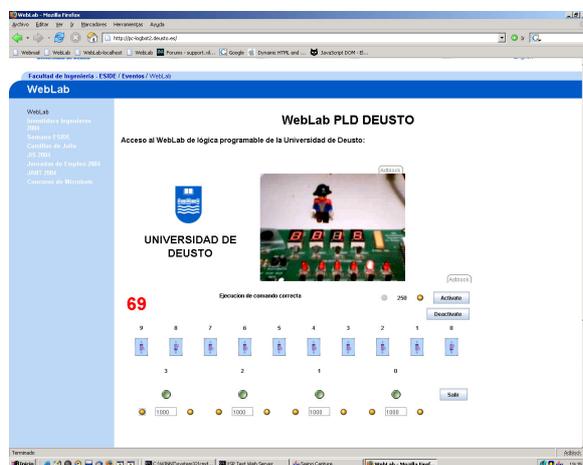


Figure 2. WebLab-DEUSTO web page

TABLE II.
DESCRIPTION OF THE SURVEYS

	Students	Surveys	%	Accesses
ED 05/06	31	17	55%	495
ED 06/07	42	39	93%	1.985
ED 07/08	33	28	85%	1.147
PL 04/05	90	10	11%	1.706
PL 05/06	58	40	67%	632
PL 06/07	37	33	89%	1.012
PL 07/08	36	33	92%	3.180
Total	327	200		10.157

PL: Programmable Logic, ED: Electronics Design

Table II describes the survey in the different years. It describes how many students were in the course, how many students completed the survey and how many times was the WebLab accessed by the students. To the best of our knowledge, this survey is the largest one in terms of number of academic years and total number of students involved.

From a methodological point of view and regarding the educational and pedagogical impact of remote labs, there are presently two general positions: a first group still arguing about its real suitability and effectiveness in educational terms, and a second group already using and integrating them in normal course contents and structure, not as a substitute to traditional hands-on labs, but rather as a complement to them. The University of Deusto assumes this last position, being supported by its students, according to the survey results presented in Table I. A problem often faced by researchers included in the first group arises from ethical considerations, i.e. experts on educational psychology argue that it is not recommendable to subject students enrolled in a same course to different tools and environments so as to measure the learning effectiveness of each one. This situation could potentially cause frustration on those students not using the tool or environment getting the highest score, at the end of the course [5].

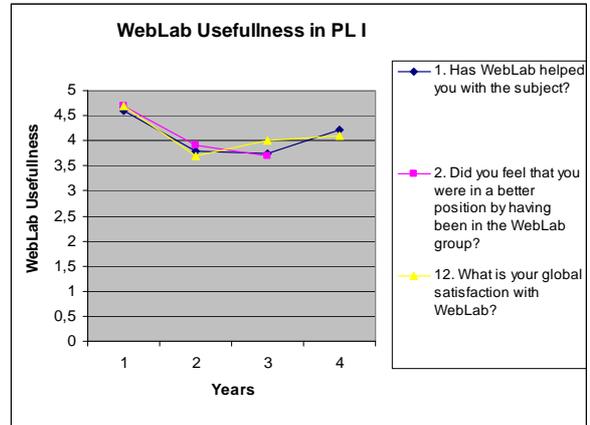
IV. ANALYSIS OF THE RESULTS IN THE SUBJECT PROGRAMMABLE LOGIC.

Figures 3 and 4 are related with the usefulness of the WebLab-DEUSTO in the subject from the point of view of the students.

Figure 3 shows that the answers for the questions –“Has WebLab helped you with the subject?”, “Did you feel that you were in a better position by having been in the WebLab group?” and “What is your global satisfaction with WebLab?”– are similar all the years and they are near to 4. It can be interpreted as a good evaluation by students for years. The score is the greatest in the first year, but it could be due to the newness of the WebLab in the Faculty.

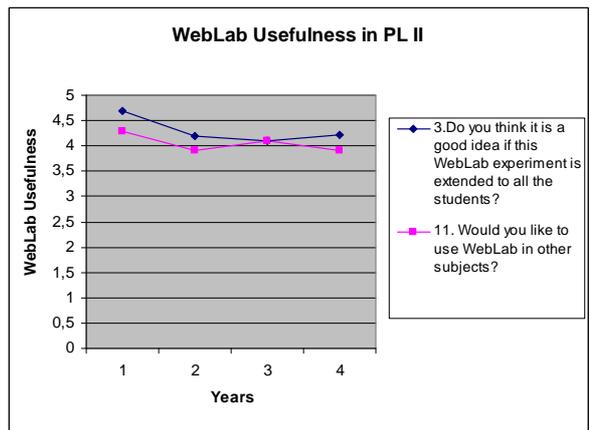
Figure 4 shows the answers of the students when they are asked about if they would like to use the WebLab in other subjects and if they think that it would be interesting to extend the use of the WebLab to other students –“Do you think it is a good idea if this WebLab experiment is extended to all the students?” and “Would you like to use WebLab in other subjects?”–. The opinion of the students is about 4, so we can think that they would like to use the WebLab again. It is very curious to observe that the students would prefer other students to use the WebLab instead of them.

Figure 5 shows the opinion of the students about the usability of service of the WebLab –“Is it easy to use?”, “How is the quality of the webcam?”, “Did you feel at ease managing the inputs?”, “What do you think about the inputs/outputs implemented?”, “What do you think about the time assigned to each connection?”, “Being far from the prototype, have you felt yourself to be in control?”–.



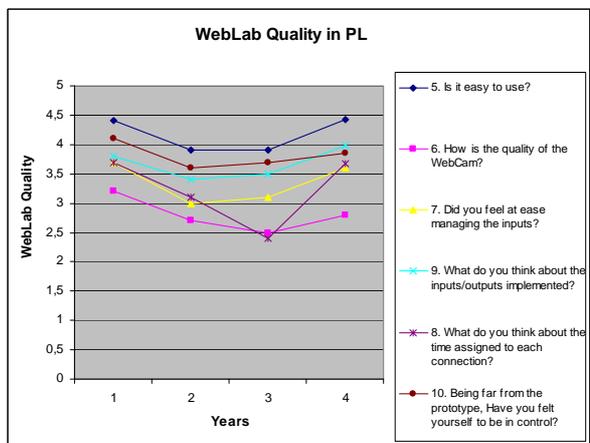
1: 2004/05, 2: 2005/06, 3: 2006/07, 4: 2007/08

Figure 3. WebLab Usefulness in PL I



1: 2004/05, 2: 2005/06, 3: 2006/07, 4: 2007/08

Figure 4. WebLab Usefulness in PL II



1: 2004/05, 2: 2005/06, 3: 2006/07, 4: 2007/08

Figure 5. WebLab usability in PL

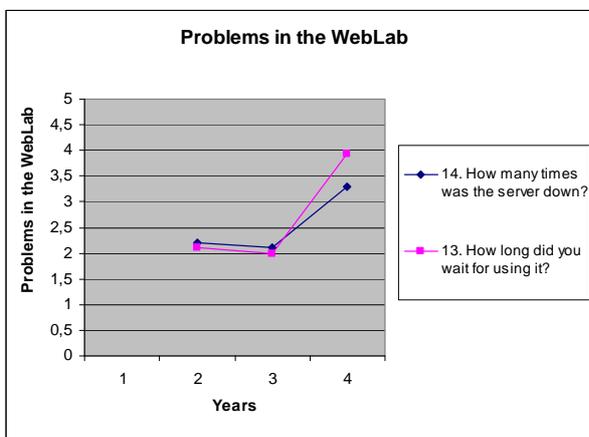
The results of the Figure 5 have to be analyzed question by question:

- Students say that WebLab is easy to use.
- About the quality of the webcam, the results are not good (less than 3). Likely the problem is due to the lighting of the WebLab's hardware. The actual webcam is better than the first webcam, and it is also concerned with the students' bandwidth.
- About the inputs management, the students' opinion is positive. Those inputs are: 10 switches, 4 buttons and a variable frequency clock.
- During the three first years, time assigned to each connection obtained the worst score (less than 3), and year by year the score was worse. In 2004 the time connection was 60 seconds and in 2008 it has been augmented to 200 seconds. With 200 seconds the students' opinions is better.
- The question "Being far from the prototype, have you felt yourself to be in control?" is a basic question [4] [6] [7] about the psychological perception of the WebLab by the student. If the student doesn't feel that through the WebLab he/she has the control over the experiment, the WebLab is not useful. In the WebLab-Deusto case, the students' answer is that they felt that they have the control over the experiment (almost 4).

Figure 6 shows the problems in the use of the WebLab only during 2005/08 –"How many times was the server down?", "How long did you wait for using it?". In both cases, during 2005/07 the student had to wait for the server twice and the server was down twice too. In the year 2007/08 the problem grew because the number of accesses was 3.180, and in 2006/07 it was around 1.000.

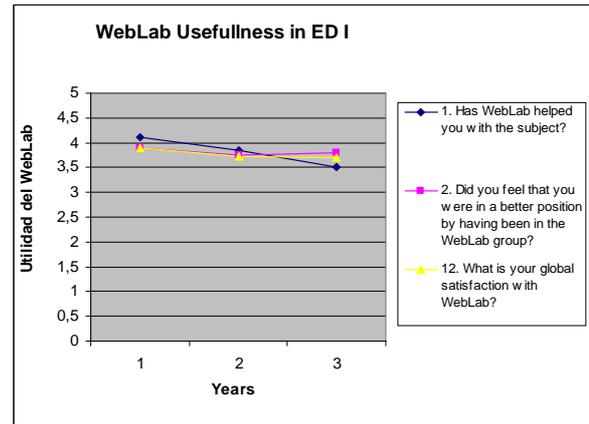
V. ANALYSIS OF THE RESULTS IN THE SUBJECT ELECTRONIC DESIGN

Figure 7 shows the students' opinion about usefulness of the WebLab-Deusto –"Has WebLab helped you with the subject?", "Did you feel that you were in a better position by having been in the WebLab group?", "What is your global satisfaction with WebLab?". Students are satisfied and the score is around 4 along the years 2005/06, 2006/07 and 2007/08.



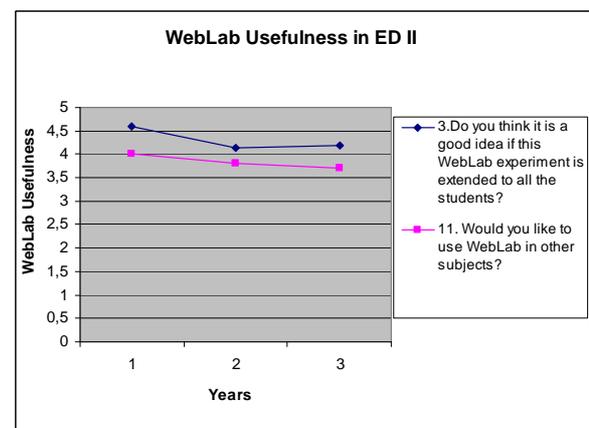
1: 2004/05, 2: 2005/06, 3: 2006/07, 4: 2007/08

Figure 6. Problems in the WebLab in PL



1: 2005/06, 2: 2006/07, 3: 2007/08

Figure 7. WebLab Usefulness in ED I



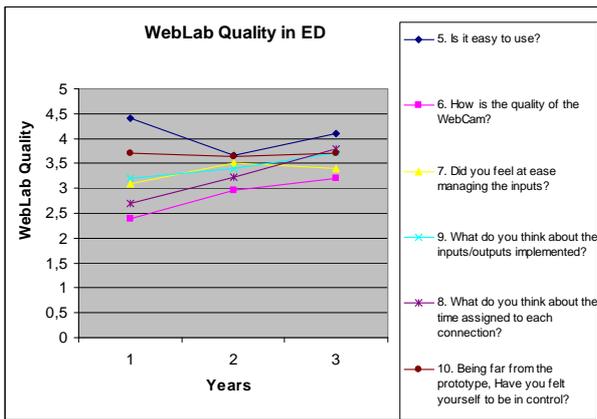
1: 2005/06, 2: 2006/07, 3: 2007/08

Figure 8. WebLab Usefulness in ED II

Figure 8 captures the students' answers to questions about to use the WebLab again, –"Do you think it is a good idea if this WebLab experiment is extended to all the students?", "Would you like to use WebLab in other subjects?". The answers are positive and the students agree to work again using this remote lab. In this subject again, the students would prefer other students to use the WebLab.

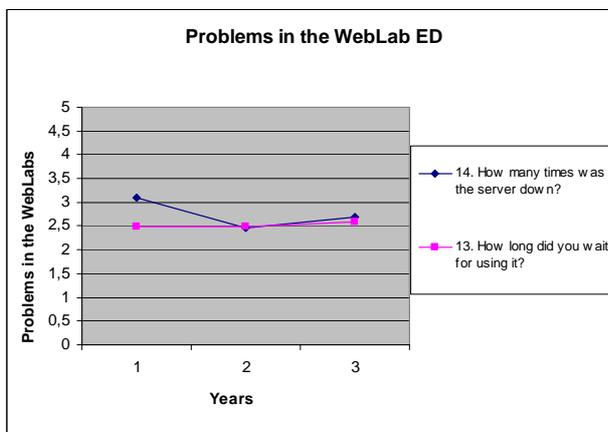
Figure 9 represents the students' opinion regarding the usability of the WebLab. For each questions, the opinion is different:

- Students think the WebLab is easy to use. The score is around 4.
- Students remark that the quality of the webcam is not good, but the score in this question improves year by year, thanks to a better lighting of the WebLab's hardware. In the subject Programmable Logic, the situation is the same and the score is less than 3.
- Students' opinion about inputs management is positive (higher than 3).
- The evaluation of time assigned to each connection improves year by year (from 2.7 to 3.8). In the year 2007/08, this question has increased 20% thanks to the increase of time connection to 200 seconds.
- Last question is focused on the student's control feeling. His answer is positive and stable along the years (higher than 3.5).



1: 2005/06, 2: 2006/07, 3: 2007/08

Figure 9. WebLab Quality in ED



1: 2005/06, 2: 2006/07, 3: 2007/08

Figure 10. Problems in the WebLab ED

Figure 10 shows the problems in the use of the WebLab –“How many times was the server down?”, “How long did you wait for using it?”. For both questions the score is near to 2.5. It can be taken as an acceptable value. It can be remarkable that although the connection time has been increased, the times that the students had to wait for the service didn’t increase.

VI. COMPARISON BETWEEN PROGRAMMABLE LOGIC AND ELECTRONIC DESIGN

Figures 11-14 integrate the obtained results for both subjects. The objective is to establish the differences and similarities between them. In Figures 11-14, odd elements are related to PL subject and even elements to ED subject. In this way, the elements are arranged in the time: 1. PL 2004/05, 2. ED 2005/06, 3. PL 2005/06, 4. ED 2006/07, 5. PL 2006/07, 6. ED 2007/08 and 7. PL 2007/08.

Figure 11 shows clearly that the usefulness of the WebLab is marked about 4. During the last year, we were working in a new version of the WebLab and the result of it from the students’ point of view is that we have been able to improve its usefulness.

Figure 12 represents that the students agree to work again using this remote lab and they propose the use of the WebLab in other subjects. This value is stable during the time again.

Figure 13 reflects that the students, in different years and/or subjects, do not agree in evaluating the usability of

the WebLab. The differences among lines are very significant when students are asked for their opinion about time connection and the quality of the webcam. In both cases, the students from ED give more importance to the quality of the webcam. And in the first case the evolution is positive and in the second one it is negative, although we have tried to improve the lighting of the room in which the hardware is located.

Anyway, the most important question of this group is related to the control feeling. In both subjects, students felt that they control the experiment.

Figure 14 shows clearly that the questions’ score related to the times the server was down and the waiting queue is between 2 and 3. The tendency can be explained because the number of accesses is growing year by year (see Table II).

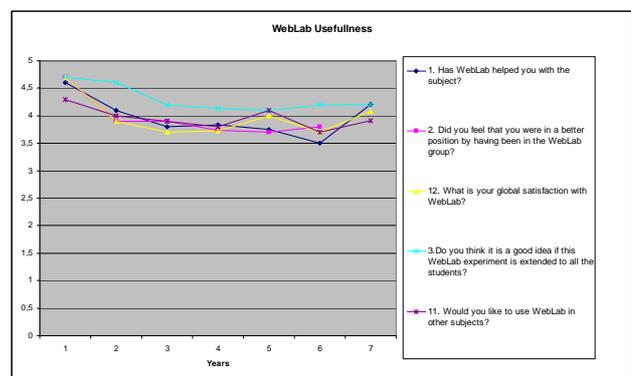


Figure 11. Comparison between ED and PL (I)

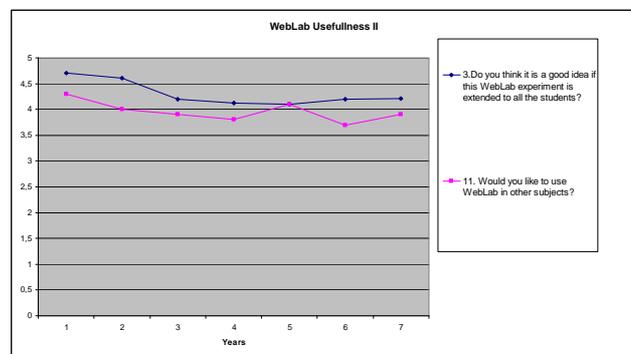


Figure 12. Comparison between ED and PL (II)

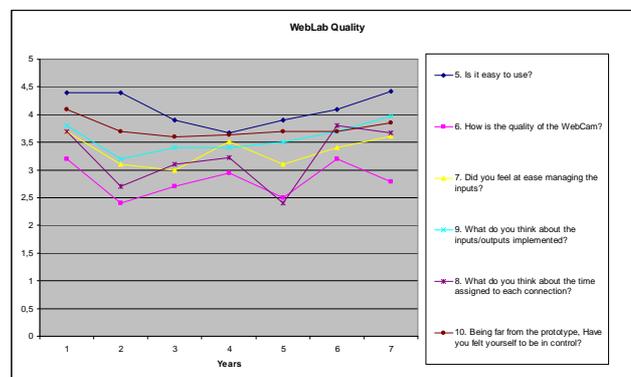


Figure 13. Comparison respect to WebLab Quality

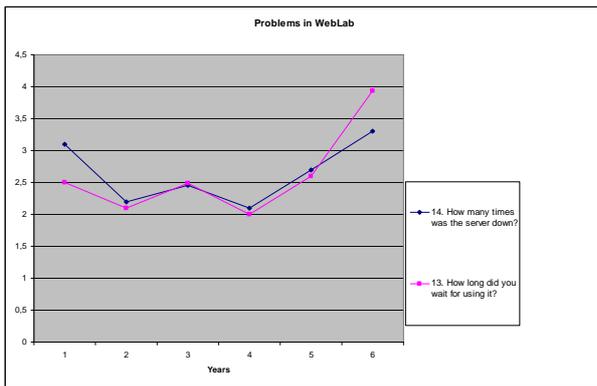


Figure 14. Comparison respect to WebLab Problems

- Question 9. “What do you think about the inputs/outputs implemented?” Most of the students accept selected inputs/outputs.
- Question 8. “What do you think about the time assigned to each connection?” Less than 5% of the students don’t agree with the time assigned to each connection.
- Question 10. “Being far from the prototype, have you felt yourself to be in control?” Almost 70% of the students recognize that they feel the control over the experiment in spite of not being in front of it.

Figure 18 groups the results of the Figures 14-16. The result is that during the year 2007/08, 65% of the students of DE subject think that the remote labs are a good or very good tool and only 10% of the students think that they are something inappropriate.

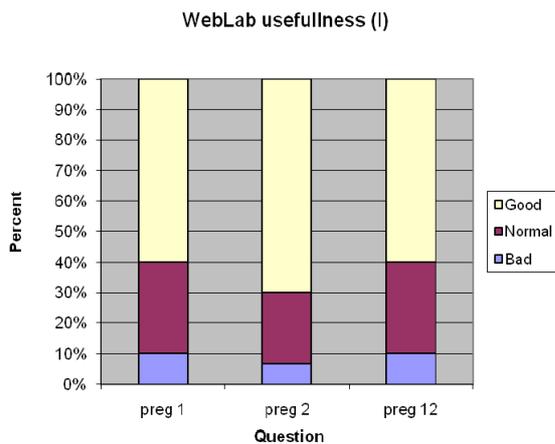


Figure 15. WebLab Usefulness in ED 2007/2008

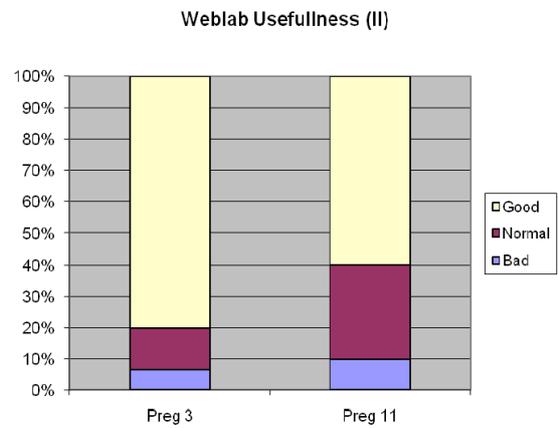


Figure 16. WebLab Usefulness in ED 2007/2008 (II)

VII. ANALYSIS OF ELECTRONIC DESIGN IN DEPTH

In this case the results of the subject Electronic Design during the year 2007/08 are studied in depth. First, the evaluation system has been change: marks 4 and 5 are called “good”, 1 and 2 “bad” and 3 “regular”. With this new evaluation system, each student’s answers are evaluated.

Figure 15 (Questions 1, 2, 12) shows that near to 60% of the students consider that the WebLab is a good or a very good tool for the Electronic Design subject. Only 10% of the students think that it is not a good tool.

Figure 16 (Questions 3, 11) shows that 60% of the students agree to use again the WebLab in other subject and only a 10% don’t agree. Respect to recommend the WebLab to other students, 80% of the students agree to do that and only 10% rule out the idea. In this last question, it is remarkable that only 10% of the students don’t have a clearly recommendation about it.

Figure 17 (Questions 5-10) represents the results related to the quality of the Weblab and it is shown a big range of responses.

- Question 5. “Is it easy to use?” Nobody finds the WebLab as a difficult tool.
- Question 6. “How is the quality of the webcam?” Almost 15% of the students that the quality of the webcam is bad.
- Question 7. “Did you feel at ease managing the inputs?” Almost 20% of the students don’t agree with the way of activating the inputs.

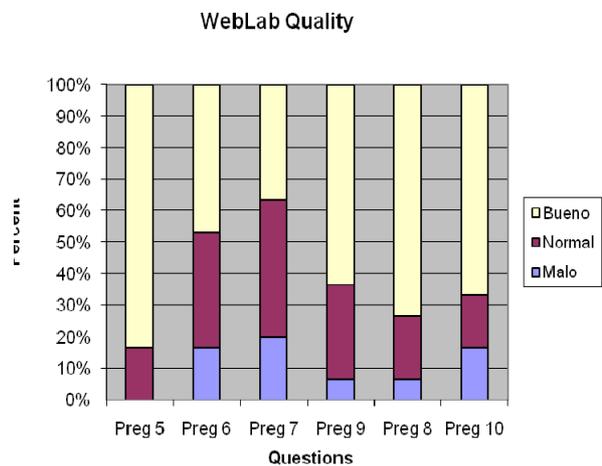


Figure 17. WebLab Quality in ED 2007/2008

Summary

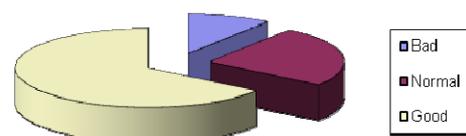


Figure 18. Summary for the subject "Electronic Design"

TABLE III.
SURVEY FOR ELECTRONIC DESIGN (2007/2008)

	S1	S2
<i>Number of Access</i>	537	610
1. Has WebLab helped you with the subject?	3,3	3,7
2. Did you feel that you were in a better position by having been in the WebLab group?	3,7	3,8
3. Do you think it is a good idea if this WebLab experiment is extended to all the students?	4,2	4,1
5. Is it easy to use?	4,0	4,2
6. How is the quality of the WebCam?	3,1	3,3
7. Did you feel at ease managing the inputs?	3,5	3,2
8. What do you think about the time assigned to each connection?	3,6	4,0
9. What do you think about the inputs/outputs implemented??	3,6	3,8
10. Being far from the prototype, Have you felt yourself to be in control?	3,7	3,7
11. Would you like to use WebLab in other subjects?	3,8	3,6
12. What is your global satisfaction with WebLab?	3,8	3,6
13. ¿Cuántas veces has tenido que esperar para usarlo?	2,7	2,6
14. How many times was the server down?	2,6	2,6

Finally, the results of the two surveys (ED subject) that have been done during the year 2007/08 are analyzed. The first survey was done at the end of the semester (S1), but some days later (S2), the number of access were the double (from 600 to 1200 access), because students had to finish their final project. For this reason the survey was repeated to analyze if the students' opinion had changed. Those results are shown in Table III.

Table III shows that the opinion of students is constant. It is remarkable that the score of the question related to time connection was better than in the first survey. That was due to the time connection was increased from 150 to 200 seconds.

VIII. CONCLUSIONS AND FUTURE WORK.

The first conclusion is that the obtained values are constant along the years and in the two subjects. Therefore, it can be said that this work is coherent. The conclusions of the work are:

- Remote laboratories have to be considered as a usefulness learning tool in the engineering courses.
- Remote laboratories are not substitute of the traditional labs. They are a complement of them.
- Students agree to use again remote labs in other subjects and they propose to be used by other students.
- The usability of WebLab-Deusto is good and it must be improved.
- Problems with the management and the quality of service in the WebLab are not appreciable.

- Instead of some universities near from University of Deusto have developed remote labs, students don't meet anybody else that uses remote labs in the subjects (Question 15 at Table I). It can be due to those remote labs are not used in regular courses.

Future work is focused on obtaining a standard survey for any remote lab. By this way the different research teams can interchange results and experiences with remote labs.

REFERENCES

- [1] Gomes, L. and Garcia-Zubia, J. eds. *Advances on remote laboratories and e-learning experiences*, Ed. University of Deusto, ISBN: 978-84-9830-077-2, 2007
- [2] Gravier, C. et al. "State of the Art About Remote Laboratories Paradigms - Foundations of Ongoing Mutations". *International Journal of Online Engineering*, Vol. 4, N° 1, 2008, ISSN: 1861-212, 2008
- [3] Indrusiak, L.S.; Glesner, M.; Reis, R. "On the Evolution of Remote Laboratories for Prototyping Digital Electronic Systems" *IEEE Trans. on Industrial Electronics*, VOL: 54, Issue: 6, Dec. 2007. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in *Magnetism*, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.
- [4] Ma, J. and Nickerson, J.V., "Hands-on, simulated, and remote laboratories: A comparative literature review", *ACM Computing Surveys*, Vol. 38, N° 3, 2006
- [5] Matute, H., & Vadillo, M. A. Assessing e-learning in web labs. In L. Gomes & J. García-Zubía (Eds.), *Advances on remote laboratories and e-learning experiences* (pp. 97-107), ISBN: 978-84-9830-077-2, Bilbao, Spain: University of Deusto Press, (2007)
- [6] Lang, D. et al "Pedagogical evaluation of remote laboratories in eMerge project", *European Journal of Engineering Education*, 32:1, 57-72, 2007 ([doi:10.1080/03043790601055626](https://doi.org/10.1080/03043790601055626))
- [7] Soysal, O. "Computer Integrated Experimentation in Electrical Engineering Education over Distance" *Proceedings of ASEE 2000 Annual Conference*, Saint Louis, MO, June 2000.

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