EOLES Project...Teaching Unit experiences

André Vaz Fidalgo[1], Denis Barataud[2], Guillaume Andrieu[2], Renaat De Craemer[3], Mihai Cristea[4], Abdelhalim Benachenhou[5], Mohammed Ankrim[6], Karim Bouchlaghem[7], Paulo Ferreira[1], Manuel Gericota[1,8]

[1]School of Engineering/Polytechnic of Porto, Portugal
[2]Université de Limoges, France
[3]KU Leuven University, Ostend, Belgium
[4]University Politehnica of Bucharest, Romania
[5]University of Mostaganem, Algeria
[6]University Cadi Ayad of Marrakech, Morocco
[7]University of Kairouan, Tunisia
[8]Buskerud and Vestfold University College, Kongsberg, Norway
{anf@isep.ipp.pt, denis.barataud@unilim.fr, guillaume.andrieu@xlim.fr, renaat.decraemer@kuleuven.be, mcristea@physics.pub.ro, benachenhou_a@yahoo.fr, ankrim@uca.ma, bouchlaghemkarim@yahoo.fr, pdf@isep.ipp.pt, mgg@isep.ipp.pt}

ABSTRACT

EOLES is an international cooperative project, with an emphasis not only on one of the facets of engineering education, but trying to involve all of them. This paper describes the course's accreditation, the structure the E-learning framework, the virtual and remote laboratories integration in the course and focuses on the experiences with one of the Teaching Units. Some data related to the first edition of the course is provided, as well as an initial analysis of the learning results and experiences. The accreditation and validation efforts are also introduced and discussed. The EOLES course is the result of an international effort involving experts from different engineering and education areas, in order to provide a better global Engineering Education.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education – *Accreditation, Computer science education, Curriculum Information systems education, Literacy, Self-assessment*

General Terms

Management, Experimentation, Human Factors, Legal Aspects.

Keywords

Online courses, Remote Laboratories, Accreditation, Case Study.

ACM 978-1-4503-3442-6/15/10…$15.00

DOI: http://dx.doi.org/10.1145/2808580.2808659

1. INTRODUCTION

The L3-EOLES (Electronics and Optics e-Learning for Embedded Systems) course, a fully on-line 3rd year Bachelor's degree in Electronics and Optics for Embedded Systems, is the most prominent outcome of the EOLES project, a 3-year European TEMPUS project involving 15 institutions, four from Europe (France, Portugal, Belgium and Romania) and eleven from the North African countries of Algeria, Morocco, and Tunisia [1]. The project started in October 2012 and was originally scheduled to end in October 2015. Presently is it expected to end in January 2016, although the academic schedule was not modified.

The project joins the expertise of the European partners in such areas as e-Learning 2.0 tools and simulation tools, and virtual and remote labs, with the priorities defined by Maghreb governments of developing higher education in advanced engineering fields, with the aim of creating the first fully on-line accredited engineering course – the L3-EOLES course – covering the field of electronics and optics for embedded systems. Designed as a specialization year, this course is oriented towards a currently expanding field in the electrical and computer engineering area, the embedded systems domain. The main originality of this course is the possibility given to students of carrying out practical and lab experiments remotely, using real equipment installed in different universities, providing they have a broadband internet connection.

The three-year EOLES project gave partners the time and the resources to adequately prepare the first edition of the course and to guarantee its continuity beyond project's end by agreeing in a suitable sustainability plan, supported by the commitment of the Universities involved in the project and in the delivering and accreditation of the course. The first edition of the course started in the middle of September 2014 and progress was closely monitored by all project partners. Some problems that arose during this first edition were promptly identified, and necessary adjustments were immediately introduced and the results rapidly evaluated.

2. COURSE DESCRIPTION

The course was prepared during the first two years of the EOLES project and comprised several steps, namely:

- Program definition;
- Technical units content and schedule definition;
- Functional e-Learning 2.0 framework definition;
- Development of the virtual and remote labs;
- Preparatory courses for instructors and technicians;
- Preparation of class and study materials;
- Preparation of the practical and lab assignments;
- Course accreditation;
- Students' selection and enrolling.

Taking into account the countries of the partner Universities and the objectives of the EOLES project, the background analysis that served as the basis for the development of the course was conducted in the three Maghreb countries participating into the project – Algeria, Morocco and Tunisia. Therefore, the preparation of the course had into account the characteristics of the target students and the national priorities defined by Maghreb governments for the development of higher education in advance engineering fields

Training was entirely conducted in English, allowing students to substantially improve their English skills, a fundamental tool in technological areas where the information, being it study materials or manufacturers' data, is only available in this language. Therefore, candidate students would have to have a minimum English level evaluated through a TOEIC or a TOEFL test or equivalent, recognized by the different partners of the consortium.

Another important aspect was that the curriculum program should allow graduated students to later apply for postgraduate degrees in any other University. Therefore, the accreditation of the course was also initially defined as one of the main targets of the project.

The course was fully delivered on-line using e-Learning 2.0 [2][3] synchronous and asynchronous tools, allowing students to be part of a "virtual learning community" and empowering team work, even if the team members are far apart. An innovative remote laboratory based on virtual experimentation and modeling and simulation platforms, and on remotely operated real instrumentation equipment installed in different universities was used by students to acquire essential practical skills.

3. COURSE RESOURCES

3.1 Management System

The Learning Management System (LMS) that supports TU organization, materials' access and delivering, on-line assessments, virtual and experimental lab access, tracking and reporting, forums and chats and all other course related activities is based on a Moodle 2.7 version platform [4].

Apart being a very versatile LMS, one of the great advantages of Moodle is to be an Open Source learning platform. This fact enables two distinct features that are very important for the EOLES project:

- The possibility of creating and adding plug-ins developed to enable the support of other resources, namely the access to external virtual and experimental labs designed by the EOLES team;
- Its zero initial and maintenance cost, which contributes to the long term sustainability, beyond EOLES project end, of the L3-EOLES course.

Figure 1 shows the organization of the materials inside the first week of a course Teaching Unit (TU).

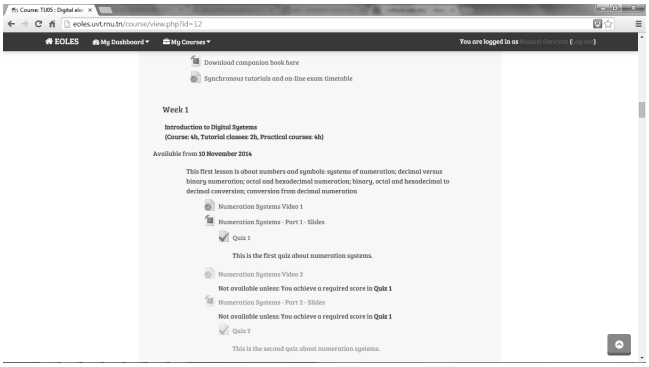

Figure 1. Organization of the study materials example

Weekly assignments, including any external links to virtual and/or experimental lab resources, were also part of the week structure supported by the LMS.

Forums and live chat resources were also available through the Moodle learning platform. These resources enabled students to feel part of a community, giving them not only a chance to interact with fellow colleagues but also to be pro-active in their own learning progression. It also helped to counter the loss of motivation in face of difficulties, both personal or due to very demanding subjects, creating a supporting network and preventing their dropping out. Furthermore, by encouraging collaboration an improvement in students' theoretical and practical skills and in their English language level was expected, contributing to increase the number of highly qualified workers in the North African countries.

3.2 Contents

The program was defined in cooperation with the North African Universities participating in the project, taking into account the priorities defined by their countries' governments. The program's focus on electronics and optics for embedded systems responds to the current tendency for integration of hardware/software into single reconfigurable platforms and to the increase on the amount of data produced and transferred requiring high-speed optical transmission, and to the need of training highly qualified professionals able to keep their countries' pace with these new technologies.

The program is divided in fourteen technical units (TUs) and in three optional units, presented in Table I.

The detailed content of each one of the TUs is available in the project website [5]. The course ran for 31 weeks, plus 3 weeks reserved for examinations – one in the end of the first semester, another one in the end of the second semester, and a last one in the final week of the course for make-up exams.

3.3 Example TU

To better illustrate the course, we will present the pedagogical solutions implemented on TU05-Digital Electronics for Embedded Systems and the subsequent preliminary results. The proposed framework was similar to all TUs, but some implementation adaptations were required as the subjects and difficulty levels are considerably different in some cases. A thorough analysis of all available results from all TUs will be performed and published after project conclusion.

TABLE I. TECHNICAL AND OPTIONAL UNITS LIST

TU	Title	ECTU
TU01	ICT - Introduction to Virtual Learning Environment	3
TU02	Mathematical and Analysis Tools for Physics 1	4
TU03	Communication Techniques in English	3
TU04	Analogue Electronics for Embedded Systems	4
TU05	Digital Electronics for Embedded Systems	4
TU06	Wave and Propagation for Embedded Systems	6
TU07	Power Electronics for Embedded Systems	6
TU08	Business Communication Techniques in English	3
TU09	Mathematical and Analysis Tools for Physics 2	3
TU10	Signal Processing	5
TU11	Instrumentation	4
TU12	Optics for Embedded Systems	6
TU13	Embedded Systems	6
TU14	Introduction to Entrepreneurship & Business Planning	3
UP12 1	Update in Optics 1	0
UP12 2	Update in Optics 2	0
UP04 1	Update in Electronics	0

In TU05 the lectures consisted of a set of 21 pre-recorded asynchronous classes with a duration never exceeding 20 minutes, where an instructor explains the theoretical basis of a subject supported by different types of visual materials as illustrated in Figure 2.

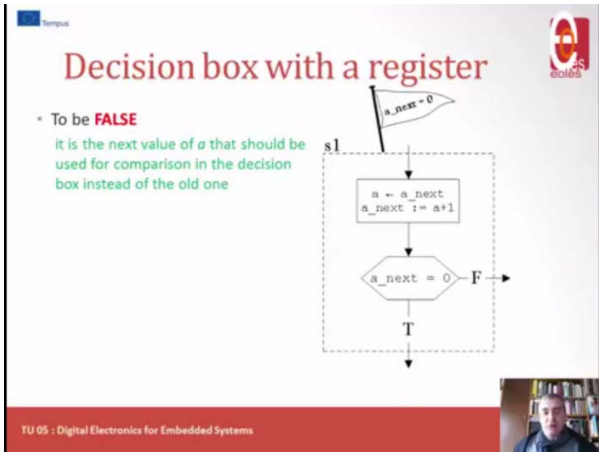

Figure 2. Example of a synchronous class.

Most classes' relied on powerpoint slides presentation recorded as online videos, with the teacher image superimposed and several visual aids (arrows, circles, etc...) used to illustrate key points. When required the classes also used external links and access to simulated equipment. The lecture materials are, whenever possible depending on their nature, available to download in a printable format.

These classes were accessed by all students, in most cases several times. It was possible to assess a subject difficulty by the number of visualizations of each specific class.

The classes were interspersed with self-evaluation quizzes, composed of multiple-choice, fill-in-the-blanks, matching exercises. These were intended to keep students' interest and attention, breaking long expositive classes. Additionally, these self-evaluation questions provided students with an immediate feedback about their degree of understanding of the subjects being taught. A quizz example is presented in Figure 3.

Students could progress at their own pace, viewing or reviewing this visual material anytime, any number of times, without restrictions. However, the student could only proceed to the next lecture after the successful completion of the self-evaluation questions associated to the previous one.

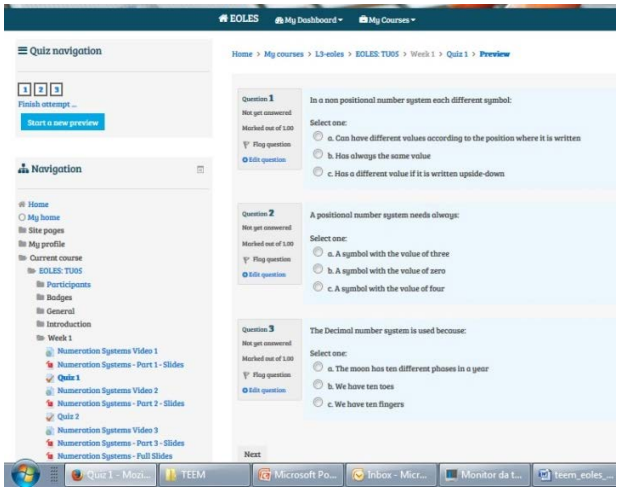

Figure 3. Example of self-assessment quiz.

All students completed the quizzes, even if sometimes requiring several attempts, as a minimum grade to progress was used. Some students reviewed the classes after failing a quiz, others posted their doubts in forums or sent messages to the teachers. As there were no measures to impede answer sharing, it was obvious that some communication between students was used to solve some of the quizzes. Although not encouraged, this behavior was not forbidden. An issue was spotted by a student on a specific quiz question that led to the need to modify its text in order to improve clarity.

A range of other materials is also available to support the study, including companion books freely downloadable from Internet, web links to other sites containing specialized information and other complementary data, depending on the TUs subject.

Tutorial classes were synchronous classes based on the use of a web conferencing tool. Their aim was to enable students to clarify any issues and ask questions related to the content of the TUs. These synchronous classes, with around two-hours' duration, took place Mondays and Thursdays. These classes were also recorded and the records made available to students. Figure 4 shows an example of one of these classes.

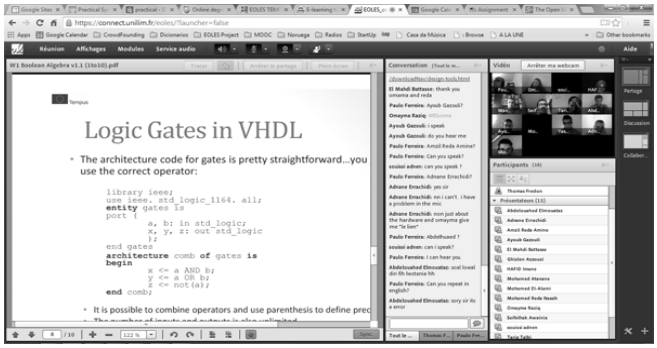

Figure 4. Example of a synchronous class.

During the synchronous classes tutor and students were required to have their cameras on. The aim was to have a visual feedback of the whole class making students feel part of a group and being able to interact not only with the tutor but also among each other. Indeed, one of the requirements for students to apply for the L3-EOLES course was to have not only a computer, but also a broadband Internet connection, a headset and a webcam.

On TU05 these classes were not intended to present new subjects, although several times it was necessary to clarify and repeat subjects presented on recorded classes, as some doubts remained. Participation was high, with over 70% of students generally present as viewers. However, video and audio participation was limited, with a few students being responsible by the majority of questions and discussion. A very important feature was the ability to share documentation and visual aids, as several questions required the discussion of available materials (pdf files, powerpoint slide presentations and external sites). This feature was not fully functional and was identified as an area where some improvement is required.

On some other TUs these classes were effectively used as interactive classes, replacing recorded classes. Although a more complete analysis encompassing all TUs is necessary, preliminary results seem to indicate the following:

- Students are more used to interactive classes, preferring those as an initial approach. This solution is feasible for simpler subjects.

- Recorded classes are a much more time efficient way to deliver complex subjects, as they allow the students to study and repeat at their own pace.

- Interactive classes are required to clarify doubts and answer questions. The use of recorded classes only is not a good solution to most students.

- Student participation in interactive classes is very diverse, requiring the teacher to be proactive.

- Additional asynchronous resources (forums, emails) are often preferred by some students, namely when lacking communication skills (e.g. English language)

Each week, one individual assessment work was proposed that had to be uploaded into the platform by the week's end. The set of works was worth 25% of the TU's final grade. The results were in general satisfactory, although several works were obviously rushed by the students. Two additional issues were identified:

- It was necessary to schedule work delivery dates not to collide with other tasks, as two TUs can be being taught simultaneously.

- There was some need to analyze the uniqueness of the delivered works, as the online character of the course can promote the sharing of results between students.

Apart from the final examination, to be held by the semester's end, a compulsory one-hour on-line exam, which worth 25% of the TU's final grade, was held before the end of each TU. For control reasons, it was mandatory that students were connected and visible all along the exam.

In TU05 this examination was designed as following:

- 80% questions multiple choice, with multiple versions and random response ordering, so that no two students had a equal examination

- 20% questions requiring a complex numeric answer and/or an essay answer.

The results were vey satisfactory and are presented in Fig 5.

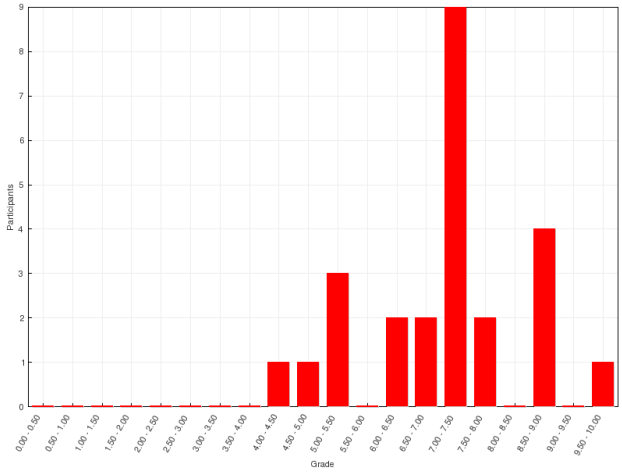

Figure 5. TU05 examination results.

As presented, most results were above the 50% mark, confirming that the TU subjects were adequately delivered. The examination results were better than assignment work results, by a considerable margin in several cases, which is also an issue that requires further analysis.

A two-hour final exam held by the semester's end is worth 50% of the TU's final grade. A bonus between 0 and 2 points could be attributed at tutor's discretion to each student according to his/her level of participation in the synchronous sessions, forums and live chats.

3.4 LAB CLASSES

The main originality of the L3-EOLES course is the remote laboratory used to perform on-line practical works. A multi-user approach is implemented allowing a group of students to work and interact in real time over the same Practical Work (PW), guaranteeing a strong collaboration among them during the training.

Two kinds of PWs are included in the remote laboratory:

- Virtual experimentation using professional software accessible in the application server or in open access from different companies and universities;

- Real remote laboratory experiments intended for students to perform real-time monitoring and control of technical equipment at distance.

The latter is the most innovative part of the remote laboratory. Each hardware setup (function generator or oscilloscope, for instance) is connected to the internet. From each TU's Moodle page students have access to the related lab's webpage and to the TUs' proposed lab works. Students are able to change the hardware configuration in real-time and have an immediate feedback of their actions, via the virtual instrument interfaces that are deployed remotely and through a high-definition camera (or other interface).

Figure 6 shows one of those lab setups using internet-controlled instrumentation and a camera. This enables students to see what is going on the real lab and how the real instruments react to their remote commands. This feedback is important for students to be sure that the interface they are seeing in their own monitor is not the visible face of a virtual world but the virtual interface of a real instrument.

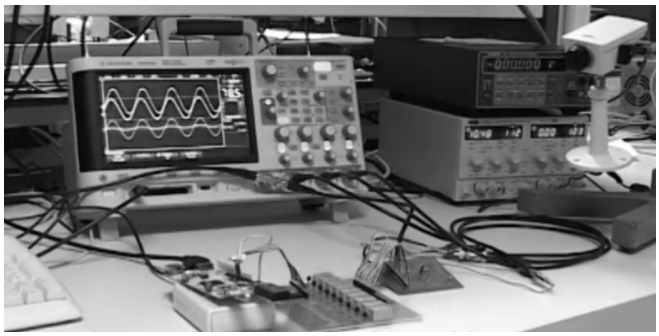

Figure 6. Experimental remote lab (University of Limoges)

The remote laboratory is expected to have a substantial learning impact as each student or group of students have the possibility of repeating the same experiment several times and of trying different configurations in a controlled and safe environment.

In TU05 the laboratories were all virtual, requiring the use of a VHDL design and simulation environment [6] and used mainly for the assignment works. The required software can be downloaded for free and therefore each student could also use it locally. The remote laboratories were used in other subjects where the real equipment was more important and were presented and demonstrated on recent conferences [7][8].

4. COURSE ACCREDITATION

Recent trends in online courses delivery indicate that accreditation is still a major requirement for course validation and recruitment. This is a major advantage of the EOLES course and with particular interest to its main target group [9].

After the definition of the course program, course accreditation was requested to the educational authorities of each one of the North African countries involved on the EOLES project, and also to the French educational authorities. The University of Limoges in France, coordinator of the EOLES project, requested the course accreditation to the French educational authorities in order to guarantee that any student from anywhere in the world would be able to access the L3-EOLES course and to receive, after its successful completion, a Bachelor's degree (Diploma) recognized in the European Higher Education Area (EHEA).

Apart from France, the L3-EOLES course was accredited by the national educational authorities of Morocco and Tunisia. All students from these two countries will receive a Joint Diploma issued by the University where they are enrolled in their own country and by the University of Limoges.

The Moroccan universities offering the EOLES diploma are the University Cadi Ayyad of Marrakech that awards a Professional Bachelor's degree entitled "Licence Professionnelle d´Electronique et Optique pour les Systèmes Embarqués (EOSE)" and the University Abdelmalek Essâadi of Tétouan that awards a Professional Bachelor's degree entitled "Licence Professionnelle Electronic and Optic for Embedded Systems (EOES)".

The Tunisian university offering the EOLES diploma is the University of Kairouan that awards a Bachelor's degree entitled "Diplôme de Licence Appliquée d´Electronique et Optique pour les Systèmes Embarqués".

In addition, to all successful students is awarded a Bachelor's degree entitled "Diplôme de Licence Sciences Pour l´Ingénieur (SPI)" issued by the University of Limoges and recognized by all EHEA members.

However, the cutting edge character of the L3-EOLES course raised some obstacles, namely because the current national legislations in the Maghreb countries are not prepared to recognize on-line courses where students' work and knowledge acquisition are assessed exclusively on-line as legitimate courses. Therefore, in order to receive the accreditation of the L3-EOLES course, Universities have to additionally perform on campus examinations, mandatory for students who want to receive the Joint Diploma. Unfortunately, in one of the Maghreb partner countries, due to insurmountable legislation barriers, it was not possible to get the course accreditation.

Recently, the course could be accredited as a Specialization course in Portugal. The accreditation procedure for this type of degree is much simpler as it can be managed inside the teaching institution (ISEP/IPP). Althought not a full accreditation in the original course scope, it is a good step in that direction and may increase the course visibility to Portuguese students.

This teaching division between European and North African teachers highly helped on the official accreditation of the Bachelor's program and on the recognition of the Bachelor's degree in the countries participating in the consortium.

5. CONCLUSIONS

As far as authors know, L3-EOLES course is the first fully on-line undergraduate course in Electronics and Optics for Embedded Systems to be recognized by the educational authorities in several countries at the same time, and the first to deliver a Joint Diploma recognized in the whole EHEA.

The existence of on-line undergraduate degree courses in Electrical and Computer Engineering was hindered by the lack of a framework for remote experimental labs, something that the EOLES consortium successfully addressed.

The experience gained and the improvements planned will make the second edition better and improve the overall course quality

and efficiency. Several issues were identified and are being solved, and several improvements are also planned. The first edition also acted as a marketing boost, and the inherent course visibility is now much more evident. The real test will be the subsequent professional and academic path of the first graduates.

First semester results show that 13 of 25 students concluded it successfully and 9 more can conclude it in the makeup session in July. Three students abandoned the course for several reasons and it is estimated that between 14 and 16 students will graduate, which represents a 60% success ratio.

The new course edition is already being finalized, based on the first edition structure and results, and enrollment is already open. This is an important step for the course sustainability, as it will survive the project end in January 2016. The second edition will have some modifications to address the identified issues and will also increase the participation of teacher from Maghreb institutions.

The sustainability strategy of the project relied on the diploma accreditation process. The official recognition of the L3-EOLES course permits to ensure its financial sustainability since with the accreditation it became part of the educational system for which institutional funds are available. An agreement signed by all partners of the EOLES consortium established the rules regarding the joint diploma, the access to the learning resources, the use of the remote laboratory and the maintenance of the equipment beyond the end of the EOLES project. One of the next objectives is to extend the degree to lifelong learning.

Finally, the long term ambitious perspective of this project is to create and to implement an international virtual university in hard sciences based on the knowledge acquired with the l3-EOLES.

6. REFERENCES

[1] Andre Fidalgo et al., "The EOLES project – Engineering labs anywhere", Proceedings of the IEEE Global Engineering Education Conference (EDUCON'2014), April 2014, pp. 943-946.

[2] T. Bates, "Understanding web 2.0 and its implications for E-learning", in M. J. W. Lee, and C. McLoughlin (Eds), Web 2.0- Based E-learning: Applying Social Informatics for Tertiary Teaching, IGI Global, New York, pp. 21-42, 2011.

[3] Boubker Sbihi, Kamal Eddine El Kadiri, "Towards a participatory E-learning 2.0", International Journal on Computer Science and Engineering, Vol. 2, No. 1, 2010, pp. 1-7.

[4] "Moodle," Internet: moodle.org [Jun 2015]

[5] "Course Content,"EOLES project Website, Internet: www.eoles.eu/ [Nov. 14, 2014]

[6] "Xilinx" Internet www.xilinx.com [Jun 2015]

[7] S. Farah, A. Benachenhou, G. Neveux, D. Barataud, G. Andrieu, T. Fredon, "Flexible and Real-Time Remote Laboratory Architecture Based on Node.js Server", 3rd Experiment@International Conference (exp.at15), POnt Delgada, Azores, Portugal, June 2015

[8] S. Farah, A. Benachenhou, G. Neveux, D. Barataud, "Design of a Flexible Hardware Interface for Multiple Remote Electronic Practical Experiments of Virtual Laboratory", International Journal of Online Engineering, Vol. 8, Special Issue 2, March 2012, pp. 7-12

[9] "Bachelor of Science in Electrical Engineering - How Online Degrees Work." Internet: distance.und.edu/degree/about/?id=electricalengbs&page=791 [Oct. 29, 2013]