EOLES course

The first accredited on-line degree course in Electronics and Optics for Embedded Systems

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***Abstract*—The EOLES course is the main result of an innovative and groundbreaking TEMPUS project, focused in Engineering Education. It covers all the problematic areas of Engineering Education, trying of find a suitable compromise in satisfying all the methods of evaluating engineering degrees.**

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 preparation and accreditation, its structure (motivated by pedagogical constraints), the E-learning framework, and the virtual and remote laboratories and their integration in the course. Some data related to the current first edition of the course are provided, namely the number of applicants and their countries of origin. While limited to a 3rd year in a Bachelor's Degree, for now, it is expected to be extended to a full course in a near future.

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.

Keywords— e-Learning; on-line degree; accredited engineering course; remote laboratories

I. 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 and eleven from the North African countries of Algeria, Morocco, and Tunisia [1]. The project started in October 2012 and is scheduled to end in October 2015.

The project joint 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 project 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, within the project's time so its progress may be closely monitored by all project partners. Any problems arising during this first edition may be promptly identified, any necessary adjustments immediately introduced and the results rapidly evaluated.

The course was recognized by the educational authorities of France, Morocco and Tunisia. As a result, all successful students receive a diploma recognized inside the European Higher Education Area (EHEA). Additionally, students from Morocco and Tunisia receive a diploma issued by one of the accredited universities of their home countries.

As far as authors are aware, this is the first fully on-line accredited degree course in an area of engineering where practical skills are mandatory, thanks to the innovative remote lab developed within the EOLES project. This is by far the most cutting edge advance in the field of e-Learning, breaking

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new grounds in an area until now mostly dominated by blended learning.

II. E-LEARNING ENGINEERING COURSES

Distance learning education has its origins in the XIX century. In 1840, Sir Isaac Pitman, the English inventor of shorthand, had the idea of delivering correspondence courses by mail [2]. The University of London was the first university in the world to offer distance learning degrees through its External System established in 1858 [3]. Despite the success of correspondence courses, the type and number of courses on offer remained limited to a small number of areas, mainly due to the low degree of interactivity between instructor and student. In those days, the exchange of material between them was restricted to writing paper material governed by the slow pace of the postal services.

In the second half of the XX century this prospect started to change, with the establishment in 1969 of the United Kingdom's Open University (OU) [4], with its mixed-media approach to teaching. Despite keeping the same way to convey the material, this was now much more diversified, from carefully constructed texts to audio and video records, and complemented with conventional broadcast radio and television. Furthermore, live sessions over the telephone were organized both individually, between the student and his assigned instructor, or in group, with other students.

However, the great revolution occurred only during the 90s with the introduction of the e-Learning concept. This concept was based on the use of a new and potent vehicle of communication - the Internet –, which enabled for the first time a significant level of interaction between student and teacher, and among students themselves.

Despite that great leap forward, only during the last decade, many established Universities started offering undergraduate e-Learning programs, in addition to their classic on-site programs, creating specific e-Learning frameworks and adapting their traditional offer to be delivered remotely. In spite of that, some courses, like languages and engineering, require attendance at a residential school [5]. Even though, while postgraduate level engineering programs awarding a final Certificate, Diploma or Master degree are easy to find, the undergraduate offer is restricted to no-engineering areas. The exception are the widely available fully on-line information and computer technology (ICT) undergraduate programs, since the same computer used by the students to follow an ICT program may be used to perform practical work in the field. Other rather generic Master degrees in engineering may also be found, but their content is essentially restricted to paper research work and writing. Apart personal teaching guidance, no classes are generally provided, meaning no lab work is executed. The only tools students have access are modelling and simulation tools. Indeed, they are the reason why Master degrees in Electrical and Computer Engineering are often found on-line. These tools are easily deployable over the Internet, enabling students to perform some practical work assignments, despite their virtual character. By the contrary, undergraduate degrees, to be successful, require students to be able to perform experimental work in subjects like physics, chemistry, mechanical and electrical machines, or digital and analogue electronics, for example. For students to acquire the required technical experimental skills these subjects require the remote access to experimental labs and real time interaction with real experimental setups that are far more complex to implement.

Until recently, the only solution has been the use of blended learning solutions as described in [6], with the entire program being conducted on-line, except for the lab classes. These have to be performed on campus, being usually concentrated by semester's end. Other examples (from the many available) are the Bachelor of Science in Electrical Engineering at The University of North Dakota [7], or the Bachelor of Science in Engineering Technology: Electrical at The University of North Carolina at Charlotte [8], two traditional universities. But even at The Open University, a distance learning university, the students have to attend two UK-based residential schools to get a Bachelor of Engineering (Honours) [5].

Blended learning solutions, however, have obvious disadvantages. First, the student must have the necessary time and funds to travel, in some cases to the other side of the world, and to spend a few weeks a year in the University campus. Second, from a pedagogical point of view, there is no synchronization among theoretical, tutorial and lab classes, which creates difficulties to the normal learning process, postponing in a certain sense the correct understanding and assimilation of the different subjects.

The absence of on-line undergraduate degree programs in Electrical and Computer Engineering is far more incomprehensible since it is possible to find in the specialized literature many examples of different labs for different areas of physics and electrical engineering [9-16], each one allowing different degrees of freedom in the configuration of the experiment by the remote user. However, their use has been restricted, operating mainly as a complement of on-campus lab classes and not as a part of fully on-line undergraduate programs.

The use of remote labs as an integral part of a fully on-line accredited engineering course seems to be a natural step in the e-Learning evolution towards fully e-Learning engineering courses.

III. COURSE PREPARATION

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, namely:

- Computing, engineering and engineering trades for Algeria;
- Computer sciences for Tunisia;
- Physical sciences, computing, engineering and engineering trades for Morocco.

Notice however that this is not a constraint imposed to candidate students. Albeit focused on students from the Maghreb countries involved in the EOLES project, the proposed curriculum is available for students living anywhere in the world.

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.

One of the first points to be agreed was that the training would be 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.

The target population of the course was defined as students already possessing 120 (European Credit Transfer Units (ECTU) obtained in such areas as:

- Physics
- Electrical
- Electronics
- Automation
- Optics
- Telecommunications

or similar and willing to follow a career in the fields of electronics and optics.

The course would be fully delivered on-line using e-Learning 2.0 [17-18] 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 modelling and simulation platforms, and on remotely operated real instrumentation equipment installed in different universities would be used by students to acquire essential practical skills.

The first edition of the course would start in the middle of September 2014, within the project time so it would be possible to all project partners closely monitor its progress, identify any drawbacks, promptly introduce any necessary adjustments and rapidly evaluate the results.

IV. COURSE STRUCTURE

A. Program

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. The latter are preparatory TUs provided at the beginning of the 1st semester to level students' knowledge in critical topics for the course – electronics and optics, since students with very different knowledge backgrounds may apply to be enrolled in this program. The TUs cover a broader list of topics. The list of mandatory technical and optional units that form the L3-EOLES course curriculum is presented in Table I.

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
UP121	Update in Optics 1	0
UP122	Update in Optics 2	0
UP041	Update in Electronics	0

Since each ECTU represents 10 hours of work per week, a TU associated with x ECTU represents x weeks of 10 hours' work per week. As an example, TU01 is a mandatory TU associated to 3 ECTUs corresponding to 3 weeks of work. It represents 30 hours of work - 10 hours of theoretical courses, tutorials and/or practical/lab work per week.

For each TU it was necessary to create:

- The list of practical and lab works for the virtual experimentation, modelling and simulation platforms, or/and to be implemented on remotely operated real instrumentation equipment;
- The assessment (exams, assignments) details;
- The list of teachers involved, selected according to their field of expertise.

To ensure an efficient collaborative work, the number of teachers involved in one training unit is limited to three, with at least one teacher from a European institution and one teacher from a North African institution.

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.

B. *Technical units content and schedule*

The aim of the first mandatory TU - Virtual Learning environment – is to introduce the student to the learning environment platform and to the interactive tools that support the course dynamics.

The remaining 13 TUs may be divided in three groups: fundamental sciences – including mathematics and physics, applied sciences – digital and analogue electronics, electromagnetic waves, digital signal processing, instrumentation and optics, and complementary soft skills units, like communication techniques in English and business management.

The detailed content of each one of the TUs is available in the project website [19].

The course runs 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.

During both semesters there are always two TUs running in parallel with an indicative schedule of 4 hours a week for lectures, 2 hours for tutorial classes and 4 hours for practical/lab work each. To always have two TUs running in parallel has two main goals:

- To avoid the monotony and pressure associated to intensive single subject classes;
- To give students time to assimilate the subjects and to correlate the new subjects with those previously studied.

C. *Pedagogical and assessment methodology*

The lectures are mainly pre-recorded asynchronous classes with a duration never exceeding 20 minutes and where an instructor explains the theoretical basis of a subject supported by different types of visual materials, interspersed with self-evaluation questions – multiple-choice, fill-in-the-blanks, matching exercises –, whose aim is to keep students' interest and attention, breaking long expositive classes. Additionally, these self-evaluation questions provide students with an immediate feedback about their degree of understanding of the subjects being taught. Students may progress at their own pace, viewing or reviewing this visual material anytime, any number of times, without restrictions. However, the student may only proceed to the next lecture after the successful completion of the self-evaluation questions associated to the previous one. The lecture materials are, whenever possible depending on their nature, available to download in a printable format.

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 are synchronous classes based on the use of a web conferencing tool. Their aim is 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, take place Mondays and Thursdays. These classes are also recorded and the records made available to students. Figure 1 shows an example of one of these classes.

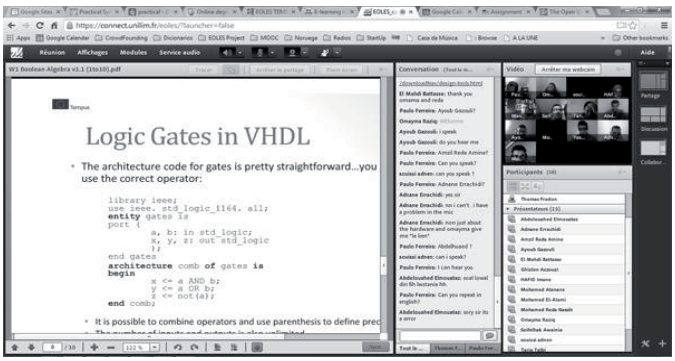

Fig. 1. Example of a synchronous class.

During the synchronous classes tutor and students are required to have their cameras on. The aim is 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.

Each week, a set of problems is proposed comprising at least one individual or group assessment work that must be uploaded into the platform by the week's end. The set of works is worth 25% of the TU's final grade.

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, is held before the end of each TU. For control reasons, it is mandatory students to be connected and visible all along the exam.

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 may be attributed at tutor's discretion to each student according to his/her level of participation in the synchronous sessions, forums and live chats.

When offering on-line courses, there are other pedagogical and non-pedagogical aspects that need to be taken into account not to collide with the different cultural and/or religious beliefs of the students. Therefore, in the L3-EOLES course Fridays, Saturdays and Sundays are left for students to finish their individual or group assignments and no synchronous classes or exams are taking place on these days.

V. FUNCTIONAL E-LEARNING 2.0 FRAMEWORK

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 [20].

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 plugins 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.

Fig. 2 shows the organization of the materials inside the first week of TU05, according to the pedagogical methodology described in section IV-C.

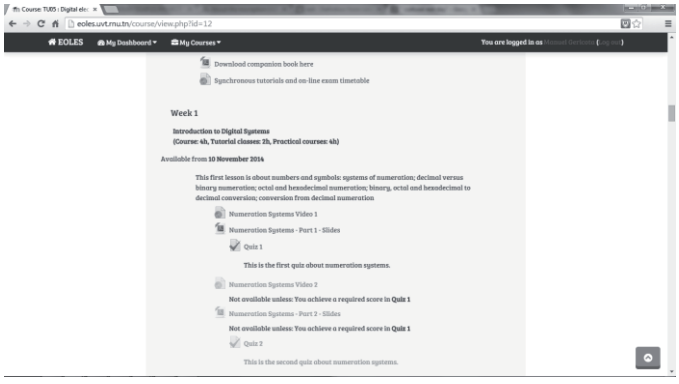

Fig. 2. Organization of the study materials inside Week 1 of TU05.

Weekly assignments, including any external links to virtual and/or experimental lab resources, are also part of the week structure supported by the LMS. Fig. 3 shows the description and links associated to the weekly assignment and the links to the recorded synchronous sessions held twice a week.

Forums and live chat resources are also available through the Moodle learning platform. These resources enable 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 helps 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 it is expected an improvement in students' theoretical and practical skills and in their English language level, contributing to increase the number of highly qualified workers in the North African countries.

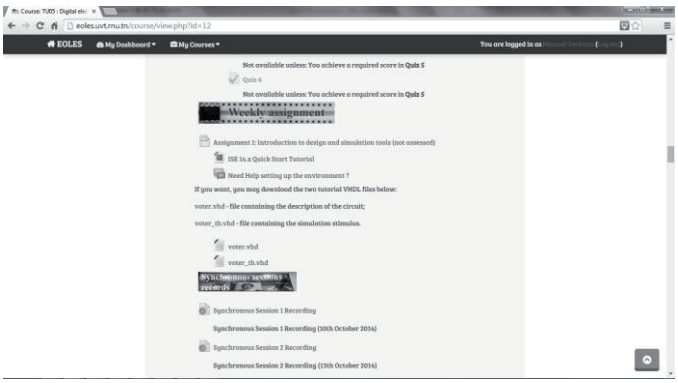

Fig. 3. Weekly assignments and synchronous session's records.

VI. THE EOLES VIRTUAL AND REMOTE LABORATORY

The main originality of the L3-EOLES course is the remote laboratory used to perform on-line practical works.

All European partners involved in the EOLES project have extensive and up-to-date expertise in this topic, and use it to assist on the development and deployment of several remote experiments on several technological fields, including optics, electronics and embedded systems. As far as authors know, this remote laboratory is the first in the world to be used as part of a fully on-line accredited degree in this area.

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 4 shows one of those lab setups using internet-controlled instrumentation and a camera. This enables students to see what is going on 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.

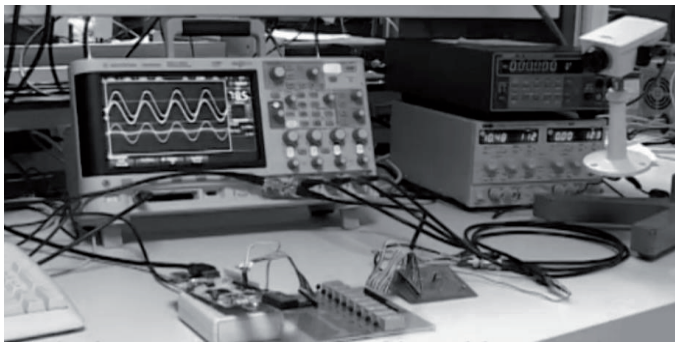

Fig. 4. Experimental remote lab setup at the University of Limoges.

Figure 5 and 6 show the interface students see and through which they are able to manipulate the circuits under test in the real lab. Notice that the instrument interface, in this case an oscilloscope, mimic the real oscilloscope panel, enabling students to perform remotely the same manipulations over the circuit under test they will be able to perform in the real lab. A relay board enables students to change the configuration of the circuit.

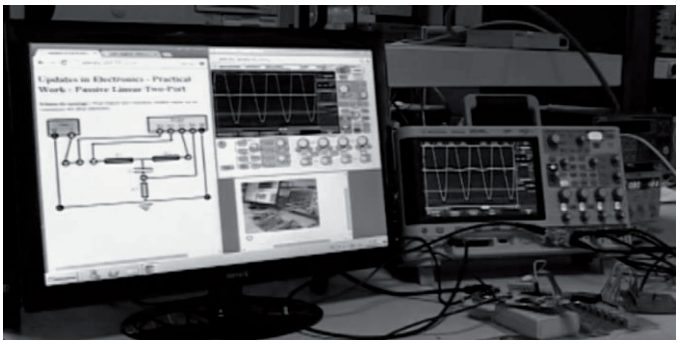

Fig. 5. Experimental real lab remote interface.

The remote laboratory is distributed by 4 different locations in order to reduce maintenance and installation costs. Furthermore, each practical work will not be duplicated to reduce the costs. The physical installation of the laboratories was performed by the North African partners, with all equipment acquired in the project being directly delivered to partner countries' Universities.

The final objective is the integration of all experiments on a single and unified remote EOLES laboratory accessible by all partner institutions and providing 24/7 access to the experiments. The remote EOLES laboratory addresses the main technological content described on the syllabus TUs.

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.

Fig. 6. Real and remote distance panel of an oscilloscope.

VII. COURSE PREPARATION AND ACCREDITATION

A. Preparatory courses

An important aspect of the EOLES project related to the preparation of the L3-EOLES concerned the training of teachers and staff from the Maghreb partner countries' institutions in order to ensure an efficient transfer of expertise from EU partners to those institutions and the mid-term sustainability of the course itself.

During the Fall semester of the 2013 - 2014 Academic Year, two on-line training courses took place related to the e-Learning platform:

- "e-Learning platform use training" a course delivered to future L3-EOLES course teachers and tutors and designed to provide an insight into the available e-Learning 2.0 tools, their use and their pedagogical interest in the context of on-line courses;
- "e-Learning platform administration training" a course about Moodle server installation and maintenance delivered to technical staff from the Maghreb institutions where the e-Learning platform was in course of installation.

In the Spring semester, another two training courses took place designed with the sole purpose of improving teachers and tutors general and technical English.

All these training courses were organized by the University of Limoges, Katholiek Universiteit van Leuven, Virtual University of Tunis and Abdelhamid Ibn Badis University of Mostaganem.

On-line and on-site courses on the EOLES experimental remote lab configuration and use were also organized by the University of Limoges and delivered to different groups from several partners, according to their future role on the L3-EOLES course organization and running, preparing them for the first edition of the course that began in the Fall semester of the 2014 - 2015 Academic Year.

B. Course accreditation

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, demanded 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.

VIII. The first edition

A crucial aspect for the success of the application phase of the first edition of the L3-EOLES course was dissemination. Due to the on-line character of the course, several paths were explored to convey course information to the target population.

Taking advantage of the social networks, the course was announced in several student forums, disseminated through the project's webpage and own project's social network pages.

More traditional dissemination methods, like leaflets and posters were also profusely distributed by the partners' institutions in their own countries.

Student's applications registration was also made on-line. During this phase, students had to upload a Transcript of Records of previous education in English and a certificate demonstrating their level of English, together with a Letter of Motivation also written in English.

The applications were selected by the pedagogical committee in July 2014, and the accepted students were required to make effective your administrative registration by the end of August.

Students involved in the double degree process wishing to receive a Joint Diploma - students living in Tunisia and Morocco - had to pay the registration fees in the University of Limoges and in the University of their choice in their country of origin.

The number of applicants for the first edition of the course, albeit highly concentrated in one of the EOLES partner countries, largely exceeded the initial expectations with a total of 660 candidates from Morocco, 15 from Tunisia, 10 from Algeria, one from Senegal and one from France.

After a careful selection 20 students from Morocco and 10 students from Tunisia are currently attending the course. All students are simultaneously enrolled in the University of Limoges and in one of the accredited Universities of their choice in their countries of origin, and thus, in this first year, all students will receive the Joint Diploma.

The first edition of the L3-EOLES course started September 22nd, 2014. All people involved in the course - partners, teachers, technicians, and, of course, the enrolled students - were invited to participate in the first meeting.

The enrolment for the second edition will start February 2015.

IX. Conclusion

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 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.

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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] D. Matthews, "The Origins of Distance Education and its use in the United States," T.H.E. Journal, Internet: www.thejournal.com/articles/14278_1, Sept. 1999 [Nov. 12, 2014]

[3] "Our history," University of London International Programmes Website, Internet: www.londoninternational.ac.uk/our-global-reputation/our-history [Nov. 12, 2014]

[4] "Degrees and courses for international students." Internet: www.openuniversity.edu [Nov. 12, 2014]

[5] "Bachelor of Engineering (Honours)" Internet: www.openuniversity.edu/courses/engineering-technology-and-design/bachelor-of-engineering-honours [Nov. 12, 2014]

[6] Jinwen Zhu, "A hybrid online-education strategy for delivering engineering and technology courses," Proceedings of the 2nd International Conference on Networking and Digital Society (ICNDS'2010), Vol. 2, 2010, pp. 448–451.

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

[8] "Bachelor of Science in Engineering Technology: Electrical (2+2 program)." Internet: distanceed.uncc.edu/programs/engineering/bachelor-science-engineering-technology-electrical [Oct. 29, 2013]

[9] M. M. Albu,, K. E. Holbert, G. T. Heydt, S. Dan Grigorescu, V. Truşcă, "Embedding Remote Experimentation in Power Engineering Education," IEEE Trans. on Power Systems, Vol. 19, No. 1, February 2004, pp. 139-143.

[10] D. Hercog, B. Gergič, S. Uran, K. Jezernik, "A DSP-Based Remote Control Laboratory," IEEE Trans. on Industrial Electronics, Vol. 54, No. 6, December 2007, pp. 3057-3068.

[11] M. T. Restivo, J. Mendes, A. M. Lopes, C. M. Silva, F. Chouzal, "A Remote Laboratory in Engineering Measurement", IEEE Trans. on Industrial Electronics, Vol. 56, No. 12, December 2009, pp. 4836-4843.

[12] J. García-Zubia, I. Angulo, J. Irurzun, P. Orduña, J. Ruiz, U. Hernández, M. Castro and E. Sancristobal, "Easily Integrable Platform for the Deployment of a Remote Laboratory for Microcontrollers", International Journal of Online Engineering, Vol. 6, Issue 3, August 2010, pp. 26-31.

[13] A. Cardoso, P. Gil, "Online Learning in Engineering Courses Using Wireless Sensor and Actuator Networks", International Journal of Engineering Pedagogy, Vol. 3, Special Issue 1, February 2013, pp. 76-80.

[14] 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.

[15] F. Priem, R. De Craemer, J. Calu, F. Pedreschi, T. Zimmer, S. Saïghi, J. Lilja, "E-Learning in Science and Technology via a Common Learning Platform in a Lifelong Learning Project," European Journal of Open, Distance and E-Learning, No.1, March 2011, 24 pp.

[16] N. Sousa, G. R. Alves, M Gericota, "An Integrated Reusable Remote Laboratory to Complement Electronics Teaching," IEEE Transactions on Learning Technologies, Vol. 3, No. 3, July-September 2010, pp. 265-271.

[17] 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.

[18] 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.

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

[20] "Moodle," Internet: moodle.org/ [Nov. 14, 2014]

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