The EOLES project
Remote Labs across the Mediterranean

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***Abstract* — This paper describes the concept, methodology and first steps of an EU supported TEMPUS project EOLES (Electronics and Optics e-Learning for Embedded Systems). Its aim is the creation of a 3rd year Bachelor degree that relies exclusively on e-learning and remote laboratories. The project involves 15 institutions from four European countries and three North African countries. The proposed course will be run from several institutions simultaneously and should be accredited as a formal specialization year in all partner institutions, awarding 60 ECTU (European Transfer Credit Units). The course will integrate a Virtual Learning Environment and a Distributed Laboratory.**

***Index Terms*—engineering e-learning course, remote laboratory, distributed learning, virtual classes.**

I. Introduction

The EOLES project (Electronics and Optics e-Learning for Embedded Systems) is a three-year Tempus project supported by the European Commission. Its goal is to support the e-learning development in Algeria, Morocco and Tunisia in the fields of Physical Sciences. To achieve this, it was proposed the creation of an English-spoken 3rd year Bachelor degree in Electronics and Optics for Embedded Systems for students already having the first two years of a university Bachelor program on a related area (corresponding to 120 European Transfer Credits Units (ECTU)). Support and methodologies are being design specifically taking into account the rules and educational objectives of the three North African countries involved in the project. In spite of that, any student from anywhere in the world may apply to be enrolled in the 3rd year, providing that it fulfills the admission requirements.

The project started in October 2012 and will last until October 2015. During the first two years of the project, the partners will elaborate the teaching materials and designing, developing and implementing the remote laboratory that will be used in the first edition of the course, which will be delivered during the third year of the project, corresponding to the academic year 2014-2015.

The remote laboratories are planned to work in a federate mode, with any potential user accessing them as a single laboratory. This remote laboratory is one of the key points of the project and one of the most innovative: indeed, thanks to it, students will be able to perform online practical works, which is rare in existing e-learning trainings in the area of electrical and electronics engineering.

The project has a particular focus on the sustainability and on the quality of the proposed curriculum. All consortium partners agreed on the integration of this offer in their own current on-site and e-learning undergraduate program offers, ensuring its continuity beyond the end of the project. A group of international experts in the field of Embedded Systems and E-Learning methodologies assessed the proposed course syllabus, issuing recommendations to improve its quality and thus endorsing it.

The project consortium is coordinated by the University of Limoges and includes a total of 15 partner institutions, 3 European universities – the Katholieke Universiteit Leuven, the School of Engineering of the Polytechnic Institute of Porto and the University Politehnica of Bucharest - and 11 North African universities from three countries - Algeria, Morocco and Tunisia.

II. E-learning Engineering Courses

Undergraduate e-learning programs are being part of the wide range of University's offer for more than a decade. While older Universities joined e-learning to their classic on-site programs, creating specific e-learning frameworks and adapting their traditional offer to be delivered remotely, some new Universities, like The Open University [1], only offer undergraduate and postgraduate online programs. However, 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 like arts and humanities, business and management, education, law, mathematics and statistics, life sciences, fine arts, and social sciences. The exceptions are the full

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online information and computer technology (ICT) undergraduate programs, which are widely available.

The reason why only Master degrees in Electrical and Computer Engineering are offered online is that on a Master degree more sophisticated modeling tools may be used, tools that are easily deployable over the Internet. By the contrary, undergraduate degrees, to be successful, require students to be able to interact with real small experiments. Indeed, experimental labs are an essential part of any engineering program, but, while the same computer used by the student to follow an ICT program may be used to perform practical work in the field, conducting experimental work in subjects like physics, chemistry, mechanical and electrical machines, or digital and analogue electronics, for example, is far more difficult.

Until now, the only solution has been the use of a hybrid approach, as described in [2]. In this case, the entire program is conducted online, with the exception of the lab classes. These have to be performed on campus and are usually concentrated by the semester's end. Another two examples (from the many available) are the Bachelor of Science in Electrical Engineering at The University of North Dakota [3], the Bachelor of Science in Engineering Technology: Electrical at The University of North Carolina at Charlotte [4]. This solution, however, has obvious disadvantages. First, the student has to have the necessary time and funds to travel and spend two or more 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 understanding and assimilation of the different subjects.

In literature, many examples of different labs for different areas of physics and electrical engineering may be found [5-10], 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 a full online undergraduate program.

The project described in [11] aimed to apply the principles and possibilities of distance and e-learning to traditional course materials and also to lab sessions, including the use of the computer as virtual measurement instrument in the laboratory. However, the maximum number of credits that might be awarded to a student using this alternative e-learning approach was 20 ECTUs, below the normal 30 ECTUs awarded to students that successfully complete a semester's program.

The EOLES project is a first step towards the objective of creating a full online undergraduate program on Electrical and Computer Engineering, with emphasis in the area of Electronics and Optics for Embedded Systems. In this first step, only the 3rd year of the Bachelor program is going fully online. Therefore, the candidate has to have previously obtained 120 ECTUs in a university Bachelor program on a related area to qualify for enrollment in this 3rd year.

In the medium term, the objective is to remotely offer the full Bachelor program.

III. EOLES Overview

A. Specific objectives

The EOLES project focuses on the pooling and sharing of skills and experience of all partners to provide students the opportunity to access a high quality education on innovative areas, in order to prepare them to continue their studies at Master level. The project main objective is the creation of an e-learning English-spoken 3rd year Bachelor degree, with 30 to 40 students graduating each year.

In particular, this project intends to:

- Create a fully online degree in hard sciences (electronics and optics for embedded systems);
- Open a new English specialized curriculum;
- Develop an innovative remote laboratory allowing online practical experiments;
- Train academic, administrative and technical staff in the partner countries institutions on e-learning, English language and remote laboratory development;
- Implement a modern pedagogical approach (e-learning 2.0) through the creation of an educational social network;
- Extend access to e-learning or face-to-face Masters for the EOLES graduated students;
- Reinforce the cooperation between the North African and the European universities involved in the project;
- Promote the study of hard sciences and motivate new students.

In order to increase its interest among partner institutions, the project also addresses the following national priorities:

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

B. Methodology

The proposed curriculum will be available for students living all over the world, albeit focused in students from the North African countries involved in the project, providing they already completed the first two years of a Bachelor degree in Physics or in similar area. It is designed as a specialization year, oriented towards the embedded systems domain, which is presently an expanding field of engineering. The curriculum program will allow graduated students to later apply for postgraduate degrees.

At a scientific level, this project will promote the teaching of hard sciences with high technology tools in order to create an "educational social network" able to efficiently reduce the loss of motivation and the dropping out of students in isolated areas or affected by logistic or financial difficulties.

Students will work in collaboration to improve their theoretical and practical skills and their English language level, contributing to increase the number of high qualified workers in North Africa.

The basis is the development of an international Virtual Learning Environment (VLE) designed to be used daily by students and teachers, and including:

- Synchronous tools (virtual classrooms);
- Asynchronous tools (screen casting, forums);
- A remote laboratory with last generation equipment and instrumentation;
- An application server giving access to professional software.

International collaboration among the partners will improve the skills of the teaching, technical and administrative staffs on e-learning tools use, e-learning platform administration and English language. European partners, in cooperation with North African institutions, will also transfer expertise for the implementation of the remote laboratory, simultaneously contributing to update and improve the available equipment.

Structural impacts on the higher education systems of North African countries are expected and desired, as the new curriculum is intended to contribute to convince the authorities to give accreditation to the resulting joint diploma (rare in North African countries), which will be the intended result of an online course completely taught in English.

The success of the innovative EOLES curriculum will be ensured by the creation of a Managed Learning Environment based on the use of a VLE, the implementation of a management information system and the development of a remote laboratory giving the possibility for students to perform practical experiments online.

Rather than using traditional knowledge and direct skill transfer from a teacher towards the students ("e-learning 1.0"), using "static" documents (pdf files, html pages,…), the EOLES proposed curriculum will develop an "educational social network" based on a strong interactivity between all the actors (students, teachers,…) and consequently create a computer-supported "e-learning 2.0" (often called "social learning") training.

This ambitious objective can be accomplished thanks to the development and deployment of numerous tools allowing enhanced interactions between teachers and students, for instance:

- The VLE, which is the basic component of e-learning. A VLE contains all the information (course syllabus, administrative information, …) required for all categories of users (students, teachers, administrative, …) and permits interactions among them thanks to collaborative tools (forums, wikis, …);
- Synchronous virtual classrooms allowing teachers to interact with students in order to deliver a course, to use technical software or to discuss with students in audio-video format. These synchronous meetings are planned in advance and can also be recorded and made available for students not able to attend the meetings live. This tool can also be used by students working together in groups;
- Screen casting lectures, synchronous whiteboard courses and interactive documents with voice narration and annotations.

All these tools permit to create well adapted and interactive lecture scenarios in order to increase motivation and reduce dropout ratios, a common risk in e-learning degrees.

The proposed curriculum is composed of mandatory and optional Technical Units (TU) divided in weeks to ensure a dynamic training. The consortium already decided that optional preparatory course TUs will be provided at the beginning of the year, in order to level out students' knowledge on critical topics.

To summarize, the program content will address the student pool characteristics and adhere to the consortium wishes about the academic or professional pursuits of the graduate students. Moreover, the main originality of this project is the creation and development of an international remote laboratory allowing students to perform online practical works and consequently to acquire essential practical skills. The objective in each TU is to provide between 4 to 6 practical experiments, which are a prerequisite to ensure that the graduated students acquire practical skills at the end of the curriculum. Two types of experiments will be performed:

- Laboratorial experiments intended to monitor and control technical equipment at distance;
- Laboratorial experiments using professional software running in the application server.

Multi-user access will be encouraged to guarantee strong interactions between students during the training. The remote laboratory is expected to have a strong learning impact as each student could repeat by him/herself the same experiment several times.

The students enrolled in the EOLES curriculum will have to respect the following criteria:

- To have a minimum English level evaluated through a TOEIC or a TOEFL test or equivalent, recognized by the different partners of the consortium;
- To have access to a good internet connection;
- To have previously obtained 120 ECTUs in Physics, Electronics or similar studies of a university Bachelor program.

The pedagogical and technical committees are defining the exam rules and terms in detail, with the objective of balancing individual and group work and to perform an evaluation work each week.

According to the experience of partners already involved in e-learning, a particular attention will be paid to avoid cheating, a potential risk in full e-learning training. In addition, the pedagogical team will be required to help students having difficulties at the end of the first semester, in order to prevent these students from dropping out, which is also an important risk in e-learning due to loneliness, by making them feel part of a community. Consequently, student representatives will be elected each year to animate the community and discuss with the pedagogical team. A student association will be created using the social networks. Students will also be called to assess the quality of the Bachelor program content, the ergonomic presentation of the e-learning platform and the performance of the remote laboratory.

Content development will require the commitment of teachers from the different partners of the consortium. To ensure a high teachers' motivation, the consortium will allow innovative learning resources created within the framework of the EOLES project to be reused in face-to-face trainings in their own universities.

The international (North Africa and Europe) academic network fostered by the EOLES project will enhanced the capacity of institutions to recruit students for Master and PhD degrees and to participate in common research projects.

The activities during the 3-year project are divided in nine Work Packages (WPs) presented in Table 1.

Table 1 - Work Package List

WP	Title
1	Definition and development of the Bachelor program content
2	Development of operational remote lab
3	E-learning 2.0 tools development
4	Staff Training
5	Implementation of the Bachelor Program
6	Dissemination
7	Sustainability
8	Quality control and monitoring
9	Management of the project

During the first three months of the project, in the first work package (WP1), the content of the Bachelor program was determined by all the partners.

In parallel to WP1, WP2 started to handle the development of the remote laboratory. As for WP1, each practical work is being developed in close collaboration between European and African partners' institutions, ensuring an efficient collaborative work on a very innovative topic.

The scope of WP3 is the development of all the e-learning tools required for the curriculum, namely:

- Installation, personalization and hosting of the VLE;
- Acquisition and installation of e-learning tools (servers, software, ...);
- Development of online applications.

One of the key points of the project, as it will ensure the transfer of expert knowledge in the use of the e-learning tools and of the remote laboratory that will support courses' delivery from the European partners to the African institutions, is the training of teachers and technical staff comprised on WP4. Five categories of trainings will be carried out during the project:

- General English language training (for teachers, and for administrative and technical staff);
- Technical English language training (for teachers and technical staff);
- Training on the use of the e-learning platform front-office (for teachers and technical staff);
- Training on platform administration (for technical staff);
- Training on the use of the remote laboratory (for teachers involved in the corresponding TUs).

During the last year of the project, the Bachelor program (WP5) will be launched in order to have the first graduated students at the end of the Tempus project. A reasonable objective should be to have 40 to 50 students following the training during this first year, with at least 80% graduating by year's end (32 to 40 students).

WP5 will begin 5 months before the launch of the 3rd-year Bachelor program, to manage the student registration and selection process.

The transversal "dissemination" (WP6) and "sustainability" (WP7) work packages will run in parallel all along the 3 years of the project, ensuring its dissemination, in particular by promoting the engagement of students on the 3rd-year Bachelor program, and its continuation after project's end.

The quality control and monitoring (WP8) plan deals with the quality assessment of the:

- Bachelor program content;
- E-learning platform's ergonomics;
- Remote laboratory performance.

All the actors directly involved in the curriculum (students, teachers, technical and administrative staffs) will be implicated in the different quality control processes.

Finally, WP9 (Management of the project) will ensure the day-to-day management of the project including the administrative, financial, and organizational aspects.

C. Syllabus

The report elaborated in WP1 includes the list of TUs with their associated ECTUs. The TUs cover a broader list of topics, including: optics, electronics, embedded systems, signal processing, power electronics, electromagnetism, mathematics, technical English, management and communication techniques. The created curriculum is composed of mandatory and optional TUs and is presented in Table 2.

Table 2 - Technical Unit 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	Analog 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	Enterprise foundation	3
UP121	Update in optics 1	0
UP122	Update in optics 2	0
UP041	Update in Electronics	0

The pedagogical committee has elaborated the syllabus for the 3rd-year Bachelor program with 3 optional update courses and 14 mandatory teaching units. The creation of optional courses is the solution to level students' knowledge out in critical topics, as students with different knowledge backgrounds may enroll in this program.

Each ECTU represents 10 hours of work per week. So 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 work per week.

For each TU it was necessary to create:

- The list of practical works to develop for the remote laboratory;
- 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 will be limited to three, with at least one teacher from a European institution and one teacher from a North African institution.

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

D. The Consortium

To ensure efficient expertise and technological transfer, European partners have been selected according to their e-learning experience in the relevant areas, their experience in the development of remote (distance monitoring and controlling of technical equipment) or virtual laboratory (web pages reproducing an experiment), and finally to their TEMPUS program experience.

The four European partners are:

- The University of Limoges (UNILIM), which is the grant applicant, launched in 2008 a French-spoken blended learning ARTICC master concerning electronics and optics topics. In parallel, UNILIM launched the "LAB-EN-VI", a remote laboratory allowing ARTICC students to perform online practical experiments [9]. UNILIM also coordinated the MODEGOV Tempus Project (2010-2013), whose objective was the implementation of a new model of governance for the Moroccan Science faculties. UCAM (Cadi Ayyad University Marrakesh) and USMS (Sultan Moulay Slimane University), partners of the EOLES project, were also partners of the MODEGOV project;
- The Katholieke Universiteit Leuven (KU Leuven), which brings a high expertise in the field of embedded systems and a good experience in e-learning, particularly in the development of online remote laboratories [11]. KU Leuven has also a strong experience in project management as coordinator of two Erasmus Curriculum Development projects called EDIT and VME;
- The School of Engineering of the Polytechnic Institute of Porto has been coordinator and partner in several European projects in the fields of e-learning and remote laboratories. Like UNILIM, ISEP published several papers in international conferences and journals about the development of remote laboratories [12];
- The University Polytehnica of Bucharest (UPB) has experience in virtual laboratories, with emphasis in Physics, Mathematics and Computer. This university has already participated in several TEMPUS projects.

Regarding the North African partners' institutions, it was attempted to ensure a good distribution map to better cover the territories, aimed to integrate isolated universities and consequently to maximize the impact of the project. The idea was to involve also partners with no experience in these fields in order to implement an efficient transfer of knowledge.

Concerning the selection of Algerian partners:

- UMAB (Abdelhamid Ibn Badis University), Mostaganem, co-initiator of this project, is already involved in a joint diploma accreditation process for the ARTICC master [13] with UNILIM, and has a good experience in e-learning, remote laboratories and TEMPUS projects;
- The University of Guelma will host the Centre for research in embedded systems and robotic (CReSER);
- The University of Batna was chosen for the importance of its number of teachers (1500) and students (56000);
- The University of Adrar was chosen to extend geographically the project to South Algeria, which has rarely been included in TEMPUS projects.

Concerning the selection of Tunisian partners:

- The choice of VUT (Tunis Virtual University) is logical as this institution is in charge of the e-learning development and coordination in the whole country;
- UK (Kairouan University) has recently launched a full e-learning curriculum in project management in 2010;
- US (University of Sfax) and;
- ISET Sousse, which already involve more than 20 teachers each in electronics and optics and will consequently be able to diversify their training offer.

Concerning the selection of Moroccan partners:

- UCA (Cadi Ayyad University) has a good experience in TEMPUS projects;
- UAE (Abdelmalek Essaâdi University) has currently more than 40 teachers working in the electronics and optics field;
- The involvement of USMS (Sultan Moulay Slimane University) will allow this recent university to develop and to diversify its training offer.

IV. LABORATORIAL SUPPORT

A very important objective of the EOLES project lies in the use of ICT and computer sciences for the implementation of a remote laboratory that will allow students to perform online practical experiments.

All European partners involved in the project have extensive and up-to-date expertise in this topic, and will 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 will be the first in the world to be implemented as part of an online accredited degree in the area of Electronics and Optics for Embedded Systems.

A multi-user approach will be implemented allowing a group of students to work and interact in real time over the same Practical Work (PW).

Three kinds of PWs will be included in the remote laboratory:

- Real-time monitoring and control of technical equipment, the main innovation part of the remote laboratory. Each hardware setup (function generator or oscilloscope for instance) will be connected to the internet. The user can access a web page to change the hardware configuration in real-time, and instantaneously see the effect of its actions, via a high-definition camera (or other interface);
- Virtual PWs (web pages reproducing an experiment);
- Software PWs (use of professional software commonly used in electronics, optics, …).

The remote laboratory will be located in 3 different locations (one in each partner country) in order to reduce the maintenance and installation costs. Furthermore, each practical work will not be duplicated to reduce the costs. The physical installation of the laboratories will be performed by the North African partners, with all equipment acquired in the project being directly delivered to partner countries' institutions.

The final objective will be the integration of all experiments on a single and unified EOLES laboratory. It should be accessible by all partner institutions and provide 24/7 access to the experiments. These will address the main technological content of the syllabus TUs and will be geographically distributed.

V. Work in Progress

The course syllabus was approved during the Second General Assembly of the EOLES project held in Kairouan in the beginning of November 2013. The course contents are now being created. The integration of all content, software and equipment is schedule for May 2014.

The EOLES laboratory is presently under development and should become operational by the middle of 2014. The first students should begin using it in the autumn semester of 2014.

More information about the project may be found at EOLES project web page at www.eoles.eu.

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