Internationalization & Globalization of Engineering

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ABSTRACT

This paper reports on two prominent approaches towards internationalizing and globalizing engineering by applying Information and Communication Technologies (ICTs) to engineering education. In the former approach, a new European and inter-institutional online master's degree program was developed and conducted among five different institutions from four different European countries. In the latter approach, a Massive Open Online Course (MOOC) was developed and delivered to the public from all over the world. In both of them, ICTs are intensely adopted in order to deliver theoretical contents to student everywhere and at any time without neither geographical nor time constraints. Similarly, remotely-accessed remote laboratories are adopted in order to allow online experimentation. The development and implementation of both approaches are discussed in this paper. Experiences and preliminary results are also provided.

Keywords: Computer-aided engineering, inter-institutional online master, MOOC, remote laboratories, RIPLECS

RESUMEN

Esta contribución informa sobre dos enfoques importantes hacia la internacionalización y la globalización de ingeniería mediante la aplicación de tecnologías de información y de comunicación en la educación de ingeniería. En el primer enfoque, se desarrolló un master en línea, Europeo e interinstitucional, que se está llevando a cabo entre cinco diferentes instituciones de cuatro diferentes países europeos. En el otro enfoque, un curso masivo abierto en línea fue desarrollado y facilitado al público de todo el mundo. En ambos, las tecnologías de información y de comunicación fueron intensivamente adoptadas con fin de proporcionar los contenidos teóricos a los estudiantes en cualquier lugar y a cualquier hora sin limitaciones geográficas ni de tiempo. Del mismo modo, los laboratorios remotos, controlados en línea y a distancia, fueron adoptados con el fin de permitir la experimentación en línea. El desarrollo y la aplicación de los dos enfoques se discuten en esta contribución. También, se ofrecen experiencias y resultados preliminares.

Palabras claves: Ingeniería asistida por ordenador, laboratorios remotos, master en línea inter-institucional, MOOC, RIPLECS

1. INTRODUCTION

Full-distance education programs weren't likely until the evolution of Information and Communication Technologies (ICT) and their application in education, what is now known as E-learning. E-learning has redefined the concept of distance learning and the delivery of educational resources allowing ubiquitous interactive learning with neither geographical, economic, demographic, nor time constraints.The adoption of technologies in engineering education started in 1972 with the introduction of electronic calculators and kept progressing till the advent of highly scaffold and personalized Virtual Learning Environments (VLEs) and remote laboratories. Nowadays, entire degree programs and courses may be taken on campus, online, onsite at a company, or in any combination. For example, hybrid learning or Blended Learning (B-Learning) is touted as a means to conserve traditional classroom pattern and simultaneously to allow the convenience facilitated by E-learning. Not only the methods of delivery are being changed, but the relationships among universities, institutions, and corporate entities are now in flux. For example: a student can take online courses, not offered by his/her institution, at another institution; workers at a company can take a course at a university thanks to a prior agreement between the university and their company; a remote expert discussant can be added to an online classroom; or collaborative research teams can be formed across institutions.

In this paper, two novel eLearning-based approaches towards internationalizing and globalizing engineering are provided. The rest of the paper is structured as follows: in Section 2, the development and implementation of a new European and inter-institutional online master's degree program is discussed, emphasizing the role of remote laboratories in general and the adoption of the state of the art remote laboratory for electronics (Virtual Instrument Systems in Reality – VISIR) in particular; In Section 3, the development and implementation of a Massive Open Online Course (MOOC) is discussed along with some preliminary results; and finally, a conclusion is drawn in Section 4.

2. INTER-INSTITUTIONAL ONLINE MASTER'S DEGREE PROGRAM

It is an online official and inter-institutional master's degree program in ICT. It is conducted by 5 European institutions from 4 different European countries and oriented to labor market needs. The program is funded by the European project, RIPLECS ("RIPLECS Project - Remote-labs access in Internet-based Performance-centred Learning Environment for Curriculum Support," 2013) and is targeted to engineers, technicians and scientists with interest on up-to-date topics in the area. Students acquire skills focused on industrial field like production organization, design of products, processes and installations, quality management or team management. Thus, part of the project management includes contacting and collaboration with enterprises in the sector to respond to the labor market needs. The master's program relies on a distributed and adaptive LMS—developed by the project partners—enabling world-wide distribution of learning resources and remote lab-experiments, by utilizing multiple Web servers across each partner's university within a single network topology. Instructors from each university can take the advantages of conducting the program and deploying remote lab experiments in their native language and personal educational point of view (Tawfik et al., 2012a, 2012b). The project partners are the following Institutions:

- Electrical & Computer Engineering Department, UNED, Spain.
- Communication & Control Systems Department, UNED, Spain.
- University of Plovdiv (PU), Bulgaria.
- Cork Institute of Technology (DEIS), Ireland.
- Technical University of Sofia (TUS), Bulgaria.
- Institute for Technical Informatics, Graz University of Technology (TUGraz), Austria.

The program was launched in the academic year 2013/2014 and will be delivered as many years as demands last. The program is based on European Credit Transfer and Accumulation System (ECTS) and is officially-accredited initially in Spain, by the Spanish ANECA accreditation Agency (www.aneca.es). In addition, a certification from all partner universities are included. The program is of one year (2 semesters) and 60 ECT, and is composed of three modules; fundamental module, specialized module, and final project module. The subjects are of 5 ECT, and the final project is of 10 ECT. All subjects are taught in English and any student around the world can be registered and enrolled in the master. The program's curriculum is organized as shown in Table 1.

Table 1: Curriculum of the RIPLECS master's degree program

		Subject	Provider
Semester 1 (Fundamentals) October-February		Introduction to Information and Telecommunication systems	PU
		Industrial and Real-time Communications	DIEEC-UNED
		Internet Technology for ICT	DEIS
		Electronics for ICT	TUS
		ICTs research and engineering competence skills	DSCC-UNED
Semester 2 (Specialized) February-June		Microprocessor Techniques	PU & DIEEC-UNED
		Wireless Communications	PU & TUGraz
		Multi Media for ICT	DEIS
	Two of electives	Power Supplies for ICT equipment	DIEEC-UNED
		Microelectronics	PU
		Satellite and Mobile Communications	PU & DIEEC-UNED
		Computer Modeling and Simulation of Electronic Circuits	PU & DIEEC-UNED
		Final Project	

2.1 ROLE OF REMOTE LABORATORIES

Remote laboratories forms an integral part of the subjects of the master's program. This promotes cross-institution co-operation and offset costs and burdens. Students at one university can access remotely to a laboratory made accessible by another university. By this way, the partners' organizations share the cost of expensive laboratories and physically establish them at a convenient location. Students have the possibility to have practical work in labs in different countries, in which labs are usually very expensive– in some cases they are even unavailable for public universities. So far, the developed remote labs that are integrated in the master's subjects are the following.

2.1.1 Remote Lab for Wireless Sensor Networks (WSNs)

for configuring and programming WSNs online. This is a remote lab from TUGraz for the subject "Wireless Communications" (H¨ormann, Steinberger, Kalcher, & Kreiner, 2013).

2.1.2 Remote Lab for GSM and 3G Telecommunications

for measuring the radiation patterns of various types of antennas to get a clear picture on their radiation characteristics, and measuring characteristics of wave propagation in mobile communications identifying parameters such as fading, phase delay, standing wave, and Doppler frequency. This is a remote lab from PU for the subject "Wireless Communications" (N., N., & Stoyanova S., 2013).

2.1.3 Embedded Systems Remote Labs

Embedded systems remote labs are a collection of mounted boards such as Field-programmable Gate Array (FPGA), Microprocessor, and microcontroller, which are totally administrated, controlled, and monitored online for education and experimentation boards. The students use these types of boards in order to program them online by programming languages such as VHSIC hardware description language (VHDL) and to monitor the results through a connected Webcam. This is a remote lab from UNED for the subject "Microprocessor Techniques" (Tauste et al., 2011).

2.1.4 Virtual Instrument Systems in Reality (VISIR)

VISIR (Tawfik, Sancristobal, et al., 2013) is a remote laboratory for wiring and measuring electronic circuits on bread board online. This is a remote lab from UNED from the subject “Power Supplies for ICT” (Tawfik, Monteso, et al., 2013). It includes a set of remote industrial electronics experiments, oriented to labor markets and industrial needs in order to diminish the gap between academia and workplace. The experiments enable: studying the behavior of electronic components and commercial ICs; using manufacturers’ datasheets and comparing them with measured values; monitoring harmonic distortions—with a high precision—due non-linear impendency of circuits, as well as studying the role of I/O filters in mitigating these distortions; and calculating heat dissipation in electronic components either in transient or in steady state, as well as studying the effect of room temperature and of applied heat sinks in heat dissipation. The experiments were realized, also, taking into consideration issues such as safety and protection of components, configuration for high precision measurement with minimum possible distortion, and full switching and automation mechanism. The new designed experiments are shown in Figure 1 and they encompass:

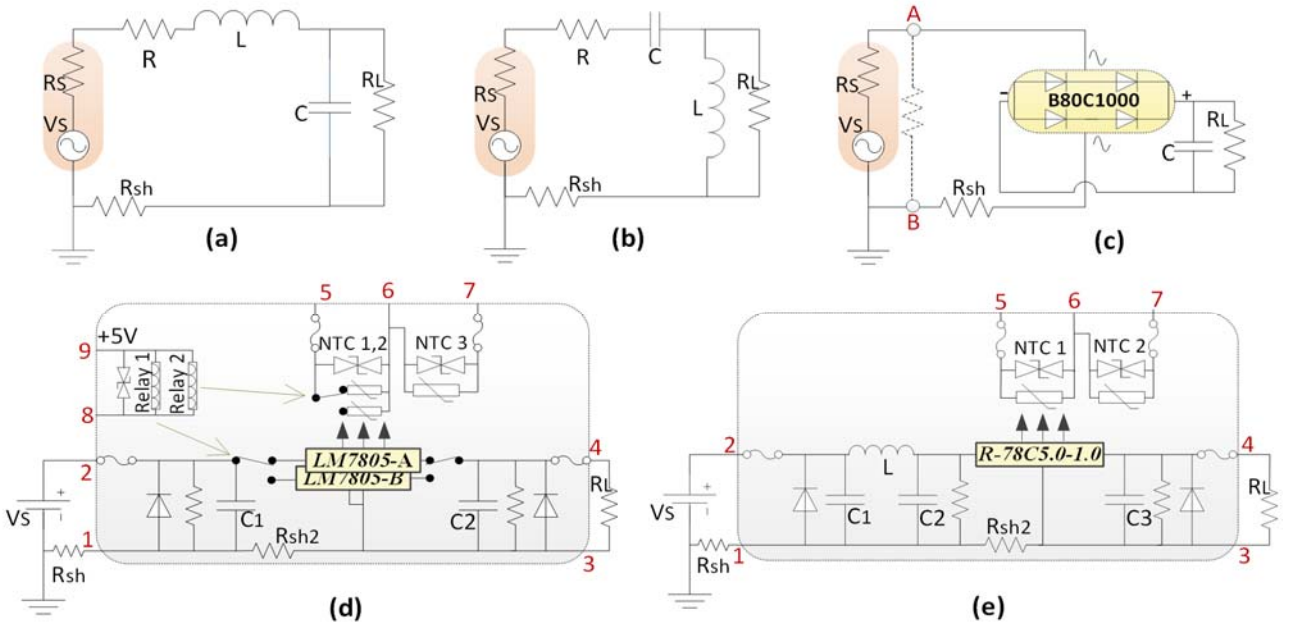

Figure 1: New designed circuits

a) Second-Order Low-Pass RLC Filter.
b) Second-Order High-Pass RLC Filter.
c) AC/DC Converter (Full-Wave Rectifier).
d) Non-Isolated Linear Regulated DC/DC Converter.
e) Non-Isolated Switching Regulated DC/DC Converter.

The experiments have already been mounted in VISIR as shown in Figure 2. Combining this kind of experiments with VISIR, as a result, yielded a unique training platform of its kind for remote industrial electronics experiments. From each experiment circuit numerous exercises are derived such as: comparing between simulations or theoretical calculations and measurement; and comparing between datasheets and component’s behavior.

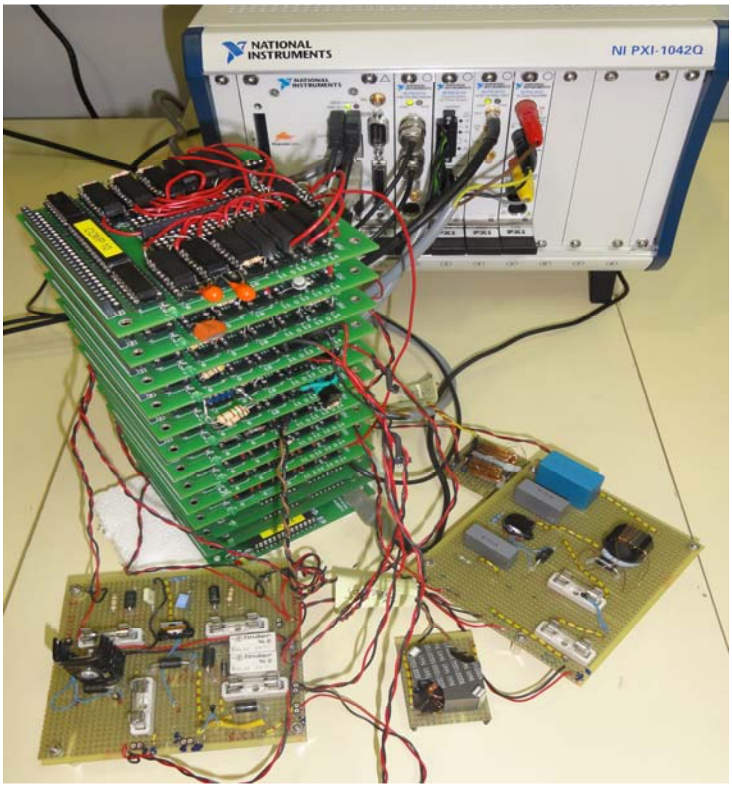

Figure 2: New designed circuits

3. MASSIVE OPEN ONLINE COURSE (MOOC)

Massive Open Online Courses (MOOCs) was originated in 2008 within the Open Educational Resources (OER) movement. MOOCs are open online courses that are more structured formal and aiming at large-scale interactive participation. Only a few percent of the tens of thousands of students who may sign up complete the course. Typically they do not offer academic credit or charge tuition fees but in some cases they offer the possibility of earning academic credit or certificates based on supervised examinations. Subsequently, several providers by elite universities have emerged such as edX, which was founded by MIT and Harvard University.

The first version of the MOOC was delivered during 5 months (from May 2013 till September 2013). The MOOC is structured in 8 modules of 10 each. Prior realizing this course and as an only perquisite, students are encouraged to pass the MIT's MOOC, "Circuits & Electronics"(MITx, 2013), in order to be acquainted with the basic theories, since this course is targeting mainly practical activities. The first module teaches students simulation with tools such as SPICE or MicroCap in order to give them the opportunity to compare between theoretical, simulation, and real results (obtained afterwards in the VISIR modules). The next module provides an overview on VISIR, teaching students how to access and use it. Experimenting with VISIR is realized through the modules 3-8.

All documents, guides and videos are in Spanish. In total, the course contains: 42 tutorial videos, 30 exams of multiple choice questions, 4 documents covering all the theoretical contents of the course, manuals for simulators and VISIR, and 30 experiment activities. Random screenshots of the tutorial videos are shown in Figure 3.

Figure 3: Video tutorials in MOOC

Access to experiments is provided by the MOOC's portal through an integrated scheduling system, which replaces the current scheduling system provided by VISIR, so that students can rely on a unique integrated educational portal. The initial settings allow 16 simultaneous users per 60 minutes slot and for each user a maximum of two simultaneous slots booked and a limitation of 14 slots per course. With these settings, VISIR allows up to 384 students to experiment with any of the designed practices of the MOOC every day.

A preliminary survey about the profile of the enrolled students was taken among more than 1100 participants before the commencement of the course, the results are shown in Table 2.

Table 2: Preliminary survey about the profile of the enrolled students in MOOC

35 years old students or older	***43%***
Active workers	*50%*
Undergraduate students in a related field	*18%*
Graduate or postgraduate students in a related field	*19%*
Students with a non-university degree in a related field	*23%*
Students enrolled in this MOOC especially because of the use of a remote laboratory	*81%*

Figure 4 shows the evolution of the course in terms of students. A clear gap is show between the initially enrolled students and the students who managed to pass the course, which is a commonplace in any MOOCs.

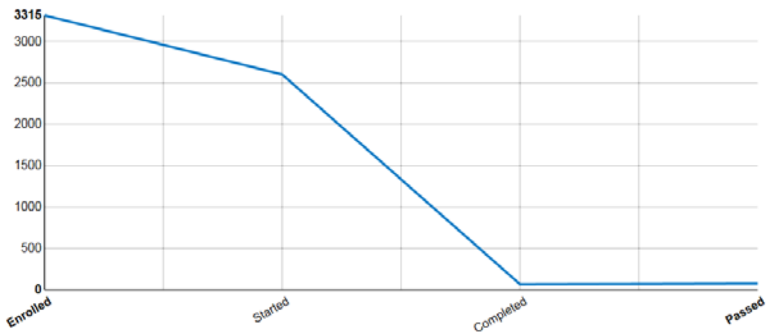

Figure 4: The evolution of the MOOC in terms of students

Figure 5 shows the results of a post and pre-survey conducted to compare the evolution of the way of thinking of students about the remote laboratories positively, and as an evaluation of the remote laboratory VISIR itself. As shown in the figure, the majority (34%) evaluated it as "medium" in the pre-sourse survey, while the vast majority (57%) evaluated it as "very high" in the post survey. Notice that the sum of either white or blue bars is 100%.

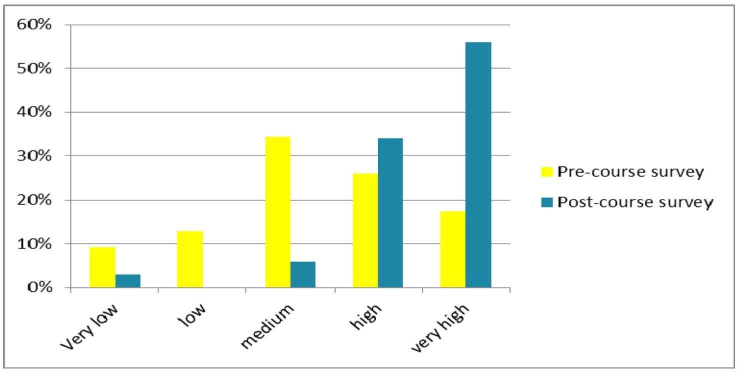

Figure 5: Reliability on the remote laboratory VISIR (before-after)

Table 3 shows the results of an end-course survey, which was answered by 233 students. The survey indicates the general acceptance of this experience among students.

Table 3: Preliminary survey about the profile of the enrolled students in MOOC

	Agree	(%)
I would be interested in a re-edition of this MOOC	*150*	*64,38%*
I would be interested in a similar practice-based MOOC on electronics but more basic than this MOOC	*93*	*39,91%*
I would be interested in a similar practice-based MOOC on electronics but more advanced than this MOOC	*65*	*27,90%*
I would be interested in a theoretical MOOC on electronics (excluding practical aspects and the remote lab VISIR)	*28*	*12,02%*
I'm not interested in new MOOCs	*3*	*1,29%*
I'm not interested in a re-edition of this MOOC	*3*	*1,29%*

In November 2013, the MOOC was re-initiated for a new semester but intensively and is due to end in January 2014.

4. Conclusion

In this paper, two novel eLearning-based approaches were provided that aim to revolutionize the way in which engineering education is delivered. In both of them, ICTs are intensely adopted in order to deliver theoretical contents to student everywhere and at any time without neither geographical nor time constraints. Similarly, remotely-accessed remote laboratories are adopted in order to allow online experimentation.

Despite the lack in skilled and qualified graduates in comparison with the high requisites of the industry and labor markets, few initiatives have been done to address these needs. The presented master's degree program response to the demands imposed by the labor markets and industry enabling a ubiquitous pool of learning resources and lab experiments from multiple European institutions. The variety of partners form different European institutions enriches and augments the program contents and will deliver experiences and outcomes that are in accordance with the European education requirements. The fact that this program is conducted by European partners doesn't impede students from all over the world to be enrolled and being an online program makes it compatible with the different life styles of the predominating students. Putting all these factors together makes the program unique of its kind. Thus, its successful implementation would pave the way for further initiatives of this kind, which are not only confined neither to ICS nor Engineering, but for many other disciplines of science.

At the end of this academic year 2013/2014, the effect of practical tasks performance and performance-centered learning resources on knowledge, skills and attitudes of different types of learners will be evaluated as applying some classical methods such as observation, surveys through questionnaires and interviews, and analysis of information flow from the discussion forum through grounded theory techniques and content analysis. The observation protocols, questionnaires and the interviews' forms will be tested for validity and reliability.

On the other hand, a best practice on MOOC was provided outlining its novelty in terms of combining it with remote laboratories, its organization, and experiences and results. The provided experiences in this paper can help in discovering new and untraditional learning methods and initiatives for engineering and applied science students.

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