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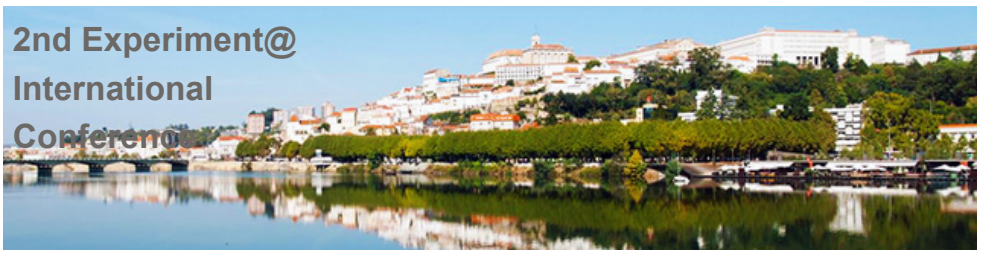

The 2nd Experiment@ International Conference

exp.at'13 is the second event of the Experiment@ International Conference series, a biannual event devoted to online experimentation, enlarging the world capabilities in this particular area and contributing to collaborative work in emergent technologies, bringing together engineers, researchers and professionals from different areas.

It is a joint organization of the University of Coimbra and the University of Porto. This second edition will be held at University of Coimbra (Coimbra, Portugal), classified World Heritage **by UNESCO** (*announced on June 22nd, 2013*).

The objectives of the conference are to promote professional interactions for the advancement of science and technology and to encourage high quality research in the fields of online experimentation, smart devices, communication protocols, web interface design, intelligent tutoring systems, collaborative environments and virtual reality and haptics interaction. It offers to the participants an opportunity to present their recent work and experience reports, and to take part in open discussions.
exp.at'13 provides a three-day forum of discussion and collaboration between academics, researchers, web designers, K-12 teachers and industry, trying to bridge the gap between academic applications and results as well as real world needs and experiences, mainly in developing countries.

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Remote electronics lab within a MOOC: design and preliminary results

Gabriel Díaz, Félix García Loro, Manuel Castro, Mohamed Tawfik, Elio Sancristobal and SantiagoMonteso
Electrical and Computer Engineering Department
Spanish University for Distance Education (UNED)
Madrid, Spain
(gdiaz, fgarcialoro, mcastro, mtawfik, elio, smonteso)@ieec.uned.es

***Abstract*— This paper describes the design and development of a novel Massive Open Online Course (MOOC) on industrial electronics circuits. It is the first MOOC that, besides the usual features of these courses, includes the extensive use of a real remote laboratory dedicated to practices in electronic circuits. Although the nature of a MOOC is completely open, this course targets especially people with at least basic circuits knowledge, related with the demand on industrial sector of labour markets. As said, the core objective of the course is to learn practical competences in basic electronic circuits. This is possible by implementing the remote laboratory for electronic circuits' practices VISIR (Virtual Instrument Systems in Reality) within the MOOC to allow online, real time, delivery of such practices— which makes this MOOC a first of its kind. The paper presents the design and development of the MOOC. We show also some preliminary results in the middle of the course that is running, with more than 2200 students enrolled, during 5 months since May.**

Keywords*— *remote laboratory; electronics circuits; VISIR; MOOC; distributed learning;

I. INTRODUCTION

The benefits of electronics laboratory practices are widely known for professionals and necessary for any person who seeks for a broad comprehension of the real-time performance beyond the ideal modelling. Therefore, when designing any electronics course, the laboratory practices are one of the pillars on which the learning is established.

The recent emergence of MOOCs is promoting different lifelong learning experiences and continuing education models and allowing free access to learning resources at any time and from everywhere [1, 2]. These courses appear to fit well to several areas of knowledge and their quality is tightly related with the designed route from the prerequisites to the objectives. However, a significant challenge exists in developing courses where experimentation plays an important role. One of the major challenges is the provision of laboratory work online along with the theoretical contents.

Furthermore, the practical and the theoretical contents must be designed to support an indeterminate number of users from around the world and with different time zones. A first approach to this problem is clearly the use of simulators and virtual labs. Although, they are still a bit far from bringing to student the real performance and features of equipment under real-life operation conditions. In this paper we consider all these issues and present a novel approach that integrates remote-accessed real experiments into a MOOC on basic industrial electronics [3].

The experiments included in the MOOC are based on the remote laboratory platform Virtual Instrument Systems in Reality (VISIR) [4]. VISIR is a remote lab for electric and electronic circuits experiments, developed at Blekinge Institute of Technology (BTH) in Sweden and in use in several universities all around the world [5]. VISIR is also been used in the Electrical and Computer Engineering Department (DIEEC) of Spanish University for Distance Education (UNED) within several grade subjects from different engineering degrees [6], providing satisfactory results with regarding to either it's performance or skills acquired by students. The main advantage of VISIR when compared with traditional electronic laboratories lies in its availability that has neither temporal nor geographical restrictions.

The basic electronic practices included in this MOOC are focused on:

- Basics of digital oscilloscope
- Measurements of resistances, voltages and currents
- Half-wave Rectifier with and without filter
- Regulator with zener diode
- Inverter and non-inverter operational amplifier
- Operational amplifier as a driver

The rest of the paper is organized as follows: in section II we describe the design and development of the new MOOC along with their rational and objectives; section III shows some preliminary results obtained at the moment of writing this paper and, finally, section IV outlines some conclusions and future work.

II. DESIGN OF THE NEW MOOC

The MOOC we are going to describe is designed as the first stage of a short-term and medium-term global strategy for offering different grades of sophisticated practice electronics MOOCs. The main idea is to establish a development of MOOCs based on two stages.

On this first stage, the MOOC developed will provide us the indicators and the information necessary to tackle the next

stage. Therefore, this MOOC can be considered as a pilot MOOC, a testing ground used with the global strategy in mind.

However this pilot MOOC is completely functional. The laboratory practices and activities around the circuits experimented and the measurements obtained highlight students the real gap between the ideal analysis and the real behaviour.

In this first MOOC, all documents, guides and videos are in Spanish. The name of the MOOC is "*Bases de circuitos y electrónica práctica*". The evaluation methodology and exams are focused on analytics aspects. For the next stage, a new MOOC will encompass an adaptation of the laboratory practices from the first stage and the experiments will be designed for a higher level of knowledge than the original activities and practices of the first stage MOOC. This new MOOC will take advantage of the indicators and information compiled from the pilot MOOC. The information collected will be critical for deciding upon the new MOOC structure, the advisability or need of including theoretical contents as a part of the evaluative process and the depth of the contents, the stability and development needs of the MOOC platform and the performance, limitations and advantages that VISIR will provide the MOOC. In contrast with the pilot MOOC, this one will be delivered in English, opening it to worldwide. The evaluation methodology and exams will comprise analytics and interpretative aspects as well as theoretical developments based on the laboratory practices measurements.

A. *Structure*

The core of the currently running MOOC is the remote laboratory VISIR. The evaluation and activities spin around the remote laboratory and the objectives and evaluation are focused on the handling of the instruments and measurements.

The MOOC will be running five months, since May to September 2013, as one of many in UNED COMA initiative [7] of UNED (*Spanish University for Distance Education)*. The students have not time limitation for completing the different tasks. The access, as in many other MOOCs is completely open and free and any one can register and participate at:

https://unedcoma.es/course/bases-de-circuitos-y-electronica-practica/

The knowledge, at least theoretical, on analysing electrical and electronics circuits and the electrical characteristics of most common components are necessary requirements for participants. The acquisition of the competences for analyzing circuits is not an objective for this MOOC. However, supplementary materials will be provided, in each module of the MOOC, in order to facilitate the understanding of the behavior and circuits for those students that, fulfilling part of the requirements, don't meet the essential requirements for addressing the laboratory practices and, however, are interested in following the course.

B. *Learning objectives and description of modules*

The learning goals, as established at the initial web page are:

- Gaining practical competences in basic electric and electronic circuits, by using a lab with real components. Also gaining practical competences in the use of the usual equipment in such laboratories.
- Improving the knowledge for designing electric and electronic circuits.
- Increasing the use of simulation tools used in the process of electronic circuits design.

The MOOC begins with a pre-course survey for obtaining some statistics basic data, as age, genre, country of origin and maximum academic level of the participants. Following this survey the participants must complete a basic electric and electronic exam. This exam is not evaluable, but gives us relevant information on the knowledge of the participants, before beginning the course.

After this preliminary part, the MOOC is structured in eight modules, with an estimated workload of 10 hours per module. A brief summary of each module learning objectives follows:

1- This module is dedicated to electronics simulation. It reviews the needed knowledge of analysis and simulation software. MicroCap software is proposed, although many other tools are valid. The main idea behind is to give the students the opportunity to test the differences between theoretical calculations, simulations results and real (obtained afterwards in the VISIR modules) results.

2- Module 2 (figure 1) shows the basics of use of VISIR: the components (resistances, diodes, etc,), the breadboard, the instruments (multimeter, function generator, oscilloscope, power supply, etc.). It also presents the students how to access the remote lab and how to reserve time for the experiment. This last point is essential considering that VISIR don´t allows an indeterminate number of concurrent users. The time slot for each reservation is 1 hour and there is no limit for the number of reservations.

Figure 1. Screenshot of one of the videos in module 2

3- Module 3 is the first real approach to build circuits with VISIR. The goals here are basic power and current measurements.
4- The goal of module 4 is to build two basic RLC circuits and check the correct measurements. The completely practical nature of these modules obliges the students to experiment with different patterns, as for example in Figure 2.
5- Module 5 objective is building diodes circuits, as for example a half-wave rectifier
6- Module 6 checks the ability to build filtered rectifiers circuits.
7- Module 7 explores the features of Zener diodes and students must build typical zener circuits and check their characteristics
8- Module 8 explores the different possibilities of operational amplifiers, by building different circuits with amplifiers.

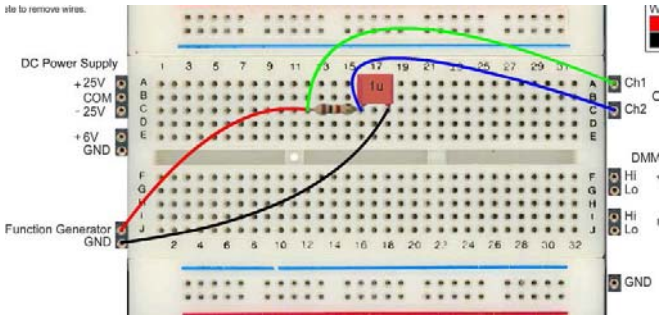

Figure 2. VISIR's breadboard setup for module IV in MOOC

All the evaluation forms in each module are closely related with the experimental results and try to highlight the differences between theoretical, simulated and real results. Also the students are encouraged to use VISIR to build different circuits, not proposed by the teachers, using this opportunity and the different social tools inside (and outside) the MOOC to improve the knowledge of the participants.

Finally there will be a last examination, again not evaluable, for validating the effectiveness of the course and the evolution of the participants, and to help us refining the tasks or revealing the needs of the course

C. Administration and support issues

As commented, the remote laboratory reservation system is integrated in the platform of the MOOC, UNED COMA [7]. Its design allows several freedom degrees to administrators: number of slots per turn, time per turn, number of simultaneous turns and total number of allowed turns in the course. Adjusting these parameters, the administrators will be able to regulate the remote laboratory availability to the demand of use. In fact, this is one of the critical points for analysing in this pilot MOOC: the adaptability of the remote laboratory VISIR to a MOOC. Unfortunately, the VISIR remote laboratory has some features that collide with a MOOC. The intrinsic limitations of a real laboratory such as VISIR collide with one of the most relevant features that any MOOC should achieve: scalability [8].

The information collected during the course by the surveys, the VISIR performance and the demand of use will provide us the indicators about the optimal settings and the convenience of the use of VISIR from the first modules of the MOOC or delay its use until the number of participants has decreased.

The initial settings allow 16 simultaneous users per turn, 60 minutes per turn, a maximum of 2 simultaneous turns booked and a limitation of 14 turns per course. With these settings, VISIR will allow up to 384 students to experiment with any of the designed practices of the MOOC every day.

The MOOC has two different support levels:

- A mentor, in Spanish a "*facilitador*" that is continuously tracking any possible issue with the reservation system. Also she helps the students trying to resolve any problem related with the documentation, the tools in the MOOC and general questions.
- When the problem is related with electronics, and although foundations knowledge is a prerequisite as commented, a teacher is accessible for helping the students.

As in many other current MOOCs, this one is almost completely based on self-learning and peer to peer collaboration.

D. Recruiting and MOOC Certificates

UNED COMA is a completely open initiative. Although our course's syllabus warns that this is a non-basic course and the participant must have previous theoretical knowledge in electric and/or electronic circuits, UNED COMA does not allow restricting those interested in enrolling.

Students will get a course certificate by accomplishing two conditions: they must complete all the activities in all the modules within the MOOC and the global grade must exceed the cut-off grade point established.

UNED COMA offers two more "official" different certificates: online certificate and in person certificate. In the online certificate, the students will have to take an exam from a battery of questions based from the experience obtained from the experimentation and the competences acquired. The in person certificate will take place in one of the 61 study centres in Spain and, on demand, outside Spain where a network of collaborating centres is established [9].

III. SOME PRELIMINARY RESULTS

The number of enrolled participants is currently 2200 although can increase during the MOOC, providing a good number of samples for the subsequent analysis and preparation of a more sophisticated MOOC.

At the moment of writing this paper (June, 28, 2013), more than 1200 participants have answered the pre-course survey, giving us an approximate snapshot of the profile of participants:

- More than 43% are 35 years old or older, with an 5% of people younger than 20 years old.
- 89% of the participants are male.
- 76% declare Spain as country of origin.
- More than 50% are active workers
- 18% are students of a grade related with electric and/or electronic engineering.
- 19% has a grade related with electric and/or electronic engineering.
- 18% has an engineering grade non related with these disciplines.
- 7% has a grade completely unrelated with science or engineering.
- 23% has a non-university grade ("*formación professional*") related with electric or electronic engineering.
- More than 81% have enrolled this MOOC especially because of the use of a real remote laboratory.
- More than 91% explicitly assert that real laboratory practices help a lot to establish the relationship between theoretical contents and real behaviour.

We have also the results of the pre-course exam, not evaluable, for approximately 1000 students. The results indicate that more than 60% of participants do not have the minimum prerequisites. The MOOC suggests for this case a number of options, for example the possibility of enrolling other MOOC [10] before continuing.

A number of approximately 800 students have passed the module 1, dedicated, as said, to simulation, with relatively good results. We cannot yet give complete results as, in the moment of writing, these results are changing. It is important to remember that the objective of this module is to give (or to remind) students the power of simulation for comparing with calculations and real results. It is a module for preparing the real practices with VISIR.

We are currently in a phase where many students have finished module 2, dedicated to basics of use of VISIR and only 20% of them have begun to build the first real VISIR circuits from module 3. A scarce 4% has completed all the open modules in the course. As a consequence, we do not have yet much information about the behaviour of the booking system and the performance of VISIR with so many students. We will show these results, and the related analysis, for the time of the celebration of conference.

One of the most relevant features in any MOOC is social interaction, mediated by the social tools included in them, and the possibility of using any other social tool out of the MOOC. During these first weeks of our MOOC we can report some interesting results, related with the use of forums:

- There are currently 50 open threads, with more than 700 messages and only 17 students very active.
- A number of threads demonstrate that many students have not read the MOOC's syllabus. They discover that they do not have the prerequisites and, probably, a significant number are leaving.
- A number of students have asked for versions of simulation software for Apple or Linux and other students have solved these problems.
- There have been a number of threads dedicated to help people to solve correctly questions of the evaluation of the modules.
- Students with experience in simulation software have helped other participants without this experience.
- Some students are sharing information and trying to answer the evaluations through a dedicated facebook group or two different blogs.

Of course, we must state that these are only preliminary results, but they are inspiring ones, showing, as in other MOOCs, much social activity and high expectations related with the use of a real remote lab as VISIR.

IV. Conclusions

The new MOOC offered by the Electrical and Computer Engineering Department at UNED, and dedicated to real basic electronic practices by using the remote lab VISIR, has been successful, with more than 2000 students currently enrolled.

The participants profile show that many different people are interested in this kind of open online labs learning experiences. However we think that a lot of students without the minimum prerequisites will leave the course, leaving only people with the minimum prescribed knowledge. As the pre-course survey demonstrates, the use of a real time online lab has been a good claim.

As in any other MOOCs the social aspect is being a very interesting one, demonstrating that, also with simulation tools or real practices, to let alone the students searching for their collaboration is a good idea. The activity in the forums shows a grade of natural collaboration similar to other MOOCs [2], making the MOOC a natural scenario of problem based learning.

At the end of the MOOC, we will show much more interesting results associated with the development of the much more practical modules with VISIR. These new modules will give us also many important details, related with the booking system, essential for a stable and reliable use of the remote lab, and also related with the performance of the lab with so many concurrent users.

As said before, this MOOC is a pilot one, designed also for preparing a new MOOC that will offer more complex electronic practices. This new MOOC will target a much more

extensive group of participants, will use English and will require more extensive previous knowledge

Also we are working to give the MOOC we are reporting on in this paper a much larger scalability. The new system will offer the same features but with a larger performance system, allowing, at least, 50 concurrent students. The new system will be a network federation of VISIR systems, integrating through Web Lab Deusto [11] three VISIR systems, at University of Deusto, Institute of Engineering / Polytechnic of Porto and UNED.

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