

# Experimentation of MOOC approach to Practical Electronics Course

Garcia-Loro, F.<sup>[0000-0001-5445-2377]</sup>, Sancristobal, E.<sup>[0000-0003-2102-977X]</sup>, Diaz, G.<sup>[0000-0001-9246-351X]</sup> and Castro, M.<sup>[0000-0003-3559-4235]</sup>

UNED, Madrid 28040, Spain

[fgarcialoro ,elio, gdiaz, mcastro]@ieec.uned.es

**Abstract.** Massive Open Online Courses (MOOCs) fit well to several areas of knowledge and their quality is tightly related to the designed path from the pre-requisites to the objectives. However, a significant challenge arises when developing courses in which experimentation plays a key role. In 2013, DIEEC-UNED (Department of Electrical and Computer Engineering, Spanish University for Distance Education) launched the first MOOC that, in contrast to the usual learning strategy of these courses (focused on knowledge), is focused on experimentation and knowledge application by accessing an electronics remote laboratory. The MOOC was named: “Circuits Fundamentals and Applied Electronics” (BCEP; “Bases de Circuitos y Electrónica Práctica”) and has been re-edited 3 times. This paper shows the results and experience acquired in this area, as well as an analytical review of every element and its integration in the whole system.

**Keywords:** Remote laboratory, MOOC, Electronics, VISIR.

## 1 Introduction

Technical courses require practical experiences: the experience acquired through laboratories provides active learning complements to theoretical knowledge and transversal benefits. The benefits of practical experiences are widely known for professionals and necessary for any person who seeks for a broad comprehension of the real-time performance beyond the ideal/theoretical models. Experimental learning scenarios can be used as an environment to corroborate electrical and electronics circuit laws and principles, or to discover the limits of ideal models. Therefore, universities and educational institutions trust in experimentation for building successful cross-curricular learning opportunities in technical courses [1], [2], [3].

Traditionally, hands-on laboratories have been the tool used by institutions which follow a traditional education model. But Distance Education requires different approaches in order to provide experimentation to students. Tools as virtual laboratories (a software accessible through the Internet designed to imitate a typical lab environment and its behavior) have been possible thanks to the Internet. However, both are still a bit far from providing to student the real performance and features of equipment under real-life operation conditions.

Remote laboratories (a real laboratory -real equipment and instruments- working on a real system, controlled remotely through the Internet) are the last tool merged to this 'experimentation pool'. A review of the current literature shows a great number of universities or organizations that have created their own virtual and remote laboratories to support life-long learning and students' autonomous learning activities [4]-[12]. But remote labs are not only useful in Distance Education as they can be blended in with traditional learning/teaching environments.

The essential difference between remote laboratories and hands-on laboratories results from how the interaction between student and workbench is performed. Therefore, remote laboratories have very limited ability to provide manual skills. On this regard, some authors, [10]-[12], argue that physical presence is only one element in the perception of reality, a student's subjective mental reality.

The possibility of a direct comparison between the different alternatives is constrained by a lack of uniform criteria with which to evaluate the effectiveness of laboratory [1], [13], [14]. It is impossible to conclude that any type of laboratory is superior to another objectively, but also each one provides different learning outcomes [1], [15]. Regardless, the best solution is still a combination of the methods [1].

In 2013, DIEEC-UNED launched the first MOOC providing access to a remote laboratory for electronics experimentation. In fact, the core of the course was remote lab VISIR (Virtual Instruments Systems In Reality): all the activities revolve around its handling and the experimentation carried out in it. The MOOC was named: "Circuits Fundamentals and Applied Electronics" (BCEP; "Bases de Circuitos y Electrónica Práctica") and has been re-edited 3 times. The goals on the MOOC deployment were:

- To provide access to anyone, with basic knowledge and interest on electronics.
- To test the VISIR remote laboratory performance under a high demand scenario.
- To analyze profile of students interested in this kind of courses and their needs to complete satisfactorily the course.

## **2 MOOC-BCEP actors**

### **2.1 MOOC platform**

UNED-COMA platform, aimed at the deployment of MOOCs (xMOOCs) from UNED faculties and technical schools, is an Open-UNED initiative (<https://uneda-biarta.uned.es/wp>). Open-UNED was created by the UNED in order to share Open Educational Resources (OER) from UNED. The platform explores the rich experience of UNED in Distance Education.

#### **Activities**

UNED-COMA platform was not intended/designed for the integration of a remote laboratory in MOOCs. Besides, the possibilities offered by UNED-COMA platform, when designing activities and assessment tasks, were: digital documents, the viewing

of videos, video-questions or P2P activities. The assessment tools for evaluating student progress were based on quizzes, tests and P2P activities.

### **Helpers**

UNED-COMA platform was intended to be a self-learning environment by means of videos, documents and the interaction between users. However, there were two figures for helping students:

- Facilitator: a person from UNED-COMA team who was monitoring the Forums and intervening when needed, resolving frequent questions, guiding participants and helping them with the platform.
- Curator: a person from teaching staff, who intervene in questions regarding to the content and/or methodology.

### **Certificates**

UNED-COMA platform provided three certificates, (one unformal and two official):

- Badge: any student got a badge course by exceeding the cut-off grade point established by teaching staff.
- Online certificate: students had to exceed the cut-off grade point established by teaching staff and pay for the certificate.
- In-person certificate: the in-person certificate took place in one of the 61 study centers in Spain and, on demand, in one of the collaborating centers outside Spain. The in-person certificate required student to have exceed the cut-off grade point.

## **2.2 BCEP course**

Although the nature of MOOC BCEP is completely open, this course targets especially people with at least basic circuits knowledge, because in no case the course addressed theoretical contents: the main objective of the course is to learn practical competences in basic electronic circuits and provide to students a work philosophy.

The core of the MOOC is the remote laboratory VISIR: evaluation and activities goes around VISIR and assessment was focused on handling the instruments and the interpretation of the measurements obtained from the remote laboratory, knowledge on electronics was no assessed, despite being necessary to understand the behavior.

### **Structure**

The course structure comprised 8 modules: Module 1 was dedicated to electronics simulation; In Module 2 the remote laboratory VISIR is introduced to students, but they do not have granted access yet, demonstrative videos with the special features of every instrument and a VISIR manual are provided to students in order to familiarize with the laboratory workbench; From Module 3 to Module 8 students interact with VISIR, building real circuits and performing measurements on them. Module 3 and Module 4 were designed for learning the handling of lab instruments (breadboard, multimeter, function

generator, power supply and oscilloscope), whereas Module 5 to Module 8 were centered on showing the behavior of real components and specific features of the instruments (coupling, trigger, cursors, measurements menu, etc.).

### **Activities**

The course contains 97 evaluative activities, 55 standard multiple choice questions (including single-answer questions and multiple-answer questions) and 42 videos. The weight of the videos is 30% of the final grade and they need 80 over 100 to obtain the certifying badge. Besides this structure, two extra modules (one before the beginning of the course and another one once the students have completed the course) are responsible of compiling the students' profile and their knowledge level by means of optional surveys and questions about basic circuit analysis and electronics components.

### **2.3 VISIR remote lab**

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 [4]. In VISIR, the traditional equipment (DC-power source, function generator, multimeter and oscilloscope) are replaced with an equipment platform, which is suited for remote control such as PXI (PCI eXtensions for Instrumentation), LXI (LAN eXtensions for Instrumentation) and GPIB (General Purpose Interface Bus). Therefore, VISIR is a real laboratory, as hands-on laboratories are, but designed for being accessible remotely.

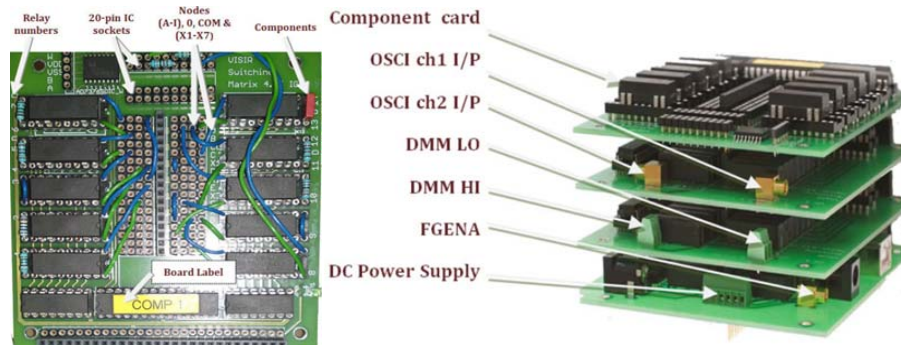
The main advantage of VISIR, when comparing with other electronic remote laboratories, lies in his concurrent access: multiple users interacting with the remote laboratory simultaneously, designing the same or different circuits and monitoring the same or different signals in real time, as in an in-person laboratory with several workbenches.

Once the user wires the components and instruments on the breadboard and the instruments are configured, the user is ready to send his/her experiment to the real lab. But, prior to the physical construction of the circuit, the designed circuit must be verified by the measurement server comparing it with maxlist files. The maxlist files act as supervisors resolving if the circuit can be physical construct, and if the instruments settings are within the range considered by the instructor. if the designed experiment match with one of the possible configurations allocated in any of the maxlist files, the measurement server sends the request to the equipment server, and the equipment receives server constructs the circuit designed by the user and delivers the results in real time. The whole process takes place in milliseconds.

### **Hardware**

*PXI Platform:* the instrumentation platform of VISIR is based on PXI (PCI eXtensions for Instrumentation) from National Instruments. In VISIR, the traditional instruments (DC-power source, function generator, multimeter and oscilloscope) are replaced by the NI PXI-Instruments cards which are plugged into a chassis. A NI-PXI-Controller is plugged into the chassis as well.

*Relay Switching Matrix:* The relay switching matrix is a stack of “PCI/104” sized boards, where the components are allocated, which controls the terminals connection of the components and the NI PXI-modules (Fig. 1, right), by the opening/closing of relays (Fig. 1, left).



**Fig. 1.** Component card (left) and NI PXI-Instrument cards (right).

## Software

- *User Interface:* The user interface is the frontal web page of VISIR that handles all the administration, access, and authentication (Hypertext Preprocessor) in connection with a relational database management system MySQL, and it is hosted in an Apache HTTP webserver.
- *Experiment Client:* represents the entire laboratory workbench through an HTML page as an embedded object. The version used was written in Adobe Flash and embedded in the HTML code of the user interface (current version is written in HTML5). The available instruments are: Breadboard, DMM (Fluke 23), Function generator (HP 33120A), Oscilloscope (Agilent 54622A), DC power supply (E3631A).
- *Equipment server:* it is a software application for instrumentation control developed in LabVIEW. The equipment server software receives validated sequential experiment protocol requests from the measurement server. The results return back to the client PC-screen with the same sequence.
- *Measurement server:* handles the requests from experiment clients. A virtual instructor module checks the circuits before they are passed on to the equipment server.

## 2.4 Booking System

The limitation imposed by VISIR on the number of simultaneous users required the use of a booking system. VISIR installed version had its own reservation system, however it requires user authentication. To save users from manage two user accounts, one for UNED-COMA platform and another one for VISIR, it was required to produce a “booking system” in UNED-COMA platform. This resource was not designed exclusively for VISIR access but was designed for any tool which required a reservation.

The settings used in the booking system from UNED-COMA for the three BCEP editions have been: 16 concurrent users per turn, 60 minutes per turn, a maximum of 2 simultaneous turns reserved per user and a maximum of 14 reservations during the course. With these settings, VISIR allows a daily maximum of 384 students to experiment with any of the practices implemented. This configuration may have been altered during MOOC depending on the demand, but it was not necessary.

The booking system was developed at the side of the MOOC platform, but it was also required to develop a new authentication service in VISIR. The available authentication services are shown in Fig. 2.

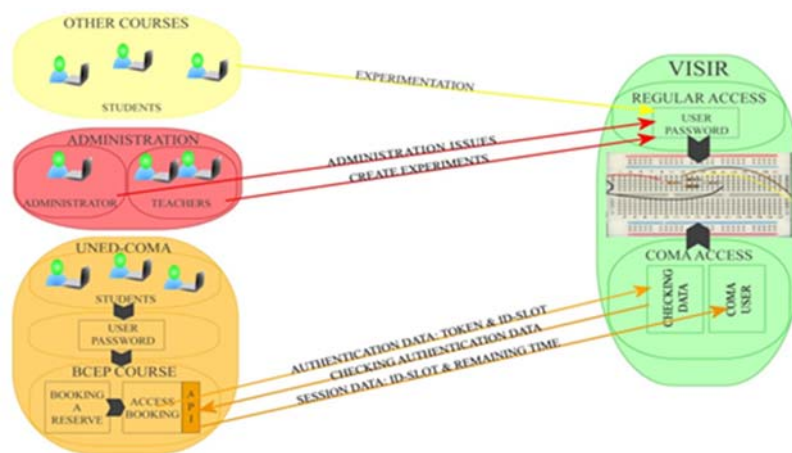


Fig. 2. Authentication in VISIR from UNED-COMA students.

### 3 Results

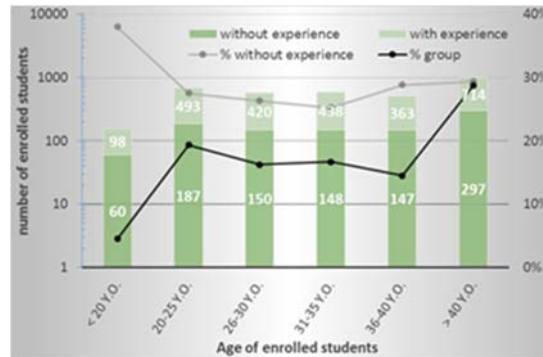
The data about students' profile was gathered from different surveys. These surveys were created in GoogleForms as UNED-COMA platform did not provide any tool for this purpose. Although surveys were optional, over 3,700 responses have been gathered from pre-course survey and 102 from post-course survey.

About the data from the course (individual monitoring final grades, dropout, etc.) the MOOC databases (PostgreSQL, MongoDB) were analyzed as UNED-COMA did not show this kind of information.

#### 3.1 Students' profile

All the videos and contents were in Spanish, this fact has been reflected in the origin of students. 71.4% of enrollments were students from Spain, 5.2% from Colombia, 4.6% from Mexico, 3.7% from Peru, 2.4% Argentina, etc.

The age of students is distributed evenly. Slightly stands out the group of students over 40 years old. By contrast, the group of students under 20 years old was the minority one. These results are shown in Fig. 3, as well as previous experience in laboratories.



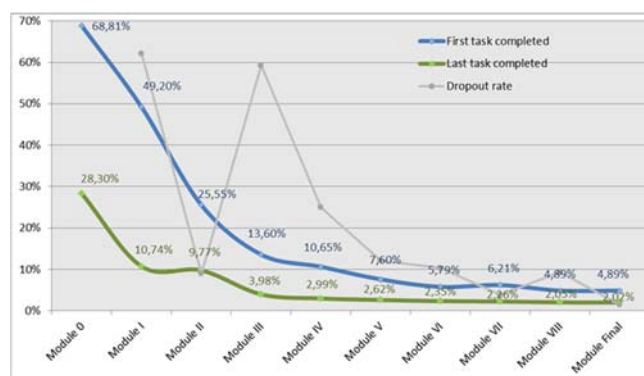
**Fig. 3.** Main y-axis: Enrolled students grouped by age and divided by previous experience in any kind of laboratory (related to electronics or not); Secondary y-axis: percentage of each group to the total and percentage of students with previous laboratory experience of each group.

### 3.2 Dropout

The dropout rate has been high as is usually in this type of courses (Fig. 4); less than 4% have obtained the course credential badge of those who started the course. One of the main reasons for this dropout have been the need of a theoretical background to understand circuits' behavior. This fact is reflected in the high dropout rate in the first module (over 60%). A second peak (dropout rate almost 60%) happened when the remote lab activities started.

### 3.3 Grades

The grades obtained for those students who have completed at least one activity during first edition of the course are shown in Fig. 5, the cut-off mark was 0.8. Most of the grades under 0.15 were obtained by viewing videos.



**Fig. 4.** Dropout. Percentage expressed from enrollments. Module dropout rate refers to the percentage of students that do not completed the module having completed the previous one.

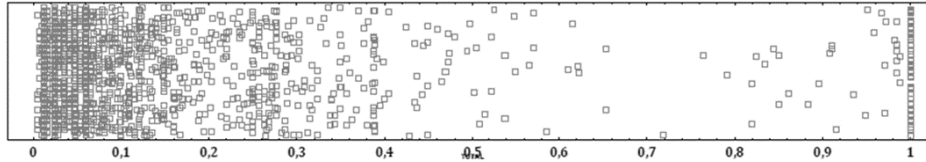


Fig. 5. Scatterplot for the final grade of those students who completed at least one activity.

### 3.4 Students' evaluation of the practical work

A bad design of the MOOC activities may cause students to focus on completing them instead of to analyze the results and to understand the behavior of the circuit and/or components. In this regard, students have been asked about the length of the experiments and the activities derived from them. In general terms, (Fig. 6), they agreed that both are long. Both distributions are skewed to the right (the mean is slightly greater than the median) and are concentrated between “5” and “8” (lower and upper quartiles).

## 4 Discussion & Conclusions

Because of the novelty of the initiative, the MOOC B CEP was well-received by the students. However, many aspects could have been better implemented. One of the worst actors has been the MOOC platform. The platform didn't provide any tool to carry out surveys, so an external tool has been used to accomplish it, therefore there is no way to identify the behavior or interaction of students according to their profile.

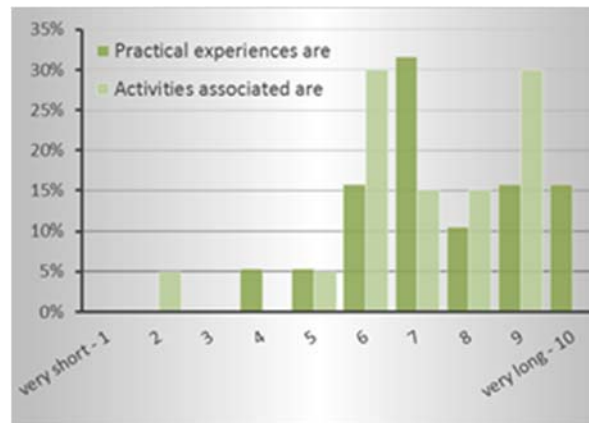


Fig. 6. Answers from students who has completed B CEP MOOC.

Besides, the possibilities offered by UNED-COMA platform, when designing activities and assessment tasks, were very limited: the viewing of videos, video-questions or P2P activities are the assessment tools for evaluating student progress.



In addition, the platform allows access to any module without any restriction. So, unexperienced students could use the remote lab. The course original design limited the access to a module to those students who had completed the previous ones.

Users were anonymous for VISIR due to the way the interaction between the remote lab and the MOOC platform is carried out, when a student from BCEP MOOC accesses VISIR, the remote lab only records in its database that a user from MOOC platform was using the lab, but no further information.

In this regard, a MOOC platform with the necessary tools for a deeper analysis of the students' learning process and that integrates both environments (MOOC and remote laboratory) seems necessary in order to evaluate the convenience of the supplementary documentation (videos, documents, activities, etc.) and their relationship with learning and dropout.

The students' feedback revealed that practices designed were easy for those students who had a previous training in electronics, but complex for those who didn't. In fact, only 33.84% of those enrolled had some training related to electrical/electronic engineering previously to the MOOC. This lack of academic training in electrical/electronic area has been reflected in first modules. As a negative data, only 11.73% of enrollments were women but this percentage increases (over 17%) for younger students.

About the activities, they agreed that, both, the activities they have had to perform in the remote laboratory (measurements, wirings, variations of the same circuit, etc.) and the activities derived from it (calculations, graphs, tables, etc.), were long.

About the course and contents, it looks like practices and activities were easy for students who had a previous training in electronics, but complex for those who didn't. The high dropout and its analysis suggest that students need a theoretical framework to jump successfully into experimentation as well as learning scaffolding designed for novice electronics students. A new design of the course is required to include theoretical content together with practical experiences, new practices and alleviate the workload.

About VISIR remote laboratory, it is well suited to courses with massive enrollments because of its concurrent access, but the intrinsic limitations of a real laboratory such as VISIR collide with one of the most relevant features that any MOOC should achieve: scalability. However, students' opinion about VISIR performance was very positive.

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