MOOC Lab, a Massive Online Laboratory with Real Time access

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Abstract— This study focuses on the usability of a remote laboratory as part of a massive, open and online course, better known as MOOC. The MOOC course for basic principles of Electric Energy is part of a Binational Laboratory project for the Intelligent Management of the Energy Sustainability and the Technological Formation, which has as one of its main objectives to train Spanish-speaking people, particularly from Mexico and Latin America, over topics of energy sustainability through MOOCs. Furthermore, the objective of this research work is to analyze the geographic scope of this massive remote laboratory, as well as the way the users work remotely on the platform. At present, by 2 times offered, the course enrolled 11,087 participants and the MOOC Lab registered 3,731 users that carry out 17,05 lab sessions.

Keywords—Electric Energy, Remote Labs, MOOC, Online Laboratory, Educational Innovation.

I. INTRODUCTION

The construction of the denominated ‘knowledge society’ is increasingly in need of technological platforms for distance education [1], in order that the student may have access to education in any place and at any time [2,3]. Distance Education is therefore a great necessity of modern society. For this purpose, a great variety of platforms, such as online courses, tutorials and web pages have been developed, but most of them devoted to the transmission of knowledge and not to its practical application. Such is the case of Massive, Open and Online Courses (MOOCs), which have been strengthened [4] knowledge society through the democratization of education, because just having internet and a computer anyone around the world can have access to a quality education [5]. MOOCs courses represents a chance to create and develop both teaching architectures and teaching models [6, 7]. Furthermore, [8] claims that MOOCs not only grant students free access to numerous educational resources, but foster interrelationships between people from all over the world. For instance, they are a plausible way to encourage staff training in the business sector since employees can take courses from anywhere and at any time [9]. However, even though MOOC courses are impacting many people around the world, they have also come under criticism, mainly due to their low terminal rate of no more than 4% [10, 11], and because their teaching model has rested in behaviorism [12]. In addition, they have also been criticized of being boring [13, 14] and for not supporting the development of practical skills.

All this has motivated the integration of innovative strategies, especially in courses whose content is complex. There are several studies that have found that motivation and digital skills are necessary for the student to achieve success [16, 17, 18], even hybrid MOOCs have been developed for higher education, in which connectivity is combined with self-direction [19, 20, 21]. Therefore, including innovative teaching strategies in MOOCs can favor the increase in the terminal rate and improve student performance [22 and 23]. However, in the Engineering field, not only the transmission of knowledge is of great importance but also the development of skills and expertise that can only be obtained by applying such knowledge into practice. That’s the main limitations and challenge for distance education in engineering nowadays, applying knowledge into practice. [24] Indicate that the learning process that occurs in practice, develop three skills: cognitive, affective, and motor.

Since the use of a laboratory in Engineering Education is a primordial mean to achieve a superior level of learning and to be able to develop the required skills and dexterity for putting knowledge into action, the laboratory experience cannot be left aside. This is the main limitation and challenge of Distance Education in engineering nowadays, Distance Training. A viable alternative to support this distance learning and training are Remote Laboratories Platforms based on Internet Technologies. The advantages of using remote labs, according to [25] are:

1. better understanding,
2. reducing geographic barriers,
3. lower cost,
4. improving quality of experiments,
5. increasing effectiveness and
6. is safe and secure, even more than in a traditional laboratory.

Currently there are several educational institutions around the world that offer the use of remote lab so that students can carry out practices by distance. In South Indian, they offer a variety of remote laboratories. The objective is that people have access to the use of laboratories in such a way that geographical and financial factors are not a limitation [26]. In Russia, a remote laboratory is used for training in nuclear physics and engineering [27], while in some institutions of Italy [28] and Germany [29] remote labs are used for experimenting with robots.
In Mexico, within the framework of the energy reform, the Tecnológico de Monterrey developed a set of MOOC courses on electric energy, with the purpose of educating the Mexican and Latin American community on those issues. As part of this project was developed a MOOC course for basic principles of electrical energy and consequently the MOOC Lab, a massive online laboratory for basic principles of electrical energy.

Figure 1. Participants’ profile [30].

Figure 1 shows the profile of the user. We can see that these courses are aimed at people between 17 and 65 years old, with completed high school and that are highly committed to their learning [31]. In this way, the laboratory practices were designed for users without previous knowledge of electrical energy and therefore to cover basic principles of electric circuits.

II. TECHNOLOGICAL PLATFORM

Under this context, this initiative aims to create technological platforms for Online Technological Formation that fill aspects like the low cost and distributed use of laboratories. Besides that, Remote Laboratories allow knowledge transmission and its application in real experiments with real time response.

The purpose of this research is to show how was the usability of the remote laboratory as part of the MOOC course, in terms of geographic scope and user time spent. In such a way that this information provides us the means to improve the quality of the laboratory infrastructure and service.

A. Main objectives

The MOOC Lab presents a remote and massive access platform to real electric and electronic circuits applications in real time, which allows for a distance work at any time from virtually anywhere in the world. Together with the fact that the exercise is a real experiment, the easy to use practice interface give the students a richer real experience.

As a further matter, Remote Labs help Institutions to overcome the growing limitations of traditional laboratories, such as:

- Not enough time assigned to the laboratory, and
- Their availability at non-working office hours.

B. Remote Labs Platforms

By integrating electronic, computing and communication technologies, and by taking advantage of the National Networking System implemented at Tecnológico de Monterrey, the institution has developed several Remote Technological Platforms that allow knowledge transmission and its application in real and practical experiments with real time response. At present, a Massive Online Laboratory (MOOC Lab) has been developed and implemented in a MOOC course. It deploys a basic laboratory for principles of electrical energy for massive use that is open to the public for continuous education.

The platform consists, mainly, of three parts:

a) A free access Web Page,
b) A Scheduling System for user control, and,
c) A Practice Interface to access the lab resource.

The Web page (MOOCLab.mty.itesm.mx) contains all the necessary information about the remote laboratory: laboratory description, learning objectives, practice documents, detailed instructions how to access the Remote Lab and the link to the Scheduling System, see Figure 1.

Figure 2. Partial image of the Web page.

Due to the fact that the students decide when and where to perform the laboratory practice, it introduces a new need for remote laboratories which does not exactly exists in traditional labs: an online scheduling system. The Scheduling System allows the students to reserve a laboratory time slot appropriate to their own activities, also giving the students the guarantee of exclusive use of the laboratory during the selected time slot, see Figure 2. The Scheduling System is accessed through the web page.
Once reserved, the students can access the Remote Lab, via the Practice Interface, enabling them to perform a laboratory session, where experiments configuration and measurements are carried out. This way, the Practice Interface gives the user the ability to interact with the remote electric circuit and test equipment without the need for the student to be physically in the lab, see Figure 3.

Figure 3. Scheduling System.

The platform of MOOC Lab consist also of an audio and video interface that allows the remote user to see and hear what is happening in the lab. As a result, the Practice Interface permits the user to interact with the lab resources in a way that is equivalent to being in front of the remote station, see Figure 4.

Figure 4. Practice Interface.

On site, physically the MOOC Lab platform consist of following components:

I. A server computer that manages user accounts, controls access and links remote users with laboratory experiments.
II. 10 data acquisition system NI ELVIS II and a set of instruments.
III. 10 protoboards with the electrical circuits that are the object of the experiment.
IV. 10 webcams for the audio and video interface, connected to the server computer via USB.

As for time efficiency, a remote laboratory would allow access to it in non-working hours, which is not common in traditional laboratories, such as weekends and night-time. This allows for a better use of the resource and for better service to a greater number of users in a greater number of hours.

III. METODOLOGY

The methodological approach was quantitative [30] since the vast data was provided by the MOOC responses’ worksheet. The sample consisted of 1000 lab sessions of the remote laboratory recorded for five weeks. Data is organized by geographic area according to the IP of the student and by schedule time of the sessions. The practice length time is registered the moment they entered and exit the platform, in order to obtain records about the traffic of users in the remote laboratory. Three categories were studied: connection day, connection time and geographic region. The connection day shows in which day of the week the user prefers to work in the remote laboratory. The connection time refers to the amount of time used in each practice as well as the use of the lab throughout the day, and the geographic region shows the geographic location of the users.

All the information was analyzed with spreadsheets and Tableau software to conduct the following analyses:

a) Connection day, this information were obtained from schedule register.

b) Geographic location, this information was obtained from the IP addresses of the users.
c) Connection time, this data was obtained from the analytics of the remote laboratory platform.

IV. RESULTS

The MOOC Lab was first implemented in the MOOC course, Electric Energy: Basic Concepts and Principles, offered in the MexicoX platform. It deploys a basic Electric Circuit Laboratory for massive use and online access. With 10 remote stations the Remote Lab allows 10 simultaneous connections, and has the capability to deliver 1680 one-hour lab sessions every week. The MOOC Lab offers 5 different practices that cover the basic principles of electric energy and electric circuits: Series and Parallel connections, Electric Power Balance, Concept of Impedance, Real and Apparent Power, and Power Factor.

The first time it was offered, the MOOC course enrolled 4997 participants and the MOOC Lab registered 1604 users from Mexico and Latin America who made 993 reservations and attended 695 remote lab sessions in just 5 weeks. By the second time offered, the MOOC course enrolled 6090 participants and the MOOC Lab registered 2127 users who made 1615 reservations and attended 1010 lab sessions. That means that the MOOC Lab carried out 1705 laboratory sessions in only 10 weeks!

In other words, 62% of the total number of registered students at MOOC Lab made reservations and 70% of total reservations were used the first time the course was offered. For the second time, 76% of the total number of registered students made reservations and that 63% of total reservations were used. In the same sense, 14% of the people enrolled in the first course used the MOOC Lab, while in the second course, 16% of the students used it. The terminal rate of the first course was 10% and for the second course was 14%.

Below are the results from the dimensions: Connection day, Geographical distribution and Connection time.

A. Connection day

As we can see in Figure 5, as expected, the most of the user (nearly 74 percent!) prefer to work at non office hours (early morning, late at night or on weekends). Also, more than one third (34.9%) would rather prefer to work on weekend and almost 39% of the user like better to work during the week at non office hours, before 8:00 am and after 6:00 pm.

This result is due to the fact that most users study or work during the day, which implies that they have greater availability of time early morning, late at night and on the weekend.

B. Geographical distribution

One of the main objectives of the Binational Laboratory project is to bring education to Mexico and Latin America, that is, to the Spanish-speaking public. Although some participants from USA and South American were observed, the participation of Mexican users was predominant.

In the Figure 6, we can see the geographic distribution of the MOOC Lab users throughout the Mexican Republic, from the north on the border with the USA to the south on the border with Honduras.
C. Connection time

One of the advantages of the remote laboratory is its accessibility, since users can connect at any time and any day, as long as they have made the reservation in advance. The reservation system is important to guarantee an optimal functioning of the laboratory.

V. DISCUSSION

Given that, the average global terminal rate of MOOCs is around 5% [10, 32, 33], it was very encouraging that 14% of the participants enrolled in the first course and 16% of the second course have used the MOOC Lab. This may mean that there is an interest in this type of educational innovation and that thanks to technology, it is possible to take it to any part of the world.

In addition, the terminal rate of the first course was 10% and 14% of the second course [34]. Although they are high, compared to the average terminal rate worldwide, both were lower than the usability rates of the MOOC-Lab, so this could mean that the use of the remote lab contributed to the improvement of the terminal rate of the MOOC course.

With regard to the day and time of the connection, we can see that users prefer to connect on weekends and midweek before or after working hours (see Figure 5). This result coincides with [9] who says that MOOCs facilitate the training of employees, since they can connect at any time and place, so the same idea can be applied to MOOC-Lab.

As we can see in Figure 9, the most frequent connection time (connection time dimension) was the 23 hours, followed by the 20 hours and from 21 to 22 hours. These results, are related to the fact, that most of the users work or study. Likewise, the most frequent connection time was, 20 to 29 minutes, followed by 30 to 39 minutes, which coincides with the time allocated to solve the laboratory practice (see Figure 8). This coincides with [25] with respect that remote laboratories can be accessed at any time and any place.

In that same order of ideas, with respect to the Geographic distribution dimension, it is agreed that, a valuable aspect of remote laboratories is that it can be accessible to people of
any geographical location [25, 26]. It is interesting that states such as Hidalgo, Yucatán, Nayarit and Campeche, that have a low population [35], present a greater usability of the remote laboratory, with respect to other entities that have a larger population.

Also, states such as Chiapas, Guerrero and Hidalgo that have a lower Per capita Gross domestic Product (GDP) than Mexico City, Guanajuato or Nuevo Leon [36], have shown greater usability of the remote laboratory. These results are very encouraging since it is evident that this type of platforms, such as MOOC Lab, democratize education, allowing users to make their practices anywhere [8, 26, 37] and in a more secure way [25, 26, 27]. In this sense, the Remote Laboratories are a valuable didactic resource that contributes to the improvement of the academic quality of distance education and open knowledge [1, 38].

VI. CONCLUSIONS

This overall experience, together with the reassurance that the process is a real process with circuits, the ease of use due to intuitive graphical interfaces, the opportunity to observe the results in the process due to audio-visual feedback, the ability to be accessed remotely and in virtually any time frame, and most importantly, that it can be done in real time, gives the student an enriched learning process.

In addition, the MOOC Lab contribute significantly to the social aspect, since it makes available to any user who is willing to learn, with an internet connection, the use of the lab resources to acquire safely practical knowledge of electrical circuits, without any concern about their geographical location and their available time.

Thanks to the massive and self-directed nature of the MOOC, the analysis of the information had a quantitative approach, however, in future investigations, questionnaires could be applied to evaluate the user's experience.

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