Redesigning a lab for engineering students using virtual and face to face activities

Cecilia STARI, Lorenzo LENCI

Instituto de Física, Facultad de Ingeniería, Universidad de la República. Julio Herrera y Reissig 565, Montevideo Uruguay

Abstract. This work presents the redesign of the Electromagnetism laboratory for engineering careers, incorporating distance activities using remote laboratories and simulators to complement the classroom activities in the laboratory. The inclusion of these activities allows for better use of class time and better preparation of students. It also contributes to the understanding of the concepts and the use of the instruments, since their use can be adapted to the time needed by each student, repeating the activity if necessary, without having the time limit of the classroom.

Introduction

The importance and benefits of laboratories in undergraduate curricula, and particularly in engineering careers, are widely discussed in the literature [1]. In particular, some authors stress the importance of allowing students to make decisions [2], focusing not so much on the demonstration of a particular model, but on the approach, skills and ways of thinking.

In the first physics laboratory course of the Faculty of Engineering (Universidad de la República, Uruguay), which focuses on data analysis techniques, several changes have been made in recent years to improve the course by optimising the teaching time through flipped classroom activities, allowing more time for discussion of the experimental set-up and data analysis. However, in the second experimental physics course, focusing on electromagnetism and optics, where instrumentation plays an important role, activities remained mostly face-to-face until the COVID pandemic. During the pandemic lockdown, activities using simulators and remote laboratories have been incorporated into the course. These activities were complemented by multimedia resources created by the teachers and supported by the Moodle platform. The results of the use of these resources have been very well evaluated by the teaching team and very well received by the students. Therefore, the course after the pandemic has been re-design and we are interested in whether the incorporation of distance activities in a face-to-face course had a positive impact on the development of the skills and objectives of the course. This work presents the design of a didactic sequence related to the use of the oscilloscope and the study of RC and RLC circuits, and the main effects of the use of mixed activities (face-to-face and at a distance).

Methods and findings

The pre-pandemic sessions dedicated to RC and RLC circuits, consisted of three sessions of three hours each every fortnight. The first lesson was dedicated entirely to an introduction to the use of an oscilloscope and on the study of the charge and discharge of a capacitor: The next two lessons covered RC and RLC circuits. After the redesign, this sequence starts with an interactive video material explaining the use of the oscilloscope and presenting questions to be answered while watching the video. The multimedia material is accompanied by brief written material, available to students on the platform, describing the key concepts and details of the instrumentation.

After this stage, students can start with the distance learning activity consisting of the use of remote and virtual laboratories. The Rexlab [3] remote laboratory was used for a first approach to instrumentation, concepts related to the assembly of different circuits and to study the charge and discharge of a capacitor. The remote lab activity allowed the students to gain confidence in the use of instruments such as oscilloscope, function generator, power supply, PCB, multimeter using remote instruments that were very similar to those they would later use in the face-to-face laboratory. All these remote activities were previously explained in a videoconference class. The work with the remote laboratory was complemented by the use of simulators and virtual laboratories to observe and analyse the behaviour of RC and RLC circuits in the sinusoidal regime, varying the values of the system parameters. The students had a period of two weeks to practise and carry out these activities, following their own pace and asking the group and the teacher in forums when necessary. Once the distance activities had been completed, the students had self-assessment questionnaires available on the Moodle platform to check their level of learning, prior to the face-to-face class. Students must also submit a brief report including experimental graphics, theoretical models and a brief analysis of the results. By this way, the classroom session dedicated to learning the use of the oscilloscope has been replaced by a session where more time has been dedicated to a more in-depth analysis of the circuits and their applications in frequency filters.

After the activity, interviews are conducted with the teaching team to follow up and evaluate the results of the proposed activity. It has been observed that students come to the laboratory class adequately prepared with the previous use at home of the remote laboratory. This enables them to start the experimental part of the activity in the lab with more trust and ability. On the other hand, the previous use of simulators that allowed students to modify the system parameters more freely and to analyse the changes they produced in the behaviour of the circuit, had an impact on classroom performance. In the reports, a good level of understanding of the concepts was detected. The acquired experimental skills have been then applied in more complex activities of electromagnetism. Although the time required by the students was slightly increased during the pandemic, in the following editions of the course, the activities were adjusted so as not to require significantly more time when considering the entire didactic unit.

At the end of the course, students were surveyed about the resources used and the activities carried out during the course. Students expressed a good level of approval and engagement with the use of these resources, particularly with the remote laboratory, which, as already stated, also looks very similar to the equipment they will be using in the laboratory later and felt confident in using it.

Conclusions

The incorporation of distance activities combining multimedia resources, remote laboratory use and simulators in a basic experimental physics course focused on instrumentation and electromagnetism topics allowed not only to optimise classroom time, but also to improve the previous preparation as well as to consolidate concepts.

References

[1] T. Litzinger et al., Engineering Education and the Development of Expertise, *Journ. Engin. Education* **100** (2011) 123-150.

[2] E. M. Smith and N. G. Holmes, Best practice for instructional labs, *Nature Physics* **17** (2021) 662–663.

[3] https://rexlab.ufsc.br/