Remote Energy Lab – Experience and Improvements of European Cooperation in Remote Labs (SHORT)

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ABSTRACT

Due to the COVID-19 pandemic, online teaching methods have gained more interest. Most formats of teaching can be easily transferred into an online format from a technical point of view. However, this is more difficult for practical courses in a laboratory. Together with partners from three European universities, we tackled the issue of providing a practical online course for higher education levels in the framework of the EuroTeQ university. In this work, we present our concept of the course and discuss the course goals and further improvements. We tested the remote lab setting in order to offer the course on a yearly basis in future.

The remote lab was focused on energy engineering and was open to students from different engineering disciplines and countries. The course was comprised of three blocks, each consisting of one lecture on the broader context of the topic and one experimental laboratory session. The experimental session was streamed via a video broadcasting service. Students were required to either deliver a written report or to write a newspaper article for each of the three blocks.

The learning outcome of the course was that students on the one hand learn about the technologies discussed in the course and on the other hand learn about intercultural communication skills. The goal was to show the diversity of technologies and to show the significance of each technology for a specific country. The online experimental sessions proved to deliver a clear explanation of the topic for the students when provided with sufficient course material adapted to online formats. Contrary, keeping a high level of interaction with students during remote experiments was found most challenging.

1 INTRODUCTION

With the COVID-19 pandemic, a new urge for developing remote labs was born [1]. Due to the pandemic, many countries restricted the access for students for on-site learning in university premises. Classical teaching formats like lectures can easily be transformed into an online format from a technical point of view. For laboratory and practical exercises this is more difficult. Transforming existing experimental setups or developing new experimental setups is challenging in terms of time and cost. Nevertheless, to limit the consequences of the pandemic on students' practical education, many approaches to teaching practical experience were undertaken [2]. Remote labs were already developed and used before the pandemic (for example [3] and [4]). A review on remote labs indicates how former reasons for these types of labs were for example space constraints or cost savings, as well as advancements in information technologies, which facilitate their implementation.

Additionally, the concept of "European universities" was developed in 2017 [5]. EuroTeQ emerged from this, as a platform for European engineering education between six partners (Technical University of Munich, Technical University of Denmark, Eindhoven University of Technology, École Polytechnique, Czech Technical University in Prague, Tallinn University of Technology). Offering online formats in teaching is an alternative way to provide courses to the students. In order to also provide students with hands-on teaching and practical experience, remote labs are a necessary solution for situations when on-site practical learning is not possible, and when the cooperation between institutions allows students the possibility of doing remote practical work in facilities and equipment their institution does not possess.

The remote lab concept presented here satisfied the need for practical education during the pandemic and contributes to the EuroTeQ course catalogue. The “Remote Energy Lab” offers an international cross campus education involving three partners from European universities. Our course is classified as remote lab since it comprises a real experimental setup and distant access of the user [6].

2 THE COURSE CONCEPT

The course “Remote Energy Lab” was offered in the framework of the EuroTeQ University in the winter semester 2021/2022. The course was designed for master's students in engineering. A graphical representation of the course is shown in Fig.1. A prerequisite is a bachelor's degree in engineering. The number of participating students was not sufficient for a robust survey. Therefore, the valuable student’s feedback was not incorporated.

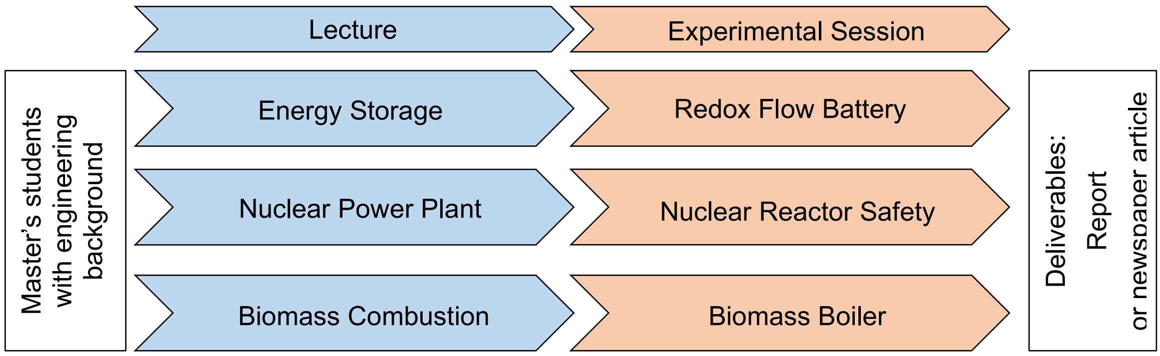

Fig. 1. Schematic representation of the course layout

2.1 Learning Objective

The learning objectives of the course focus mainly on communication skills in an international context. Additionally, students should learn new technologies related to energy engineering solutions. Students are supposed to:

- Learn how to work effectively in an international team.
- Learn to communicate and work with people from different disciplines and cultures.
- Learn how to communicate online.
- Present technologies in an easy and understandable manner.

2.2 Course Content

The course was split into 3 topics. Each block consists of one lecture and one experimental session. The following blocks were offered:

1. Redox flow battery for energy storage

2. Low emissions household heating with a biomass boiler
3. Nuclear reactor safety

The lecture (90 minutes) was given before the experiment and introduced the students to the broader perspective of the topic. Additionally, the lecture introduced important concepts and background information needed for the experimental session. This is important since students with a broad variety of study backgrounds can participate in the course. The experimental session took between 60 and 180 minutes. Students participated during the experimental session via an online conference platform like Zoom for example. For topics 1 and 3, the experiments were performed live during the session. For topic 3, students used a software at their computer that allowed them to directly read data from the reactor. This enhanced the hands-on feeling. For topic 2, the experiment was recorded and played during the experimental session, due to the inherent long duration of the experiments (over 5 hours).

2.3 Deliverables

Students were asked to write either a short report or a newspaper article. The type of deliverable was determined before the course by the instructors. Reports and newspaper articles were graded, and a mean grade was assigned to the students based on the grades from all three topic blocks.

The report was limited to 5 pages and should include only necessary information and results of the experiments. The idea behind the newspaper article was to make the students write about the investigated technology for a general audience. The focus of the article was not further specified to not limit the creativity of the students. With this deliverable the fourth learning objective to present the technology in an easy manner could be assessed.

3 IMPROVEMENTS AND CHALLENGES

The most relevant challenges and possible improvements are listed here based on our experience from the winter semester 2021/2022. Some challenges were already overcome before the course started. Others were noticed during the course. A total number of 7 students split in 2 groups participated in the course. We received 4 reports and two newspaper articles. The following challenges and improvements were identified:

1. Group work: In the remote lab, the student's work was done individually, as student split their tasks. In a typical lab setting, student’s collaboration within their group would be more intense. A solution would be the creation of breakout rooms within the video broadcasting platform to foster collaboration between students. The collaboration for the preparation of the deliverables is organized by the students and cannot be influenced by the instructor.
2. Complexity of the topics: Considering that the students could have different engineering backgrounds, the complexity and depth of the topics could hinder a proper understanding of the remote practical sessions. Each topic selected was

specific to an energy technology solution, whose working principle was connected to a different engineering field (energy storage, solid fuel conversion, nuclear energy). Therefore, it was necessary to have a practical session joint with a theoretical session to introduce the scientific background, operating principles, and basic concepts related to each topic. We were able to contextualize and introduce the technology with the help of the lecture before the experimental session.

3. Time of experiments: The experiment “biomass combustion” requires over four hours for completion due to the need for a complete analysis, collection of data, and the need to explain the experimental setup and procedure prior to the experiment. A solution to this was recording the experiment and dividing it into multiple video records of each experimental step from the start up to the data collection. Compared to an on-site experiment, the time of interaction with students was shortened during the online version. Therefore, we see the advantage of showing longer experiments in a shorter time period.
4. Visibility: It was observed the impediment of a small field of view for some experiments due to the large size of equipment (for example biomass boiler and peripheral equipment) that is used in the experimental process. This prevented a proper recording or display of the equipment, affecting the student's understanding. To avoid misestimation of the real measurements a schematic, flow chart, as well as diagrams and description of the equipment were provided to counteract this weakness. Compared to an on-site session, this material would also be provided, but less detailed.
5. Interaction between students and instructor: During the experiments, it was hard to interact with the students. Questions were only asked via the chat. A lively discussion did not take place. Activating the students to participate with online quizzes did work. Nevertheless, in comparison to an on-site lab, the interaction needs to be improved to foster the learning outcome. Triggering the interaction during an on-site experiment is easier than for the online session.

On the other hand, remote practical sessions can overcome some of the challenges that are commonly faced in on-site laboratories. For example, one challenge in on-site laboratories is that students are often grouped together in large groups to perform experiments, this can compromise the student chances of success at a meeting. This challenge is addressed in remote labs, by providing the students the possibility of rewatching the recorded practical session as many times as necessary, until conceptual clarity is obtained.

4 SUMMARY

The course was a first attempt to offer hands on experience to students via an international remote lab. The concept of three partners offering one experiment each guaranteed a variety of different topics. The observed challenges contributed to determining what aspects can be further improved in a future remote energy lab course. The course with the improvements mentioned above will be offered again in winter semester 2022/2023. Our experience gained throughout the course can also be transferred to remote labs in other fields except engineering.

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