

Inspiring innovation using virtual environment to conduct laboratory practicals

S Rajasingham¹, U S Premarathne¹

¹The Open University of Sri Lanka
sraja@ou.ac.lk; uspre@ou.ac.lk

Abstract - The COVID-19 pandemic has compelled the education sector to evolve into a adopting the distinct use of technology to facilitate online learning. This adoption of online learning necessitates the change in the design and delivery of the syllabus especially for laboratory practicals, which was primarily designed for a conventional set-up. The laboratory practicals mostly before COVID-19 pandemic were based on hands-on and design-oriented curriculum, which during the pandemic needs to be adopted and facilitated for online learning. The design element should include the three key components in order to provide a good educational experience: social presence, cognitive presence and teaching presence. This case study presents the outcomes with respect to the learners' attitude towards the perception of self-regulated learning, participation and the content knowledge conducted during the online laboratory practicals that was designed using the social, cognitive and teaching presence. The sample size includes students (n=334) from the Bachelor of Technology programme for three different courses at The Open University of Sri Lanka for the academic year 2019 to 2021. The participants were involved in both virtual and onsite laboratory sessions for three courses, which use similar laboratory activities, related to electronic and communication related topics. An online feedback form was designed to assess the interest level of the learners for the onsite laboratory sessions between the periods of 2019-2020 and virtual laboratory sessions between the periods of 2020-2021. The content knowledge was evaluated through assessments that were provided throughout the academic year 2019 to 2021. The average marks received by the students for the assessments increased by 15% for the laboratory practical conducted online while the participation improved by 30% for the laboratory practical conducted online when compared to onsite and online laboratory practicals. The student feedback demonstrated the intention to continuously enrol in virtual laboratory sessions in the future indicating motivation for the self-regulated learning approach.

Keywords: virtual, inspiring innovation, self-regulated learning

1 INTRODUCTION

The advent of the COVID-19 pandemic have forced the society to adopt a new-normal working environment. Health guidelines and restrictions were imposed during the pandemic on the physical gathering and the group size in view of reducing the spread of the viral-borne disease. These restrictions affected the education sector as well. Conventional physical setup for teaching and learning activities were not possible with the imposed restrictions. As a result, it was vital to change the education setup with the distinct integration of online learning platform. There were many challenges in transforming the design and delivery of the curriculum to online learning (Looi et al., 2021; Neuwirth et al., 2021; Rapanta et al., 2020). There was a significant impact in conducting laboratory classes online, which were predominantly facilitated using laboratories before the COVID-19 pandemic. It was a challenging process for both the teachers and learners and these new-normal conditions intrigued the use of online tools to facilitate the teaching-learning process. In addition, this provided an opportunity for the community to explore the online tools available to ensure a seamless educational process. Although there were many online tools available, innovative methods had to be designed and constructed to facilitate the online mode of delivery. It was a challenging process to adopt this mode of delivery especially for laboratory practicals. The research by (Asgari et al., 2021; Lamo et al., 2022) state that the laboratories that are predominately based on the hands-on and design oriented syllabus when transitioned online will provide logistical/technical issues, lack of significant hands on training and other learning and teaching challenges. Although there exists certain challenges there are many positive attributes as well. As evidenced in the recently published literature, (Costabile, 2020; Dunnagan & Gallardo, 2020; Flynn et al., 2021) the online laboratory classes were effective primarily in considering the ability to: (i) maintain social distancing in adhering to the health guidelines and (ii) use of multiple online platforms, simulations and tools to assist the laboratory based activities for relatively small groups of students. In physical

setup, a laboratory class group size largely depends on the availability of space, resources and the accessibility of the equipment and/or devices depending on the nature of the practical activity (Chang et al., 2021).

2 THEORETICAL BASIS

As evidenced by various teachers in the field that is similar to electronic and communication specialization that requires a laboratory setup (Kapilan et al., 2021; Klein et al., 2021; Naji et al., 2020) the out-break of the COVID-19 pandemic and its aftermath present a unique opportunity for innovation within the teaching community. However, when implementing new learning technologies reluctance to change in existing practices and skeptical perspectives arising with the adoption of online platforms and tools were evident (Liu et al., 2020). Based on the existing theoretical work done in the field of distance learning, to guide the development of online electronic and communication engineering education, learning cannot be separated from the social contexts in which it occurs (Bourne & Mayadas, 2005; Bozkurt, 2019; Picciano, 2021). We are familiar with a classroom setup, where interactions between participants creates inquiry based learning (Lipman, 2003). In the engineering discipline interaction with peers and staff is helpful for their learning (Gelles et al., 2020; Mora et al., 2020; Vlachopoulos & Makri, 2019)

3 SETTING AND DESIGN CONSIDERATIONS

3.1 SETTING

The participants are student who are all following the undergraduate engineering degree programme. Curricula of these three (03) courses are based on outcome based learning paradigm. The learning outcomes related to the laboratory activities are directly assessed upon the completion of all the relevant laboratory activities. We focus on three courses which use similar laboratory activities related to electronic and communication related topics. There were three instructors to support the two course coordinators. Student numbers and the topics related to the laboratory activities are outlined in the Table 1.

Table 1

Details of the Laboratory Activities for Each Course

Course	Number of activities	Tools required	Number of online sessions	Group size/No. Of groups	Evaluation
C1	06	Proteus simulation software	02	15/12	Lab report Demonstration of the simulation outputs and the circuit designs Viva-voce examination
C2	03	Scilab simulation software	01	15/22	Lab report Demonstration of the simulation outputs and the circuit designs Viva-voce examination
C3	03	Scilab simulation software	01	15/23	Lab report Demonstration of the simulation outputs and the circuit designs Viva-voce examination

3.2 DESIGN CONSIDERATIONS

According to (Garrison, 2016), “a group of individuals who collaboratively engage in purposeful critical discourse and reflection to construct personal meaning and confirm mutual understanding”. Such groups need three key components to provide a good educational experience, which are, social presence, cognitive presence, and teaching presence. Social presence is the ability of the members in the community in the group to present themselves and have interactions comfortably and freely (Garrison et al., 2000). The cognitive presence is defined as the reflective learning that takes place through discussions between students and teachers (Garrison et al., 2001). Teaching presence includes both the design and facilitation of educational experiences to enhance cognitive and social processes (Anderson et al., 2001). By considering these three presences and the practical guidelines described in (Fiock, 2020), virtual learning communities for the online laboratory activities were designed. Preliminary, informal feedback suggested that students found webinars useful, particularly valuing the small group nature, interactivity and ability to ask questions and work collaboratively on screen. The subsequent process was followed to communicate the instructions and the details of the laboratory activities to the students.

- P1 - Laboratory activity guides and the schedule of the online sessions (e.g. date, time, web link to join the session) were provided by posting on the relevant Learning Management System (LMS) classroom.
- P2 - Separate online meetings were scheduled to explain to the students prior to the commencement of the online laboratory sessions.
- P3 - Additional familiarizing introductory online meetings were conducted to familiarize the students with the simulation tools.
- P4 - Clarifications on the installation process, issues in downloading and accessing the tools were addressed via Gmail and message posted through the Moodle class.
- P5 - Conduct the online laboratory activities
- P6 - Assessment and marks.

With the advancements in the mobile computing and interactive applications developments to suit various portable devices, there is a plethora of online communication platforms and tools available. Circuit simulation platforms that are recommended for electronics and communication specialization are described in (Abdrakhmanov et al., 2021; Erfan, 2017; Huang et al., 2020). Among the considerations for selecting the tools and online platforms included the ability for the students to independently design and implement the circuits designed and to observe the output waveforms and the related observations, interact socially and academically with their peers and staff. These considerations helped to continually assess students' understanding, effective teaching, and give individual feedback in real time, which is valued by students in distance learning environments (Martin et al., 2012) (Murphy & Manzanares, 2008).

Social presence enablers were designed at various stages of the process. Recommendations on the potential social presence enablers are described in (Flynn et al., 2021). Preparatory guidance and material to support the learners were given in different ways. Table 2 and Table 3 summarizes the type of material and the online platforms that were used to deliver the content at each stage for social presence and cognitive presence respectively.

Table 2

Social presence enablers for learners

Stage	Design Consideration	Online Platform
Preparatory	Laboratory manual with the details of the experiments and activities	LearnOUSL Moodle classroom
	Introductory sessions	Zoom

	Demonstration on installation of the simulation software	Zoom
	Demonstration video on installation of the simulation software	LearnOUSL Moodle classroom, Google drive repository
Scheduling	Schedule was designed focused to small group sizes (maximum of 12)	LearnOUSL Moodle classroom
	Ten (10) week-end and week-day sessions were scheduled	LearnOUSL Moodle classroom
	Four (04) additional sessions on week-days and week-ends were scheduled for the students with special requests	LearnOUSL Moodle classroom
	Additional two (02) viva sessions were scheduled during the week-end for the student requests considering special requests	LearnOUSL Moodle classroom

Table 3

Cognitive Presence Enablers for Learners

Stage	Design Consideration	Online Platform
During the online session	Introduction to the laboratory session which covers descriptions of the activities, learning outcomes and the expected results	Zoom
	Discussion session prior to the commencement of the laboratory tasks to clarify the installation related concerns and the activities related concerns	Zoom
	All participants were visible with their registration number and the name - useful to mark attendance and to interact	Zoom
	Instructor and the Course Coordinator were present during the session to communicate - Chat, video and microphone based communications were enabled	Zoom
	Clarifications on the design of the circuit and the simulation output generation related queries were acknowledged, responded and clarified during the live online session	Zoom

4 DATA COLLECTION

4.1 SURVEY 01

Due to the pandemic most of us had to use alternative assessments and online activities. Unlike the physical laboratory classes, the additional preparation and support extended by the academic/academic support staff is invaluable. This questionnaire was intended to gather data on the extent of student support provided for facilitating the online laboratory sessions for BTech courses in 2021. Seven (07) instructors responded. Majority of these instructors conducted eight (08) the online laboratory sessions on average. Average group size was indicated as 10. Largest group size was 15 and the smallest was 06. Based on the feedback, it was revealed that the group size with 12 students is the most effective group size to manage by one instructor. Furthermore, the feedback responses revealed that additional support was needed if the group size is much larger. Zoom, Gmail and LearnOUSA Moodle classes were used as the primary communication platforms with the students prior, during and after the laboratory sessions. Depending on the course, additional simulation tools including SciLab, Matlab, Net2Plan, 4NEC2, Proteus were used to conduct the laboratory activities.

While conducting the online laboratory activities main issues that were raised by the students is stated in Box 1, the concerns that were identified through the student feedback is stated in Box 2, the additional student support needed during the online laboratory sessions is stated in Box 3 and the suggestions to complete the laboratory activities successfully is stated through the feedback is stated in Box 4.

Box 1

Issues raised by the students during the online laboratory session

- Online connectivity issues. Power failures and interruptions caused disturbances to complete the laboratory activities
- Issues with the installation of the simulation tools due to device specific constraints and unavailability of accessibility to the Internet

Box 2

Concerns identified through the student feedback.

- “Faced some difficulties due to lack of technical knowledge of some students.” For example, at the VIVA session, they need to show their simulation by sharing their screen. Sometimes they don't know how to share the screen. So have to spend more time to explain about such technical things.

Although we provide an introduction session and asked them to do some pre-tasks, which should be done before participating the lab, most students hadn't try the software before.

- “Some students were unable to join due to sudden power cut offs.”
- “Difficulties of installing the software.”
- “Difficulty in connection problem”
- “Due to sudden power cut offs had to leave the session. Cannot monitor students continuously whether they are doing the lab or not. Although we provided some pre tasks to be familiar with the software, many of them hadn't try it.”
- “Had to leave the session sometimes due to poor internet connection”

BOX 3

Compared to the physical laboratory setup following additional support that the students suggested as needed during the online laboratory sessions:

- “Should provide them a brief idea about the experiment doing in the physical laboratory by a video. While we are using simulation tools in online sessions, it is important to get a knowledge about equipment in the laboratory also.”
- “As we are monitoring them time to time at physical lab, we should be in touch with them frequently at online sessions also.”
- “Explaining the theory related to the lab.”
- “They need a pre task. They will get a knowledge”
- “As we are guiding them, time to time at physical lab, should guide them here too. Also should provide the knowledge of equipment used at the laboratory.”

BOX 4

Suggestions to complete the laboratory activities successfully stated through the feedback

Should make sure they understand the aim of lab tasks.

- Monitoring each student individually.
- prior to the lab, should show an example task of the required software.
- Should make sure student understand the purpose of the lab experiment.
- Provide an examples related to the lab.
- Monitoring each student individually.
- They need to familiarize with software
- Monitoring each student individually. Also should make sure students understand the aim of the lab tasks.
- Explain them the theory related to the lab.
- Monitoring each student individually
- Monitoring each student individually, explaining the theory related to the lab tasks

For the assessment, lab report submissions through LMS classes, demonstration of simulation and output during the viva-voce examinations via online meetings were conducted.

4.2 SURVEY 02

Student feedback was collected using a Google Form. The survey questions were constructed to deduce the conformance to the process steps P1 - P6 and their overall satisfaction. Outcome of the survey results on the conformance to the process steps P1 - P6 is shown in Table 4. The overall satisfaction in completing the online laboratory activities was recorded as 79.3%.

Table 4

Responses in conformance to the process steps P1 - P6

Process steps	Percentage of responses in conformance
P1	86.2%
P2	93.2%
P3	86.0%
P4	75.9%
P5	93.1%
P6	75.9%

5 RESULTS AND DISCUSSION

The overall performance for the assessments considering the total marks obtained for each course is shown in Table 5. The results show that there is an increase in the participation in the online laboratory than that of the laboratory conducted in the physical set-up and that there is an increase in the average marks received for the online laboratory as well. Fig.1 shows that only 12.8% would not like to have lab practical classes in the online mode and the rest of the students do prefer online laboratory classes.

Table 5

Performance assessed based on the total marks for each course

Course	Online				Physical			
	Participation	Average	Maximum	Minimum	Participation	Average	Maximum	Minimum
Course1	64	67.5	90	37	45	58	80	35
Course2	188	71.8	92	55	132	62	90	40
Course3	87	73	90	55	61	60	80	40

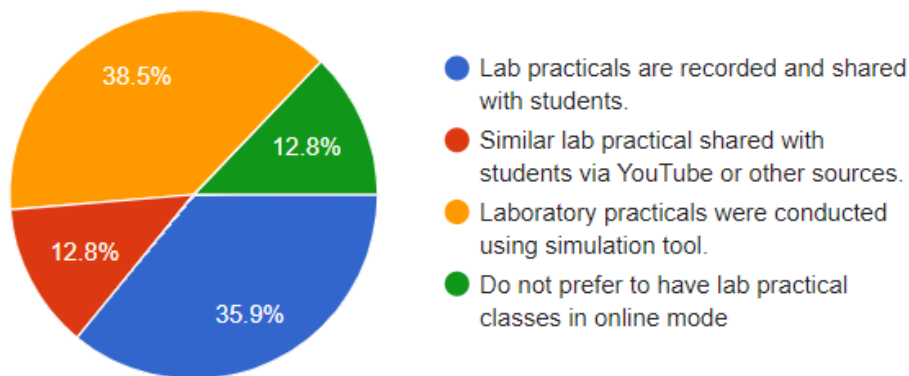


Fig1: The preference of online laboratory activities in future

Conclusion

The COVID-19 pandemic have compelled the educators to adopt to online learning which has imposed many challenges especially in transforming laboratory practicals to cater to online learning that was mostly designed and delivered for a conventional set-up. This paper indicates that it is possible even for a challenging activity such as the laboratory practicals to be motivating and inducing self-regulatory learning when carefully designed using the three components such as the social, cognitive and teaching presence. The results show that there is a significant improvement in the student performance with respect to the assessments and the participation of students for the laboratory practical conducted during online than the onsite and intention of taking interest in continuing online laboratory practicals.

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