

Student and staff experiences with international collaboration in the remote laboratory NetLab

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ABSTRACT: Remote laboratories increasingly have been used in engineering and science education as a complementary tool to traditional proximal laboratories. In some cases, they replace real laboratories to enable students' access to otherwise unavailable or unique equipment and facilities, or to expose students to a unique educational experience. Such a unique experience is an opportunity to collaborate over the Internet with other students either in the same city, the same country or internationally. The latter case adds an extra dimension to the development of communication and collaboration skills required to conduct technical experiments on real components, instruments and systems. Challenges may arise due to different culture, language and learning habits. This paper reports on the authors' and their students' experiences with international collaboration in the remote laboratory NetLab. These experiences are compared with feedback provided by domestic students and observation of their performance by supervising academics. Preliminary recommendations are formulated for effective international collaboration in remote laboratories.

INTRODUCTION

A remote laboratory environment allows any participants to log on and conduct the experiments remotely on real equipment. There are very few collaborative remote facilities in the world. This is unfortunate as such an environment would allow the students to network and collaborate. This creates an exciting world without borders for all willing or encouraged to become part of the framework, to become engaged with students from different locations, cultures, religions and work habits. These generic skills are becoming increasingly important for professional engineers to become effective international team members [1].

At the University of South Australia (UniSA) the first version of a remote engineering laboratory NetLab was implemented in 2002 [2] and has been continually developed and improved through a concentrated effort of final year engineering students, Masters and PhD students, overseas exchange students and supervising academics. The working environment was designed from the outset as a collaborative one, and since implemented for hundreds of UniSA students, both in Adelaide and overseas – for our transnational students in Singapore and Sri Lanka. Although the system would allow any number of students to collaborate, the number of domestic and transnational students to work together has been limited normally to three, to avoid inevitable incontrollable action and interaction of users on the common equipment.

The technical details of the NetLab developments have been reported in another paper of this conference [3]. The system now includes on the hardware side: variable controllable RLC components, a transformer, a digital oscilloscope, a signal generator, a multimeter, a user-controllable Web camera to increase sense of reality in the experiments and a 16x16 switching matrix to physically connect a circuit together. NetLab has a comprehensive user booking system, allowing any interested or encouraged person to register and establish an account, and enhanced student communication facility. It also features a remotely configurable circuit builder that allows remote connection of the circuit components and instruments with each other by a click of the computer mouse.

NetLab is one of the most user-friendly and, at the same time, most sophisticated collaborative remote working environments in the world. The experiences and reflections on the NetLab developments and applications have been reported in more than 70 refereed journal and conference papers. Among numerous student projects related to the remote laboratories, two PhD projects in the School of Electrical and Information Engineering at UniSA are in the final write-up phase or are finalised: Aaron Mohtar, *A Remote Laboratory for Testing Microelectronic Circuits on Silicon Wafers* – degree awarded; and Jan Machotka, *Development and Application of the Remote Laboratory NetLab in Electrical Engineering* – to be submitted soon.

The successful application for the Australian Learning and Teaching Council (ALTC) Competitive Grant 2009-2010, AU$220,000 on *Enriching Student Learning Experience through International Collaboration in Remote Laboratories* has boosted the authors' team engagement in investigating the international collaboration aspects in remote laboratories [1]. The focus of the research has been on enhancing student learning outcomes through international collaborative activities.

THE PROJECT

The ALTC project targets the development, implementation, evaluation and dissemination of practice in international on-line collaboration in remote laboratories (RLs). RLs will be used as an enabling medium for creating student international perspectives through the development of international collaboration and intercultural communication skills. The main pedagogical concepts to be applied are the Community of Practice and Collaborative Learning framework [4].

The expected outcomes include the development of students' international and intercultural perspectives, a framework that would best support student intercultural communication and international collaboration in RLs. Also, the framework will add strength at the learning and teaching level of universities and in assessment strategies that will maximise student learning of international collaborative skills. The UniSA Ethics Committee has approved student and staff involvement in the project, including national and international partners.

A pilot study was designed for international collaborative experiments, and preliminary assessment tasks were developed and implemented in the study. These assessment tasks included students' reflection on activities, which are part of their reports. Effective assessment strategies are being developed as planned for the last part of the project when the framework will be implemented on a larger scale.

The framework for the use of the remote laboratory, NetLab of UniSA, has been developed and implemented for two UniSA undergraduate courses: Electrical Circuit Theory (a second year course) and Signals and Systems (a third year course). An assessment component incorporating student questionnaires was introduced for these courses to assess student participation, communication and collaboration skills.

In preparation for the collaborative remote experiments various software environments were examined for the purpose of recording the collaborative laboratory sessions for subsequent evaluation. The Centra® Saba software was selected because of the following features:

- Application sharing (including Multisim, Matlab, OrCAD, Microsoft Office, NetLab, etc);
- Video, audio and text communication;
- Whiteboarding (including drawing of electrical circuits, markers, inserting text, etc);
- Session recording.

A pilot project using four teams (4 students in each) from the Signals and Systems classes, with the international membership combined from Adelaide and Singapore has been accomplished. The results of the remote experiments in NetLab in the form of joint practical reports have been collected. The students' collaborative sessions during pre-experiment activities, during the remote experiments and during post-experiment activities have been recorded and are being analysed.

Students in Adelaide received training in using Centra®. In their initial collaborative sessions they trained their peers from Singapore on how to use Centra®. This was found to be a good icebreaking activity for students from both countries.

The initial plan was to run a pilot trial with 4 groups; two would include 2 students from Singapore and 2 students from Adelaide each and the other two groups would include 1 student from Singapore and 1 student from Adelaide each. However, none of the recruited students felt confident to work alone with a student from another country, so four groups were formed of 2 members in Adelaide and 2 members in Singapore. This ensured that the project was pioneering the development of skills completely lacking in current engineering curricula. From the students' point of view, it proved to be a good exercise as they enjoyed the experience, built confidence and learned valuable skills important for their future careers. From their feedback it was learnt that they appreciated being involved in this project and the opportunity to meet and work with peers from another country.

THE EXPERIMENT

The international collaborative pilot experiment was structured around examining the third order electrical circuit transients in a RLC circuit (Figure 1) and its simulations using MATLAB and PSpice. The process included pre-experiment preparatory work, including the simulations, the experiment itself with transferring results to students' computers and the post-experimental phase consisting of analysing the experiment results, comparing them with simulations and drawing conclusions.

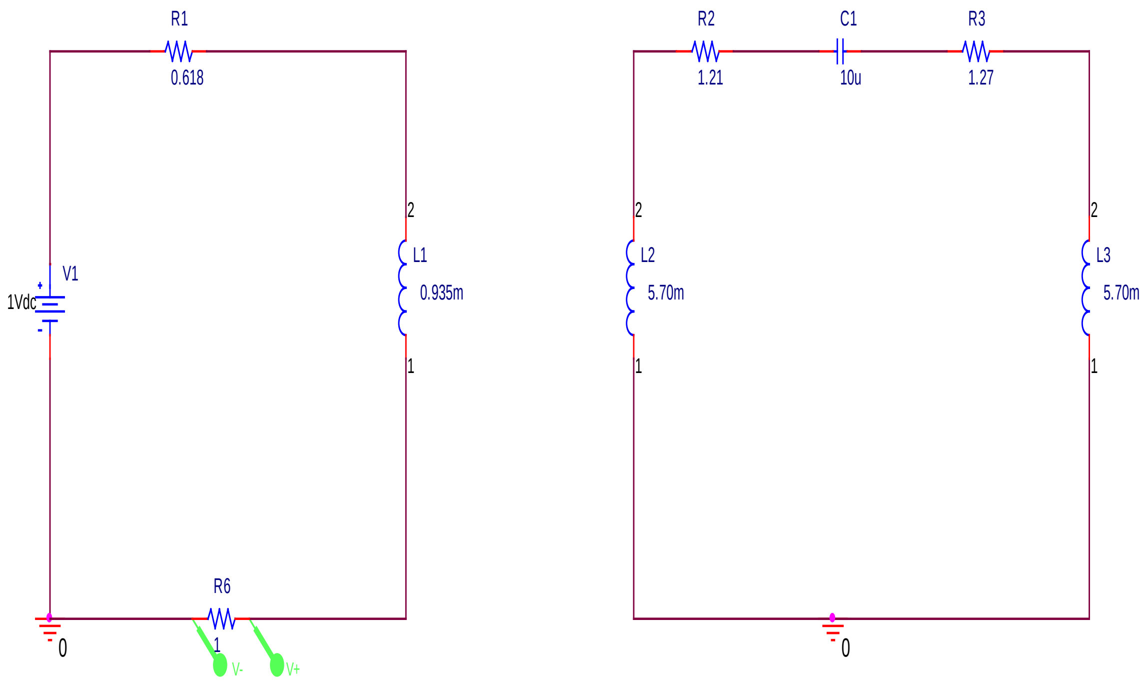

Figure 1: Circuit diagram of the third order system.

In addition to the technical guidance throughout the experiment, communication and collaboration guidelines and recommendations were included in the laboratory manual, for example:

Consider how you will collaborate and communicate with your fellow students at each stage. If you have not done so already:

1. *Introduce each other e.g. give your name and your program of study; previous experience of languages and cultures and your expectations for the collaboration and communication within the group;*
2. *Check each other's previous experience of working with NetLab;*
3. *Negotiate your roles, relationships and expectations e.g. what you need to achieve in the experiment; your understanding of the different stages; how each person will contribute to the experiment; how you will divide up the responsibilities; how you will communicate with each other (e.g. email, SMS etc); when you will meet to decide further actions.*

As you conduct the experiment consider:

4. *Recapping/confirming procedures for the experiment, how you have agreed to collaborate and what your expectations are for each stage;*
5. *Checking each other's understanding of the RL and the progress of the experiment;*
6. *Assisting each other through e.g. making suggestions; giving instructions; discussing options; checking values; comparing results and identifying possible problems; checking accuracy of results; discussing whether to repeat the experiment* [5].

THE QUESTIONNAIRE

The questionnaire and results of the current pilot project with responses involving students from Adelaide and Singapore are listed in Table 1 for the main 13 general questions [6]. It is interesting to note that the majority of involved students were very satisfied or satisfied with all aspects of the remote laboratory international collaboration. It may be necessary to note, also, that the participating students, being volunteers, could explain the high level of satisfaction. This may also explain the large proportion of students who hesitated when asked if they prefer to work in the real laboratory (Question 9).

Highly interesting were the responses to questions 13-16 on collaboration and communication aspects of the 2009 survey. It was very encouraging that the participating students appreciated the collaboration aspect of the experiment, its remoteness as being close to the proximal aspect, and the possibility of repeating the experiment as often as needed. The students acknowledged that roles in the project needed to be allocated, with that of Team Leader being critical. The aspects of saving time by doing the projects from home with a headset for audio communication were emphasised.

The initial stages of the project were difficult because of timing synchronisation problems. But at later stages the students managed to coordinate discussions and time zones to maximise the contribution of all team members. The combination of Centra® and e-mail enabled effective communication.

One group leader complained that the team members were relying solely on him and he did 70% of the required tasks; one of the team members from Adelaide did not show up, with other team members lagging behind. A suggestion was made to improve the assessment procedures and processes to make participation in teamwork a part of them.

Table 1: 2009 pilot ALTC project study participants' responses.

		SD	D	N	A	SA
1	It was easy to book a session				4	4
2	It was easy to access the NetLab				4	4
3	It was easy to learn how to use NetLab				4	4
4	It was easy to control equipment	1		1	3	3
5	I had a feeling as if I was working in the real laboratory			4	2	2
6	I liked moving the camera around to see what was in the lab			1	1	6
7	The collaboration with other students was useful			1	3	4
8	I liked the option of being able to repeat the experiment on my own			1	1	6
9	I prefer working in the real laboratory			5	2	1
10	I like to be able to do wiring of the circuit by myself		1	2	3	2
11	I would like the option to be able to talk to other students during the experiment.			1	3	4
12	Using NetLab was fun				4	4
13	What did you like the most about Netlab and what you did you not like?					
	Collaboration and Communication					
14	How did you manage the process of collaboration and communication within your group?					
15	Describe some specific successes or problems you encountered.					
16	How would you improve collaboration and communication in doing your next experiment?					

11* one comment for 11:

We had this option (provided with headphones), which all group members found extremely useful!

A more complex picture was portrayed when surveying the first- and second-year students in using the remote laboratory NetLab in their year one and two [7].

The questions in that survey of 2003/2004 students are listed below:

1. It was easy to book a session
2. It was easy to learn how to use NetLab
3. It was easy to control equipment
4. It was easy to access the NetLab
5. I had a feeling as if I was working in the real laboratory
6. I liked moving the camera around to see what was in the lab
7. The collaboration with other students was useful
8. I liked the option of being able to repeat the experiment on my own
9. I prefer working in the real laboratory
10. I would like to be able to do wiring of the circuit myself
11. I would like the option to be able to talk to other students during the experiment
12. Using NetLab was fun [7].

Comparison of student responses is shown in Figure 2. As expected, in their second-year students were more confident in using NetLab, particularly after using it earlier. The responses also show that first-year students much more enjoyed implementing camera than the second-year students. However, the second-year students showed more maturity in using NetLab and they highly valued the opportunity offered by NetLab to repeat experiments and learn more. The highest appreciation of the second-year students was the opportunity to repeat the experiment on their own. This feature is rarely available in real laboratories.

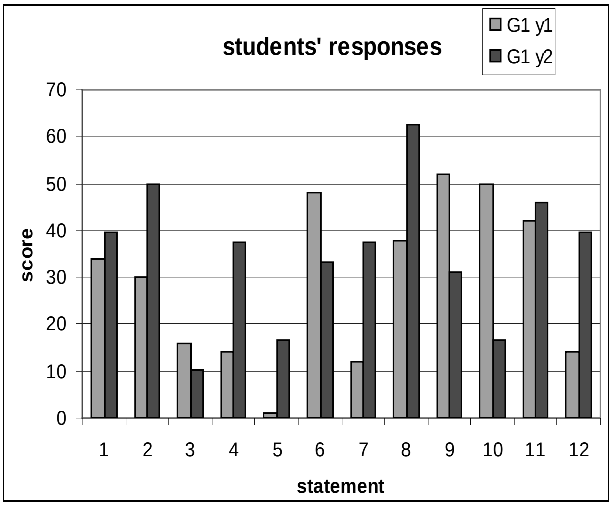

Figure 2: Students' responses: Same students (G1) in Year 1 and (G2) Year 2, 2003/2004.

Similar trends were exhibited by Gustavsson et al, where in VISIR (Virtual Instrument Systems in Reality) - an Open Source Software Initiative for Distributed Online Laboratories has made a major impact on the world accessibility of remote laboratories [8]. Students thought that VISIR is a good learning tool so it can be integrated in many subjects. Some suggestions included improving the sense of reality in the remote laboratory.

RECOMMENDATIONS

Experiments in the majority of remote laboratories, including NetLab, are conducted by students only with minimal real-time supervision and advice from academic staff. This is very different from real laboratories where the supervisors are present all the time and can interact with the students at any time. This feature of remote laboratories dictates two necessities: initial training for students in using a remote laboratory and a detailed, pedagogically sound guide for an experiment. If collaboration is an important aspect of an experiment, it should be a part of all teaching and learning materials.

The initial training can be conducted in lectures to illustrate the most important aspects of a remote laboratory, by using pre-recorded instructional videos on-line, and by introducing students to a remote laboratory in the first real laboratory session. For the best efficiency, all three can be used in conjunction.

A study guide for an experiment on-line is most essential for the success of a laboratory session. It should be thorough, covering in-depth the process of conducting the experiment and producing the report. It should have a feature of a cookbook, to include all ingredients and the kitchen procedures; however, it should leave some space for creativity for motivating good students.

Another recommendation for the successful implementation of remote laboratories is its technical robustness. There is nothing more frustrating for students, or visitors, when the whole system or its subsystems are non-operational. Down-time in the period of most demand can cause outrage in hundreds of students and should be avoided by all means. It is not easy in an environment where the technical support is based mainly on voluntary involvement of students and staff, as in the case of NetLab. The minimum is a backup server that can restore the remote laboratory's functionality in a relatively short time.

CONCLUSIONS

The use of the remote laboratory concept opens the world's facilities to all students. As educational globalisation progresses, opportunities grow to enable anyone in the world to conduct remote experiments on sometimes expensive and unique equipment. The sustainable society needs engineers who have international experience of working with remote equipment and facilities and, more importantly, in multicultural teams linked by Internet accessibility.

The experiences with the international collaboration in the remote laboratory NetLab gives the confidence that such an exposure to student learning, after an initial adjustment phase, has an overwhelmingly positive impact on the learning outcomes.

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