

Collaborative Learning in Engineering Remote Laboratories

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Abstract— This paper reports on practices in national and international on-line cooperation in engineering remote laboratories (RLs) to support student collaborative activities. A structured aid enables them, in addition to acquiring technical skills and knowledge, to develop intercultural communication skills and the global perspectives sought by their profession. The concept of a Community of Practice (CoP) is a central pedagogical consideration for collaborative learning and is discussed in the paper. After reviewing practices of others, an emphasis will be placed on a team-based laboratory environment of NetLab – a remote laboratory framework created at the University of South Australia (UniSA).

Index Terms—Collaborative learning, communities of practice, experiential learning, remote laboratories.

INTRODUCTION

A remote laboratory (RL) is a computer-based learning environment that usually allows students from anywhere in the world to access and perform experiments on real laboratory equipment from a distance via the Internet. The experiments are not simulated and are not virtual. As such, RLs are excellent platforms for students to network and collaborate.

There are relatively few remote laboratories worldwide that allow student collaboration to re-create the invaluable proximal student laboratory experience in the online environment.

Benefits of collaborative remote laboratories include convenience of use, high availability, access to specialised or unique equipment, self-paced learning and the removal of geographic boundaries.

In case of international student teams, there is also an opportunity to learn from students of differing locations, cultures, languages and work practices. These generic skills are becoming increasingly important for professional engineers to be effective members of international teams.

THE CONTEXT

International education and the internationalisation of the curriculum, the development of flexible learning environments, problems with laboratory access and availability due to the growth of student numbers, diminishing technical support, increased use of

specialised, unique and expensive equipment, trigger the growth of remote laboratories.

In educational terms the use of remote laboratories contributes to the development of the intercultural capability of graduates based on the concept of the Community of Practice (CoP) [1] where individuals engage collectively in learning and problem solving, with minimal supervision – very much along the student-centred learning paradigm.

Remote laboratories offer a unique advanced learning environment that is reshaping the way in which courses with practical component are conducted. The exposure of students for interaction with others in remote locations prepares them for their incoming professional practice.

The capacity of RLs to facilitate international collaboration of student cohorts is yet to be fully recognised and utilised to its full potential. The emerging importance of this attribute of RLs is seamlessly coupled with the emerging need for engineering graduates to be prepared to work within the modern collaborative international industrial environment.

COMMUNITIES OF PRACTICE

Engineering graduates need to be interculturally capable, that is to be able to negotiate meanings across languages and cultures [2]. The development of this intercultural capability (as a graduate attribute present in all the major engineering degree accrediting guidelines) requires an emphasis not only on additional content, but also on teaching and learning as a process, that is centred on individual interpretations and negotiations of meaning within and across disciplines. There is a clear need for current students to become aware of the importance of the development and constant nurturing of these skills.

The CoP concept – the center of the pedagogical platform of RLs is defined [1], [3] as a network of individuals who engage in a process of collective learning in a domain of shared interest. Members of CoPs build relationships that enable them to learn from each other. In a CoP students can engage in a given professional, meaningful task and actively participate in problem solving. An RL constitutes a contemporary platform that enables CoPs to be formed among nationally and internationally distributed teams.

Students' collaboration and cooperation skills can be acquired via conducting projects with an embedded

remote experiment and working as a part of a team. Collaborative learning or cooperative learning, are forms of situated learning, which include group activities with emphasis on cooperation rather than competition among students [4]. These require students to have additional skills such as the ability to work in diverse groups. Cooperative learning is distinguished from collaborative learning. In cooperative learning teachers take most of the responsibility for decisions about what is to be studied and how the groups are to cooperate; while in collaborative non-competitive learning group activities, students are engaged in making decisions about what is learned and how [5].

COLLABORATION IN REMOTE LABORATORIES

Globally distributed systems are or will be typically interconnected to function concurrently. Such systems are designed and controlled by international teams of specialists and students, also distributed worldwide. Members of such teams have to collaborate and communicate effectively to achieve the required objectives. Remote laboratories, which started their development about two decades ago, are currently seen as the beginning of future global systems. They represent a unique opportunity to deliver a teaching and learning platform for the development of skills required for efficient collaboration and communication on a local and global scale.

Laboratories are critical and indispensable part of engineering education. In addition to real laboratories that are expensive to maintain and run, new technologies offer collaborative remote engineering and laboratories that are a combination of augmented and mixed reality environments – a “collaborative learning space” [8] that support collaborative work between remote sites. Fig.1 represents the differentiation between hands-on and virtual, local and distributed, single user and collaborative laboratories.

nature of equipment \ user access	local	distant
	physical (real)	hands-on lab
virtual (modelled)	virtual lab	distributed virtual lab

Figure 1. Laboratory environments [8].

Collaborative working environments in distance education, that include remote laboratories, deliver productivity and efficiency through synchronized communication between collaborating partners, locally or globally. Multiuser environments have been successfully implemented in air control systems, team-oriented military systems, chat text tools and multiplayer games. User support becomes critical for the success of collaborative experiments, where in addition to human support, e-tutor (rule-based) can be implemented [9].

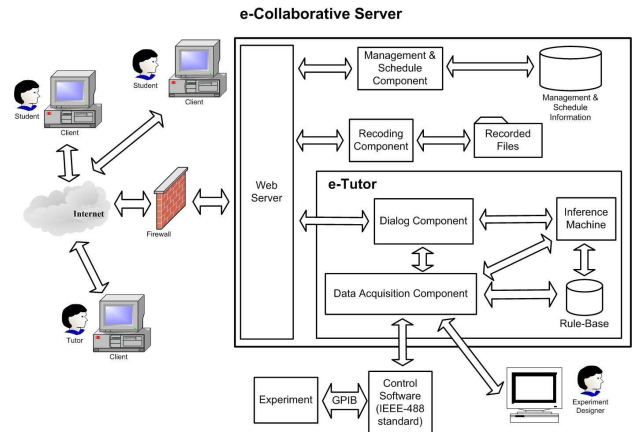


Figure 2. Collaborative environment for remote experiments [9].

Currently there are more than 120 RLs reported worldwide [6], yet only a few allow involved participants to collaborate in real-time. Examples of those include RLs developed as part of the MARVEL (Virtual Laboratory in Mechatronics: Access to Remote and Virtual e-Learning) project [7], WebLab at MIT (Massachusetts Institute of Technology) [10] and RL at UniSA called NetLab [11]. Other examples are DIESEL (Distance Internet – based Embedded System Experimental Laboratory) [12], [13] and Computer Supported Collaborative Work (CSCW) application [14].

Remote or virtual laboratories become a reality in engineering education as augmented traditional laboratories. The students in them have a central part in the learning process [15] and can use grid technologies as a collaborative environment (Fig. 3.)

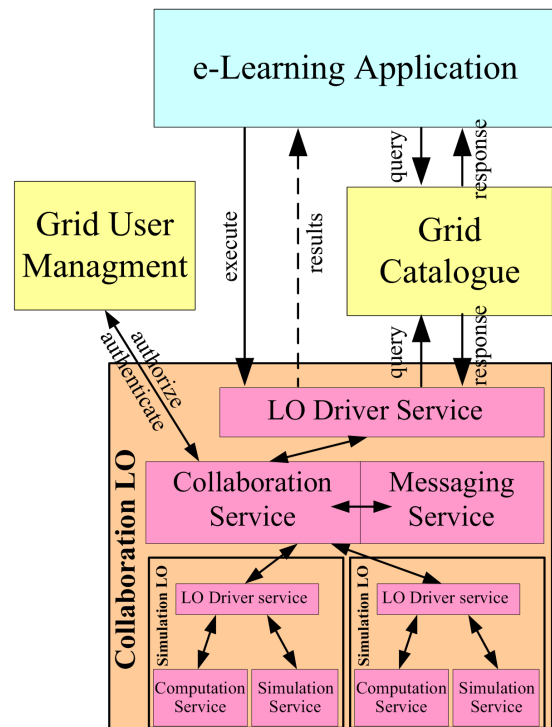


Figure 3. Collaborative execution environment [15].

NETLAB AT UNISA

The UniSA RL NetLab [16], shown in Fig. 4, is situated in the Sir Charles Todd building at Mawson Lakes Campus in Adelaide. It can be accessed at URL: <http://netlab.unisa.edu.au>. Its hardware includes: the remote laboratory server, a number of other hardware items like 16x16 switching matrix, the web camera and various Internet controllable instruments and components.

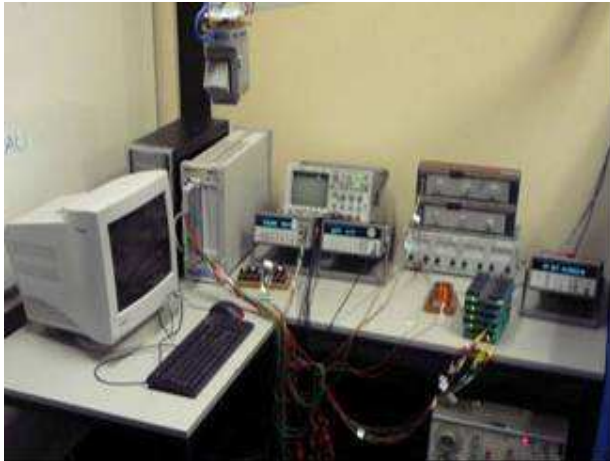


Figure 4. The NetLab hardware.

The laboratory builds on our extensive research and development of remote laboratories over many years at UniSA as well as on that of our colleagues at partner institutions. The UniSA remote laboratory NetLab is an interactive, collaborative learning environment and as such it offers a unique opportunity to offer students international collaboration. In addition to local students, our off-shore programs delivered through Asia-Pacific-Management Institute APMI-Kaplan in Singapore allow us access to a large number of international engineering students who use NetLab to perform the same experiments as the on-campus students in Australia. This has enabled us to pilot the program with a small group initially and later, after initial evaluation, implementation of it at a large scale under UniSA supervision. The involvement of partner institutions in Portugal, Australia and Sweden are crucial to the success of the collaborative project. Recruiting students from their own institutions, and possibly from other European Community countries to collaborate in RLs with UniSA students, will increase the cultural diversity of the participating student body. It will also provide crucial insight into the experiences by students from other cultures that will be further used as a catalyst for guiding the directions of the international collaboration.

NetLab users create their own account by designating a username and a password, following which they can book a NetLab session using the time in their own time zone, which is then transcribed into the South Australian time zone. The online *User Guide* has 8 different video clips, each giving detailed description and help for the different components of the remote laboratory. Students can use NetLab individually or as a team of up to three

concurrent users. All users have full control over the instruments in the laboratory via the NetLab GUI (Graphical User Interface) depicted in Fig. 5. Although it is possible to allow the participation of more students in an experiment, it is impractical and ineffective as demonstrated by experiences in proximal laboratories.

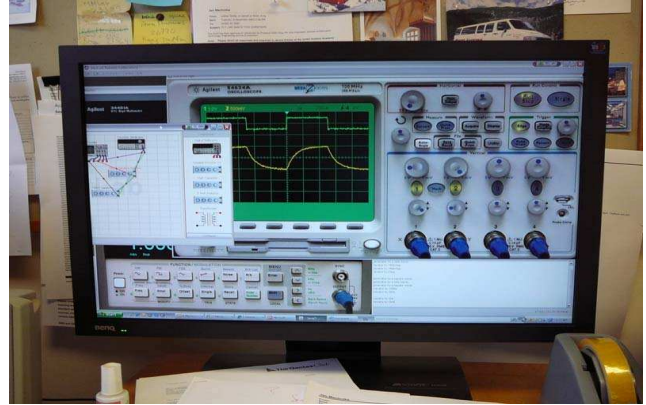


Figure 5. GUI of NetLab.

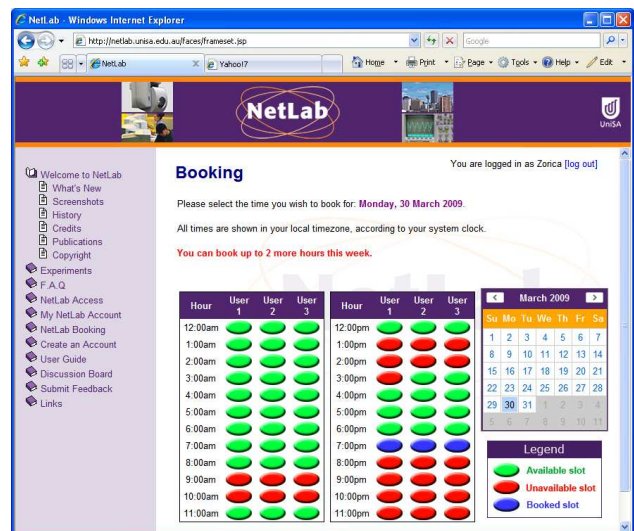


Figure 6. NetLab booking system.

Fig 6. Shows the unique NeLab booking system that allows students from around the world to work together on common experiments.

Students in Adelaide and Singapore have been trained in the use of Centra®, that is an excellent virtual learning environment in software with most of the features needed for the collaborative project including recording facility of all activities – critical for the evaluation of student communication and collaboration. The trial has been already accomplished successfully in April 2009.

After the trial a modified framework will be implemented for whole large classes and evaluated as an ongoing part of the action research process. The findings will be documented and disseminated in a form of guidelines for best practice in remote laboratories accompanied with case studies that can be used by students and teaching staff.

CONCLUSIONS

The paper presents existing RLs and suggestions for the development of future ones, that support development of on-line collaborative skills for engineering students in the environment where they work together on laboratory experiment and on small projects that enhance their experiences, skills and knowledge. During the process students are expected to develop communities of practice as one of the most effective learning setups.

The ability for professional engineers to collaborate in this context is an emerging and ongoing requirement and RLs can assist in equipping the next generation of students with the skills necessary to realise it.

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