Online International Collaboration - a Case Study: Remote Laboratory NetLab

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Abstract: - Remote laboratories are relatively recently developed systems that allow users to control laboratory equipment from remote locations. Most of these systems are developed at various universities worldwide and used as a part of a modern educational environment to support students in performing laboratory experiments. Large number of these remote laboratories are developed and used in engineering disciplines. However, only very few of them support online collaboration which is a significant deficiency taking into account that engineering students work collaboratively in conventional laboratories. Almost a decade ago the University of South Australia has developed a remote laboratory NetLab that uniquely supports students’ online collaboration. In this paper we describe the interactive collaborative features of the remote laboratory NetLab and showcase how it was used for teaching engineering students international collaboration skills.

Key-Words: - Communities of practice, engineering education, international collaboration, remote laboratories

1 Introduction
With a rapid globalization of the world economy, it is expected that in a very near future employers of engineering graduates will be highly regarding their international collaborative skills. To enhance graduates intercultural competence skills and their readiness to work collaboratively in the global international environment we are trialing a project funded by Australian Learning and Teaching Council (ALTC) aiming to enrich students learning experience through international collaboration in remote laboratories. Remote laboratories are chosen as a medium of collaboration because they offer online hands-on laboratory environment where students access and perform experiments on real equipment via the internet. Unfortunately there are no many remote laboratories that offer collaborative learning environment, which is a drawback of this state of the art technology with increasing demand from universities worldwide.

NetLab is one of the very few [1-4] remote laboratories where concurrent users have full control over all equipment. The fact that only four of numerous remote laboratories worldwide are collaborative learning environments comes as a surprise because in real laboratories, students perform experiments in small teams of 2-3 students. As a collaborative online laboratory, NetLab gave us a unique opportunity to investigate how it can be used for teaching and learning international collaborative skills.

With globalization of the world economy, the ability to communicate and work with people from other cultures is becoming more important. For some people it seems to come naturally, others require more training. This is often referred to as intercultural capability, which is becoming very important for engineering graduates with increasing requirements to work as members of internationally distributed teams.

In our project sponsored by Australian Learning and Teaching Council (ALTC), we embarked on teaching students international online collaboration skills including intercultural communication skills. This is a lifelong learning process and there is no single point in time when someone becomes interculturally competent. Students should be aware of the importance of intercultural competence in their future professional career, but to be aware is not sufficient.

Therefore, we have developed a framework for teaching intercultural communication skills which include online experience through collaboration with students from other countries. The framework for international collaboration in remote laboratories addresses three general aspects that affect this collaboration:

- Discipline knowledge
• Enabling technology and
• Cultural intelligence also referred to as intercultural capability (ICC).

For successful collaboration a member of a distributed international engineering team should be highly competent in all three aspects listed above. The question is how to encourage and how to facilitate the development of these competences in students as teaching and learning intercultural communication skills is a difficult and delicate task. Teachers and students may constantly run into a risk of over-generalizing and consequently into stereotyping. We believe that the best environment for the development of intercultural communication which includes nonverbal communication skills and other forms of tacit knowledge is within the context of the communities of practice [5, 6] as a form of situated learning where students are able to actively participate and negotiate the meaning of their interactions and collaboration activities.

2 NetLab as a Collaborative Learning Environment

The remote laboratory NetLab can be accessed through the Internet at http://netlab.unisa.edu.au/. NetLab has an open access, i.e. everybody can use it after creating their own account by registering, defining a password and booking a time slot. This allows our University onshore and offshore students and any users from any location in the world to conduct experiments in NetLab.

The NetLab has its own dedicated server which is connected on the one side to the Internet allowing users to access the RL. On the other end, the server communicates with a number of programmable laboratory instruments via the IEEE 488.2 standard interface, also known as the General Purpose Interface Bus (GPIB). These instruments include a digital oscilloscope, a function generator and a digital multimeter. All these instruments and components are connected to a 16x16 programmable matrix relay switch which provides the user with an option to wire and configure various electrical circuits from available components and instruments shown in Fig. 1.

A special software named Circuit Builder has been developed for the purpose of remote wiring of electrical circuits. The main hardware component that allows connection of selected circuit components is the relay matrix switch with connections shown in the center of Fig 1. A 16x16 relay matrix E1465A module from Agilent is used for this purpose. This relay matrix switch requires supporting hardware that includes: E8408A VXI Mainframe and the E1406A Command Module. These components form a relay matrix-switching unit that is capable of communicating externally with the NetLab server through the GPIB. The VXI standard communication protocol is used for the internal communication within the Command Module.

Fig. 1 the physical setup of NetLab

The NetLab server uses an implementation of the Virtual Instrumentation Software Architecture (VISA) Application Programming Interface (API) to direct the commands to the appropriate programmable instrument. The VISA API allows software to communicate with a variety of hardware devices using the same software interface.

The Circuit Builder software is designed in a way to mimic circuit wiring as would be performed by students in a real laboratory. Using the Circuit Builder interface the available components may be dragged from the component pane into the circuit diagram. The components may be placed or moved to any location within the assigned area. Components can then be connected using the mouse. The lines representing leads are assigned one of the ten available colors upon creation to increase readability of the diagram. After the Configure button is pressed the circuit is physically wired through the switching relay matrix.

Implementation of the Circuit Builder (Fig. 2) not only enables users to perform remote wiring, but also allows them to use the laboratory for running different experiments, without the need to physically interfere with the laboratory equipment. Variable components were created to give students the choice of setting up different values of resistances, capacitances and inductances such as in the real laboratory. Different values of resistance can be selected by turning the knobs on the front panel of the animated image of the resistor box using a computer mouse pointer. Although it looks to users like a mechanical action, in reality the
resistance is changed by sending commands from an animated GUI of the resistor box to an electronic board where the commands are decoded into positioning of a set of relays for a corresponding value. Fig. 3 shows an example GUI of a variable resistor. On the bottom left-hand side of component’s GUI the range of the component is shown. Next to it is the value currently set up. Clicking on the OK button the user will change the actual value of the resistance. The change is done in a similar way by turning around knobs of animated images of variable capacitors and inductors using the mouse pointer. This is a very unique feature of the NetLab which allows the use of a wide range of different parameters without the need to use as many matrix connection terminals. Currently four remotely variable resistors, two variables capacitances and one variable inductor are available. Additional components can be easily added to or removed from the system at any time.

The GUI consists of the instrument representations: the oscilloscope, the function generator and the multimeter, and the Circuit Builder as described above. There is a communication window in the lower left-hand side corner which shows all users that are logged on and where users can exchange text messages. Voice and video communications are also available for NetLab users. On the lower right-hand side there is a window reporting all actions of the users (Fig. 4).

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Fig. 2 the Circuit Builder interface

The NetLab Graphical User Interface (GUI) was initially written in LabVIEW, but later rewritten in Java. Therefore the Java Runtime Environment (JRE) must be installed to allow the NetLab application to run. The user can control the real instruments through the client software, consisting of the interactive GUI. The users’ commands are then sent to the NetLab server and processed by the server software.

Fig. 3 the variable resistor of value 1Ω

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and zoom functions. It has preprogrammed positions pointing to most common objects in the physical laboratory. The video feed from the camera is not part of any experiment and can be switched off to save on the bandwidth. However, it is an important part of the system because it provides distant users with telepresence in the laboratory.

A booking system is an integral part of NetLab. It allows a user to book up to three one-hour sessions per week to have the system available to either 1, 2 or 3 students at a time. The number of hours per week has been limited as some users booked excessively prohibiting other users’ access. Technically, there is a possibility of any number of students working on the same experiment at the same time but as all of them have the full control over the circuit configuration it is not practical. The booking time is shown in student’s own time zone. The example of the booking system is shown in Fig. 5. The time slots booked by the user are shown in blue, green are available and red are the slots booked by other users.

3 Concept of Situated Learning

Concept of the community of practice is introduced by Lave and Wenger [5] as part of their more general social theory of learning. The concept was originally introduced to describe learning in the context of apprenticeships where new apprentices learn from senior members of the group through mutual engagement in a shared practice. Although most people associate word "apprenticeship" with learning situated in a traditional trade environment, lately [7, 8] a concept of cognitive apprenticeship was introduced with the focus on cognitive skills and processes rather than on physical ones. However, the concept emphasizes that knowledge must be used in practice e.g. for solving real-world problems and that expert knowledge is necessary but not sufficient for expert performance. They also give a framework for cognitive apprenticeship and postulate four principles for designing effective learning environments: content, method, sequencing and sociology, where sociology focuses on social characteristics of learning environments.

Unlike majority of theories that treat learning as an individual process in which we acquire knowledge of objects or abstract categories, Lave and Wenger argue that learning is a social phenomenon as it occurs in a community through interactions of the members and for the benefits of the members as social entities of the community.

In fact, there are many aspects of learning and as many theories of learning. However, in this project we focus on social aspects of learning as students acquire knowledge while involved in professional activities, through interactions with other students in small internationally distributed teams. As such, we find the community of practice to be a suitable model for developing intercultural capability in engineering students while collaboratively working on experiments in remote laboratories.

Communities of practice are self-organizing systems which can form spontaneously or through seeding and nurturing. However, they develop only through internal leadership. In our project, lecturers form groups. To support development in a relatively short time, we can only teach students about the importance and role of leadership inside the group and encourage members to take leadership roles by setting it as a task for each group to dedicate different leadership roles to different members [9]. Although these can be formal or informal roles, we prefer to ask students to formally assign all of these roles among the members. As there are more roles than students in a group in our project, each student will take up more than one role. They may divide these roles into two groups: major and minor and each student can be assigned one major and one or two or none minor roles. The group may also decide that some roles are not as relevant and may exclude them or substitute them with other roles. Providing students with this list and guidance on each leadership role will give them ideas of what is expected from them and may also inspire them to undertake more active roles in their community. It will also serve as a starting point in negotiating roles and reflecting on what each of the members’ skills and aspirations are.

As lecturers cannot provide leadership from inside of the communities, they should nurture the communities from the outside. In [9] Wenger gives examples of how organizations can nurture communities of practice from the outside.

4 Case Study - NetLab
In the ALTC project we engaged students from different countries in online collaborations in the remote laboratory NetLab developed at the University of South Australia (UniSA). Students were asked to collaborate on experiments of a level of difficulty suitable for their stage of enrollment in their programs. While collaborating, students were recording their collaborative sessions using software Centra®, which later gave us an opportunity to analyze these sessions.

All our observations come from recorded collaborative sessions between students who volunteered to participate in this project. The recorded sessions include students from Singapore, Sweden and Australia, both from Mawson Lakes and Whyalla campuses of UniSA. Details on programs and courses in which these students are enrolled, and the technology used can be found in our previous publications [10-13].

Our findings from these case studies show that:

- Students are too much focused on discipline knowledge or the lack of it;
- In sessions of some groups long periods of silence were observed;
- Students exercised cautiousness and politeness in communication;
- Some students focused more on commonalities and ignore differences.

The framework is based on creating opportunities, followed by induction, inspiration and guidance. Students are not given proscribed conversation that would make the whole experience very artificial. Rather, they are given discipline tasks to perform collaboratively and a set of questions they need to discuss with students from foreign countries. These questions are introduced in order to encourage students' intercultural curiosity in the context of engineering practice. This was done as an intervention measure after we noticed student's ownership of meaning. Non-participation may be allowed and acceptable, probably through setting the task as voluntary, or for bonus marks.

The framework that we have developed for students to develop their ICC includes:

1) Open access to remote laboratory (NetLab) as a collaborative online experimentation environment.

2) Supporting communication environment in a form of a text based chat within the NetLab itself and Flashcom Ltd. based video communication integrated with NetLab that also supports whiteboarding, for drawing as an important communication tool in engineering disciplines.

3) An induction guide that explains to students what ICC is and how their participation in the context of an on-line community of practice may facilitate the group activities and their development of ICC. It also includes questions that encourage intercultural curiosity and supports development of the dynamics of the group intercultural communication.

4) Experiment instruction sheets with specific discipline tasks including experiments to be performed on-line in collaboration with students from other countries (cultures).

5) Samples of assessment tasks specific to assessment of the development of ICC. These include self-reflection questions like:

- Explain the differences that you have noticed between how you perceive yourself as an Australian (or another culture) and how they perceive you as an Australian (or another culture). It may be useful if you can point out statements about your and other culture that both sides agreed on and statements that you did not agree on.

- Explain a situation in which you tried to overcome forming/reinforcing a stereotype(s) about the other culture.

- Explain mutual alteration of actions, attitudes, and understandings based on interaction with members of another culture (based on adaptation model where adaptation itself is taken as a criterion of competence [14]).

Not being members of the collaborating students' teams, lecturers do not have control over processes taking place within the teams. However, we have an opportunity to externally influence dynamics of the teams. With properly designed assessment tasks we can encourage positive processes such as development of identities of participation through active engagement, and discourage negative ones, such as marginalization. For that purpose the assessment should value active participation through engagement, imagination and alignment by sharing knowledge and experiences, but should not value ownership of meaning. Non-participation may be allowed and acceptable, probably through setting the task as voluntary, or for bonus marks.

The philosophy of the framework developed for our project is to induct staff and students into a fundamental theoretical background of what intercultural competence is and how it can be developed through a collaborative discipline specific practice in on-line environment. It also aims to support students' active engagement in collaborative activities in the context of
communities of practice. Samples of support material and assessment tasks are developed to facilitate students' collaboration, but also as examples for staff to use it in similar courses or as an inspiration for the development of their own material. The framework is definitely not meant to serve as a rigid environment for use with no modifications and contributions by other academic staff intending to include development of intercultural competencies in their courses.

5 Conclusion
We believe that an open, unpaid access to unique/expensive/easy to use remote facilities will rapidly expand nationally and internationally. Simply because it is economical, flexible to the students, giving online access 24/7 and in case of collaborative laboratories, such as NetLab, enriching student teamwork and intercultural experiences nationally and internationally preparing graduates for the challenges in their future work environment in the era of globalization.

References: