Enriching student learning experiences through international collaboration in remote laboratories

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Partner institutions and team members:

**University of South Australia**
Professor Andrew Nafalski
Dr Zorica Nedić
Dr Jan Machotka
Associate Professor Özdemir Göl
Associate Professor Angela Scarino
Dr Jonathan Crichton

**University of Porto (FEUP) Portugal**
Associate Professor José Martins Ferreira

**Blekinge Institute of Technology Sweden**
Associate Professor Ingvar Gustavsson

**University of Technology Sydney**
Professor David Lowe
Mr Stephen Murray

Report authors:
Dr Zorica Nedić
Professor Andrew Nafalski
Dr Jan Machotka
Associate Professor Özdemir Göl

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Executive summary

Globalisation of the world economy has led to creation of many internationally distributed collaborative teams. Consequently, it is expected that university graduates will soon be commonly working in such contemporary environments where frequent online collaboration and communication is required among the team members with different cultural backgrounds. Being able to communicate well with people from different cultures requires good intercultural communication skills. In the modern global society the development of these skills is essential and referred to as development of intercultural capability.

Modern university educational environment includes on-campus students from various cultural backgrounds who are often required to collaborate on projects, but are rarely taught how to communicate properly with members from other cultures. Also there is a tendency for students coming from minority cultures to “fit” into the main culture, which unfortunately reduces opportunities for students to develop their intercultural capability.

Working in an international team and collaborating online brings in a different working environment. It requires from members not only intercultural capability, but also proficiency in using technology as a medium for communication and collaboration. In such complex collaborative environment each team develops their own culture that supports the effective communication and collaboration of the team. Consequently, it is important to equip university graduates with skills and abilities to create these micro-cultures where all members feel supported and confident to make effective contribution towards the successful completion of the joint project.

During the project online collaborative sessions between Australian students and students from other countries (Singapore and Sweden) were recorded and analysed in terms of student’s interactions. The study shows that students are very enthusiastic about participating in the project but lack confidence and skills, and most importantly understanding of the meaning of being interculturally capable in the context of a professional work environment.

This project addresses the development of international online collaboration skills and intercultural capability in engineering students; however, the issues and concepts are general and the same model can be applied to other disciplines. The project has developed a framework that includes samples of materials, which can be directly used by engineering students for online collaboration with students from other countries/cultures. It also includes open access to the University of South Australia remote laboratory NetLab (http://netlab.unisa.edu.au/) that is a unique learning environment for online collaborative laboratory experimentation.

The framework experiments have been incorporated into the electrical engineering curriculum in the lead institution. An equally important outcome of this project is the valuable knowledge and experience gained by the students and staff who participated in this project.
Accessing project materials

Materials that have been developed as part of this project can be accessed from the project website: http://resource.unisa.edu.au/course/view.php?id=1411.

Materials that are available for downloading form the framework for teaching students international online collaboration skills and include:

- Guide for Students
- Open access to the University of South Australia remote laboratory NetLab at: http://netlab.unisa.edu.au/
- Instructions for using remote laboratory NetLab and examples of practical exercises
- Samples of collaborative tasks/experiments including intercultural activities and assessment tasks
- List of publications related to the project co-authored by project team members.
Introduction

Background

The laboratory paradigm in engineering, technology and science education is increasingly moving toward incorporating to a larger or lesser extent e-learning methods. Real laboratories with hands-on experiments on physical equipment are still an important part of the curricula but, increasingly, virtual laboratories – web-based simulations – both locally and remotely, and remote laboratories, where experiments are conducted remotely on real equipment, are becoming a routine part of the laboratory programs worldwide (Elawady & Tolba 2011).

A remote laboratory (RL) is a computer-based learning environment that allows students 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 potentially excellent platforms for students to network and collaborate with students from other countries and through this interaction to learn skills that will prepare them for work in international settings.

The reason for the growth of remote laboratories in engineering and science must be seen in context with the growing need for flexibility of access at any time from any geographical location via the Internet to support student-centred learning and students with special needs. Remote laboratories intrinsically require far less supervisory support than traditional laboratories with the added advantage of user safety and security of equipment. Reduced numbers of experimental sets, hence reduced cost of equipment and need for maintenance, translate into scales of economy in operation. Furthermore, remote laboratories enable student access to shared unique and expensive hardware and software at external academic and industrial institutions.

Experiments in real laboratories, also called proximal laboratories, promote student collaboration by their very nature. This is not necessarily so in the case of RLs as only a handful of them, worldwide, provide a collaborative environment. NetLab, the remote laboratory developed at the University of South Australia (UniSA), is a collaborative online environment, allowing multiuser interactive synchronous access from anywhere in the world to real laboratory equipment placed at the Mawson Lakes Campus of UniSA in Adelaide.

The literature review conducted at the outset of this project has revealed deficiencies in terms of research into the collaborative aspects of using remote laboratories and their potential for teaching students international collaboration and intercultural communication. This project addresses these gaps.

Aims and objectives – definition of outcomes

The research into international collaboration in RLs has led to the formulation of the project aims which are to develop, implement, evaluate and disseminate best practice in international online collaboration in remote laboratories. The project has created a framework and a toolkit for use in support of student collaborative activities in RLs in a structured way that will enable students to develop intercultural capability and the international perspectives sought by their profession.

The main outcome of the project has been the development of students’ international and intercultural perspective through collaborative work with students from other countries remotely via the Internet.

The framework should strengthen the learning and teaching at universities that will
adopt and implement the framework. The project is also beneficial in its design, as it engages students as partners, encouraging independence, advice, feedback and to make their own evaluations of suitability of RLs as a medium for international collaboration and the ways RLs can be utilised in the future.

The project aimed at improving the communication and collaboration skills of domestic students as members of the Australian multicultural student body. In addition, the project has recommended strategies for assessment of students’ intercultural capability. It also strongly advocates that future RLs be developed as interactive collaborative learning environments.

Approach and methodology

Approach

The project builds on a continuous process of research and development of remote laboratories 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 offered a unique opportunity to take the lead in this project. In addition, our off-shore programs delivered thorough Asia-Pacific-Management Institute APMI-Kaplan in Singapore allowed us access to international engineering students who use NetLab to perform the same experiments as the on-campus students in Australia. This feature has enabled us to pilot a collaborative program.

APMI-Kaplan employs only administrative staff and could not be involved as a partner on this project. It stands to reason that the involvement of partner institutions in Portugal and Sweden was seen as crucial to recruiting students from their institutions to collaborate in the UniSA RL NetLab with UniSA students. Their involvement was also highly beneficial for determining directions of the project and for dissemination of the project outcomes outside Australia.

The project utilised the UniSA RL NetLab, illustrated in Figure 1 that is physically placed in the Sir Charles Todd building at Mawson Lakes Campus. It can be accessed via the website at URL: http://netlab.unisa.edu.au and students and staff from any university worldwide can access it free of charge. Its architecture, shown in Figure 2 includes the remote laboratory server, seen at the centre surrounded by real hardware, including a web camera and various controllable instruments. Also depicted are students and lecturers accessing the RL from various remote locations as users.

Users can create their own NetLab account by selecting a username and password. Then they can book a NetLab session using the time in their own time zone, which is then translated into the South Australian time zone. The online User Guide gives detailed description and help for 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) presented in Figure 3.
Figure 1. UniSA remote laboratory NetLab.

Figure 2. NetLab Architecture
A booking system for NetLab has been created to support its concurrent use by collaborating students. As shown in Figure 4 the booking system offers three "seats" in each one hour duration (time slot). Students can also see the names of the users who booked sessions and decide who they want to work with. The booking system allows offshore students to make bookings in their local time.

Figure 4. NetLab booking window

UniSA RL NetLab, as described above, has a potential to provide a fertile ground for the creation of Communities of Practice (CoP), which constitutes the core pedagogy
of this project. As described in the literature review section of this report, a CoP (Lave & Wenger 1991; Wenger 1998a), is defined 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 this project students engage in a given professional, meaningful task and actively participate in problem solving. An RL is a modern platform that enables CoPs to be formed among internationally distributed teams. RL NetLab as a collaborative learning environment uniquely allows students to form worldwide groups/networks while collaborating on projects/experiments and to learn from each other through engaged interaction.

However, students need guidance and support in order to fully benefit from the proposed learning environment. For this purpose, we have proposed and developed a framework with materials to support students in these collaborative activities. It should be noted that online international collaboration on a discipline specific task requires knowledge of the discipline, technology and intercultural capability. On the one hand this makes the whole exercise very complex as different students have different levels of proficiency in these three aspects of the collaborative environment. On the other hand this complexity offers a rich ground for student interactions and opportunities to learn from each other.

The framework developed in the course of this project aims at supporting students in developing knowledge and skills in the three aspects of the collaborative environment mentioned above. However, it is not rigid, rather it provides flexibility and encourages students to take the initiative in considering, evaluating and adopting other models and technologies that may work better for their collaborative community in order to prepare them for the future leadership roles in their professional careers.

Methodology

The process of developing the framework considered a number of aspects relevant to online international collaboration of students on discipline specific tasks although the logistics of the project activities proved to be a challenge. The support provided by the research associate turned out to be quite helpful and the enthusiasm and the coherence of the project management team quite beneficial in steering the project forward.

The specific methodology used in the project involved the following:

**Recruitment**

Volunteers were recruited from among students enrolled in the 3rd year UniSA course titled Signals and Systems to collaborate with each other on a common experiment for which the UniSA RL NetLab is used. Four groups were formed comprising two UniSA students each from Adelaide and Singapore.

In the second part of the project students from Blekinge Institute of Technology, Sweden were recruited by our international partner to collaborate with UniSA students from Adelaide and Whyalla campuses. These students worked together on an experiment in the 2nd year course Electrical Circuit Theory that is typically a common fundamental course for all electrical engineering students worldwide.

**Induction**

Students were inducted into the program with explanations of the aims of the project and their roles in the project. This induction gave students the opportunity to clarify their concerns regarding the project and especially in relation to the use of recorded sessions in which they were to participate.
Subsequently, students in Adelaide were trained in the use of Centra® (virtual classroom software) by Saba® Ltd as a communication medium because it provided a suitable interactive collaborative environment and the option of recording the sessions. It was decided to provide Centra® training only to students in Adelaide, in order to start the first collaborative session with a relatively easy task, i.e. Australian students teaching offshore students to use Centra software. More details on the use of Centra® software in this project is provided in the attached publication (Machotka & Nedić 2009).

**Online Collaboration**

Students were provided with a discipline specific assignment where they needed to discuss and to assign roles and tasks to members of the team. To complete the given assignment students were required to arrange several collaborative sessions, firstly to prepare for the laboratory session which may have included analysis of the task and simulation of the system to be examined, secondly to work collaboratively on the experiment using RL NetLab, thirdly to analyse the measurement results, and finally to write a group report. It was noticed that some groups merged some of the sessions as it was more convenient for them to meet less frequently for longer sessions due to work and other commitments.

**Analysis of recorded sessions**

The collaborative sessions were recorded and students’ interactions were analysed. It is important to note that students were not supervised during any of these sessions and that they had full control over the recording of the sessions. During the induction process students were advised to feel free to stop recording at any time if they felt the need to do so. Despite the risk of impeding the analysis of interaction, we felt the need to give students this flexibility. We also concluded that it was impossible to control students’ communication outside the recorded sessions, so we adopted the approach to survey the ways they communicated outside these sessions, rather than attempting to monitor or prohibit it.

This decision was made early in the project during the first meeting of the project management team including the international partners. In the course of the analysis of the recorded sessions it was taken into account that some parts of the recorded sessions were deliberately or accidently omitted by students and not available to us for analysis. However, we felt it was an important decision to make in order to develop trust and make students feel comfortable with their participation in the project.

The recorded sessions were analysed in terms of all three aspects of international collaboration: discipline knowledge, use of technology and intercultural capability. Particular attention was focused on the relationships between those three aspects of collaboration. Activities and interactions were analysed within the context of situated learning taking into account the complexities of this particular collaborative environment.

**Surveys and Interviews**

We surveyed students' experiences in this project through questionnaires, interviews and questions leading to reflective answers. We also surveyed academic staff attending international conferences and our workshops on their perception of student collaborative practices and opinion on additional attributes of a good international online collaboration team member.

The results from these surveys and interviews have been published and are available on the project website [http://resource.unisa.edu.au/course/view.php?id=1411](http://resource.unisa.edu.au/course/view.php?id=1411) (Machotka, Nedić & Nafalski 2011; Nedić, Machotka & Nafalski 2011).
Literature review
The literature review with more details given in the next section focused on several aspects. Firstly, the review of theory of the CoP concept, and in particular its focus on the social context of learning gave us a model on which we based the development of the framework. It gave us an important understanding about the concept of situated learning and how people develop knowledge and skills through mutual interactions while engaging in common activities. Understanding and integrating the concept of CoP into the framework aimed at providing students with a model around which they can structure their activities and interactions in order to actively contribute to successful outcomes of their professional (and other) communities of practice (Nedić & Nafalski 2011a).

Secondly, we investigated the literature on building intercultural capability with a specific focus on what it means to be interculturally competent in the context of a professional online collaboration environment. We also investigated models on how intercultural competencies can be developed and what the best ways of assessing them are (Nedić & Nafalski 2011b).

Finally, we investigated the impact of the modern technology on the development as well as on the activities and intercultural interactions among members of online communities of practice (Nedić, Nafalski & Machotka 2011).

Framework Development
The framework was developed progressively during the project. Literature review on the CoP concept, development of intercultural capability and the impact of technology on online collaboration guided the development of the framework throughout the project. Outcomes of the recorded sessions, surveys of staff and students by questionnaires, interviews, reflective answers and feedback were used to develop and improve materials that constitute the framework.

Advancing existing knowledge

Literature review
The engineering profession has always highly regarded collaborative skills in graduates. The increasing world economic globalisation supported by modern Internet technologies requires engineering graduates to be prepared for work on international projects through collaboration among distributed international professional teams in a diverse global work environment.

In this context, the engineering graduates need to be interculturally capable, that is, to be able to negotiate meanings across languages and cultures (Crichton & Scarino 2007). This need has implications for the way we live our lives and interact with others, and for education at all levels (Smith 2003). In this sense the internationalisation of higher education requires acknowledgement of the intercultural in both the substance and process of change (Crichton et al. 2004; Scarino, Crichton & Papademetre 2006; Scarino, Crichton & Woods 2007). Not only do we need to understand the discipline as embodying knowledge of content, but also that this knowledge is embodied by people (Candlin 1999) who have to interact professionally within the reality of multiple languages and cultures, that is, develop an intercultural capability. The development of this intercultural capability (as a graduate quality) 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.

The importance of developing an intercultural capability in this sense is supported in the literature (Buttjes & Byram 1991; Liddicoat 2002). There is also agreement that
intercultural communication requires recognition of the ‘interculturality’ of each communicator and how it contributes to intercultural teaching and learning (Byram & Zarate 1994; Kramsch 1998; Liddicoat, Crozet & Lo Bianco 1999). Consequently, there is a clear need for students to become aware of the importance of the development and constant nurturing of interculturality, which will certainly underpin Australia’s economic competitiveness and social openness as well as enabling opportunities for personal growth. The question is how to achieve this in a most effective way?

The core pedagogy of this project is based on the Community of Practice (CoP) concept (Lave & Wenger 1991; Wenger 1998a), defined 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 is a modern technology that enables CoPs to be formed among internationally distributed teams. The implementation of UniSA RL, NetLab, has already shown improvement of student performance in the practical component of courses. It has given students the flexibility to freely form groups and negotiate time to collaborate on experiments. Unlike in real (also called proximal) laboratories where students often work within a very limited time, closely monitored by a supervisor and without an option to repeat experiment, RLs offer freedom to explore, but also demand more responsibility from students for their own learning – a well known concept of student centred learning. Our experience shows that students mostly value RLs for their opportunity to repeat experiments whenever they observe a discrepancy between their measurement data and their calculated results. This is reflected in their better performance and grades in practical components of courses (Nedić & Machotka 2007).

In RLs students acquire collaboration skills by conducting projects with embedded online remote experiments and working as a part of a team. Collaborative and cooperative learning are types of situated learning that include group activities with emphasis on cooperation rather than competition among students. These types of learning require students to have additional skills such as the ability to work in 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 engage in making decisions about what is learned and how (Maddux, LaMont & Johnson 2001). Collaborative learning has been defined in a number of ways, but generally understood to refer to small group learning, where the group members actively support the learning processes of one another (Göl & Nafalski 2007). The introduction of the Internet has established the collaborative online environment (Roberts 2004). The range of collaboration opportunities has thus advanced from small group learning confined to the classroom or laboratory, to the cyber space, where the information and communication technology (ICT) has increasingly assumed dominant importance (Purvis, Savarimuthu & Purvis 2006). Collaborative work has always been anchored in engineering practice as engineers seldom work in isolation. The success of large engineering projects depends on coherent collaborative engineering teams. Consequently collaborative learning is the most suited approach, indeed a must, in preparing engineering students for the challenges that lie ahead.

In the near future, if not already so, globally distributed systems will be interconnected to function concurrently. Such systems will be controlled by international teams of specialists distributed worldwide. Members of these 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 humble beginnings of future global systems. They represent a unique opportunity to create a teaching and learning platform for the development of
skills required for efficient collaboration and communication on a local and global scale. In 2007 there were about 120 RLs reported worldwide (Gröber et al. 2007), yet only a few are constructed in such way to allow their participants to collaborate in real-time. Those are: RLs developed as part of the MARVELL (Virtual Laboratory in Mechatronics: Access to Remote and Virtual e-Learning) project (Müller & Ferreira 2005), the DIESEL (Distance Internet – Based Embedded System Experimental Laboratory) project (Callaghan, et al. 2007) and the UniSA RL NetLab (Nedić, Machotka & Nafalski 2003; Nedić & Machotka 2007). However, a number of other institutions have recognised the advantages of collaborative RLs and are in the process of redeveloping their RLs into a collaborative learning environments.

RLs are becoming a common feature of the tertiary education environment (Elawady & Tolba 2011). Yet, each RL is unique, different from others as there is no common standard that would guide their development. Notably, our partner institution Blekinge Institute of Technology (BTH), Sweden, has initiated an introduction of uniformity, in both the architecture of RLs and the user interface, as part of the VISIR project (Gustavsson et al. 2009). Currently there are five RLs developed as part of the VISIR project that have adopted the same architecture originally designed by our partner institution BTH. Also, our Australian partner institution, University of Technology, Sydney (UTS) is leading a national project called LabShare which aims to develop a national grid of RLs (Lowe et al. 2009, Lowe et al. 2011). All RLs are to be seamlessly integrated into a common RL management system, called SAHARA, developed at the University of Technology, Sydney. The system will allow laboratory resources to be shared among all Australian universities and possibly will also involve secondary educational institutions through outreach and conventional programs with the aim to increase interest and participation of pre-tertiary students in science and engineering disciplines.

On the other hand, very little research has been done on the evaluation of collaborative learning in RLs. This does not come as a surprise because a large majority of RLs are designed as single user laboratories and student collaboration is not possible. This contradicts professional engineering education practice where students normally perform laboratory experiments collaboratively in groups of two or more students. However, the academic community recognises the importance of collaborative work in engineering profession and in RLs (delAlamo et al. 2003, Nedić, Machotka & Nafalski 2003), and recently there have been proposals for developments of RLs as collaborative environments (Callaghan, MJ et al. 2007).

NetLab, an interactive collaborative RL learning environment, was initially financially supported by a UniSA 2002 Teaching and Learning grant (Machotka & Nedić 2002) and later by the UniSA School of Electrical and Information Engineering. Since 2002 it has been incorporated into the curriculum of a number of engineering courses (Machotka & Nedić 2006), and is currently used both by on-campus students as well as by offshore students enrolled in UniSA transnational programs in Singapore and Sri Lanka. This created opportunities for UniSA students to collaborate internationally with students from other countries and to build their intercultural capability.

In this project we situated the learning of international collaboration skills and the development of intercultural capability within the concept of the communities of practice. Teaching and learning intercultural communication skills is a difficult and delicate task. Teachers and students may often be at risk of over-generalisation and stereotyping. Therefore, we believe that the best environment for the development of intercultural communication, which includes non-verbal communication skills and other forms of tacit knowledge, is within the context of the communities of practice as a form of situated learning where students are able to actively participate and negotiate the meaning of their interactions and collaboration activities.
Learning of international collaboration skills in this project is placed within the concept of the Community of Practice introduced by Lave & Wenger 1991, as part of a more general social theory of learning. Unlike the majority of theories that treat learning as an individual process in which one acquires 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 groups. These small groups are identified as communities of practice defined by Wenger 2006, as “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly”. We believe that there are so many different communities of practice that even this broad definition may not include every type of community of practice. For example, students in our project may interact regularly, but only for a limited time, while involved in activities set by the teacher, whereas the majority of other models require sustainability of the community of practice. In our case it is a desired, but not an expected or compulsory outcome.

Why the community of practice concept?

Some may question the suitability of the community of practice concept as a model for student collaboration in our project. The concept was originally introduced to describe learning in the context of apprenticeships (Lave & Wenger 1991), where new apprentices learn from senior members of the group through mutual engagement in a shared practice. Lave & Wenger 1991, describe how the participation of new apprentices moves over the time from “legitimate peripheral participation (LPP)” towards “full participation” as they acquire mastery of knowledge. However, later there have been departures (Wenger 1998b) from the assumption that in communities of practice all participants move from peripheral towards full participation. Although this move may be compulsory in learning environments such as a traditional apprenticeship, with the adoption of communities of practice as a model of situated learning for many other learning environments, it has been accepted that not all participants are able, or aspire, to achieve full participation. There may be even members who for various reasons, such as not accepting some of the community norms, choose not to participate, or their participation is marginalised by core members when there is an issue of power imbalance within the community of practice. This is certainly a situation we wanted to avoid in our project. We believe that we can at least discourage it through the induction phase and by setting assessment tasks in such a way that will encourage participants to support each other, rather than to compete against each other.

Recently the concept of cognitive apprenticeship was introduced with a focus on the development of cognitive skills and processes rather than on physical ones (Brown, Collins & Duguid 1989; Collins, Brown & Newman 2006). However, the concept still emphasises 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” (Collins, Brown & Newman 2006). Although these are building blocks for any learning environment, and as such they are not new, when considered together they give different dimensions to a learning situation, to classrooms and to the roles of teachers and students (Berryman 1991).

It is natural to assume that collaboration takes place between students who are approximately at the same stage in their degree studies, at similar levels of mastery of the discipline knowledge; with similar technology skills and no previous formal
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intercultural communication training. In reality a group of 2, 3 or 4 students may have quite different levels of discipline knowledge, technology based skills and intercultural experience. Thus, it is not likely that some students will be in the centre and others on the periphery of the circle of participation. It is more likely that over a time participants will take various positions in the participation circle depending on their knowledge and skills, but also on their confidence in contributing knowledge and skills to the group depending on their personal and cultural peculiarities.

Consequently we envisaged that less knowledgeable members would learn from the more skilled members, but we did not expect that the same student would always be in the centre and others on the periphery. Because the practice in this case included various competencies, we expected that the most knowledgeable/skilful student for a given task/problem would actively step into the centre of the circle and would share his/her competences. For a different task this student would move towards the periphery and another student, who had more knowledge for the new task, would step towards the centre. We anticipated that over a time all members would generally make a shift towards the centre of the circle as they have gained more competence and confidence through collaboration within their community.

Brown & Duguid 1991 pointed out that "what is learned is very much linked to the condition in which it is learned" and that "outsiders" become encultured (Brown, Collins & Duguid 1989) through the process of participation in a Community of Practice. Thus, the ultimate result is not expressed in terms of gained "objective knowledge", but in terms of becoming an "insider" and attaining abilities to behave as community members. In this process all community members shape their identity and change the community values and views.

In order for this to happen, it was important for students to take an active role of stepping towards the centre of the circle and to contribute their knowledge and skills. Not less important was the opportunity for members to freely take the position of legitimate peripheral participation which would allow them to observe the activities of practitioners (experts). However, they would do that only in a nont hreatening environment. Wenger 1998b, (pg. 229) argues that "learning cannot be designed: it can only be designed for – that is, facilitated or frustrated". So, we saw our task as discovering how to best support students in the creation of a safe learning collaborative environment that would encourage active dynamics within the community, which would maximise participation of all members and consequently support their shift towards the centre of the participation circle during the life of the assignment, and ideally beyond the life of the collaborative project.

The community of practice concept gives important insights into what learning is, how it occurs through collaborative interactions of the community members and the description of the mechanisms that support learning. By adopting the community of practice concept as a well-developed theory of situated learning suitable for the context in which students are involved in international online collaboration learn intercultural skills through interactions with each other, we were able to base the activities and develop a framework that supports the development of healthy dynamics within the groups in order to maximise the student learning opportunities.

Characteristics of communities of practice

A Community of Practice is not just a group of friends or a social network. It differs from other communities by its specific characteristics. The structural model of a Community of Practice is based on three fundamental elements: domain, community and practice (Wenger, McDermott & Snyder 2002).

The domain is normally defined as the domain of knowledge, or more specifically a
topic or a set of issues that community members are concerned with or a set of problems they are trying to solve. However, we do not see the domain as a static knowledge area with clear boundaries. We see it more as a structural element which "creates common ground and a sense of common identity. A well-defined domain legitimises the community by affirming its purpose and value to members and other stakeholders. The domain inspires members to contribute and participate, guides their learning, and gives meaning to their actions" (Wenger, McDermott & Snyder 2002).

In our project, students were given well defined assignments in the form of laboratory experiments on which they worked collaboratively with students from another country. This would usually involve solving problems, discussing issues related to the background theory, performing experiments and writing a joint report. However, students also knew that the aim of this assignment was to gain international collaboration skills including intercultural communication skills. Because they worked and communicated in an online environment they also needed to develop certain technology related skills. In other words, their knowledge domain was multifaceted and boundaries were not clearly drawn. As such, it was a fertile ground for learning various skills some of which were often in the form of tacit knowledge.

The community is a group of people who care about the domain that a particular Community of Practice is based on. The members of the community are important as they "create the social fabric of learning. A strong community fosters interactions and relationships based on mutual respect and trust. It encourages a willingness to share ideas, expose one’s ignorance, ask difficult questions, and listen carefully... Community is an important element because learning is a matter of belonging as well as an intellectual process, involving the heart as well as the head" (Wenger, McDermott & Snyder 2002).

In our project each team of 2-4 students working together was seen as one Community of Practice. Although all community members worked on the same experiment and were expected to have similar discipline knowledge, their personality would vary as well as their attitudes and cultural backgrounds. This would influence the behaviour of each member and consequently the dynamics of their participation.

We have concluded that there is no simple way in which students can be coached to be successful members of these communities of practice. Particularly, in circumstances where the grouping is imposed on them and when the lecturer may not have control over how students interact with each other. On the other hand it is not sufficient to just make students aware of the importance of intercultural communication. Students need guidance and support for their activities. We have adopted a view that students’ guidance should focus on teaching fundamental principles of what a community of practice is and basic principles of creating and nurturing a successful community of practice. This certainly includes motivating students to become active participants in their community of practice by teaching them the importance of wanting to become a member of a community of practice and the benefits they can expect from their participation.

"The practice is a set of frameworks, ideas, tools, information, styles, language, stories, and documents that community members share. Whereas the domain denotes the topic the community focuses on, the practice is the specific knowledge the community develops, shares, and maintains" (Wenger, McDermott & Snyder 2002).

In our project students were given documents with theoretical background and instructions on how to perform the set experiments in a remote laboratory and guidance on how to use the online communication tools. They were given instructions on initial steps on how to organise their collaborative work on
experiments and which tools they could use to accomplish their tasks. Thus, students were initiated and equipped with enough discipline knowledge and technical skills to successfully complete their assignment in an international online collaborative setting and to produce a joint report to be assessed. However, because of their different backgrounds, not only cultural, but also variation in expertise in using different tools, e.g. online communication tools, word-processing, simulation and graphing tools, they needed to negotiate which tools to adopt and those not familiar with particular tools had an opportunity to learn new tools as well as new ways of using the tools. Generally it was envisaged that, depending on its composition, each group would develop, to some extent, different practices and tools. Students would be adopting different words and phrases from each other through negotiating their meaning and in such a way they would even develop their own language that would "work best" for the particular group.

To emphasise the intercultural side of the assignment it is important to set tasks that allow students to reflect on what they have learned and on differences in practices of students from different countries. Our experiences from the initial trials (Machotka, Nedić & Nafalski 2011) show that students focus almost only on the technical problems and fail to take the advantage of meeting people from other countries to enrich their knowledge about different cultures and to observe the differences and similarities in their practices. To encourage intercultural experience in the ensuing trials we embedded questions in the assignments with an aim to shift students’ focus from purely technical (engineering) tasks to various aspects of international collaboration and intercultural communication.

Table 1 lists a set of the questions which we introduced in our trials. It should be noted that this is only an example of a set of questions and should not be interpreted as an exhaustive set or as a recommended set of questions. We expect that each lecturer will be creative in setting their own questions and even encourage students to recommend relevant questions. However, we do suggest questions, at least some of them, to be within the context of the discipline/professional domain in order not to dilute the professional and discipline context of the setting. In our example we introduced questions related to similarities and differences in programs and courses that students do in different countries (Nedić, Machotka & Nafalski 2011).

Table 1: Questions to encourage intercultural experience.

<table>
<thead>
<tr>
<th>Q1</th>
<th>What have you learnt about the foreign country from this collaborative exercise?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2</td>
<td>What have you learned about programs that your colleagues from foreign countries are doing (include differences and similarities)?</td>
</tr>
<tr>
<td>Q3</td>
<td>What have you learned about the course that your colleagues from foreign countries are doing (include differences and similarities in structure of the course, theory approach, simulation software used, etc)?</td>
</tr>
<tr>
<td>Q4</td>
<td>What is your perception of foreign partners’ knowledge background (i.e. is it at a similar level as yours, if not, is it higher or lower, or in some area higher and in other lower)?</td>
</tr>
<tr>
<td>Q5</td>
<td>Comment on cultural and behavioral differences that you have observed.</td>
</tr>
<tr>
<td>Q6</td>
<td>Do you think that you have enriched your collaborative learning by using different practices and knowledge?</td>
</tr>
<tr>
<td>Q7</td>
<td>List what you consider as desirable attributes of an international group member.</td>
</tr>
</tbody>
</table>
Community of practice and construction of identity

The community of practice concept focuses neither solely on the individual, nor solely on the community. Rather, it focuses on how an individual and a community are interdependent (Corder & Meyerhoff 2008) and how the identity of an individual is constructed through his/her participation in the practices of the community. Here, the identity is defined as understanding of “self”. In his social theory of learning, Wenger 1998b, argues that learning is not just acquiring knowledge, but also a process of understanding who we are. This on the other hand determines our participation including various levels of participation in different communities of practice and consequently determines in which communities of practice we belong and are accepted. In other words, identity is reflected in, and constructed through our participation (including non-participation) in communities of practice to which we belong.

Wenger 1998b, introduces three different modes of belonging: engagement, imagination and alignment:

- “Engagement – through processes such as interactions, sharing practices and forming relationships, community members negotiate the meanings that matter to their community;
- Imagination – by creating images of possibilities, images of past and future, images of the world and images of themselves, community members extrapolate from their own experience;
- Alignment – through agreements, disagreements, compliances and discourses community members invest energy to coordinate their activities to fit within broader structures.”

Wenger 1998b, represents the interrelationships between the identity of a person as a member of a community of practice, structure and the mode of belonging in a diagrammatic form, as illustrated in Figure 5. It delineates that identity is constructed through two complementary processes: identification and negotiability. Identification is seen as an investment of self in a community of practice through different modes of belonging. Negotiability is reflected in the degree of control over the meanings. Figure 5 implies that both identification and negotiability can give rise to identities of participation or non-participation. For instance, if a person’s opinion is continuously ignored or his/her engagement is marginalised, it may result in developing an identity of non-participation. Examples for different modes of belonging are also presented in Figure 5.

The diagram in Figure 5 also depicts identification leading to different forms of membership and forming communities as their fundamental structure. It shows negotiability leading to ownership of meaning, which is interrelated with economies of meaning as a social structure of their relative values, as some meanings may at certain times attain special status.

We have considered this diagram with interwoven dependencies of identity, participation, belonging and structure as an important background in understanding the social aspects of students’ online collaboration. Although students do not focus on the social context of their collaboration, the social context is probably the most important aspect of this collaboration, as the primary objective of their collaboration on engineering experiments in this case is developing intercultural capability. To be able to develop a framework that supports this type of learning, it was important for us to understand the social fabric of communities of practice as their fundamental organisational units.
Not being members of the collaborating student teams, lecturers do not have control over the processes taking place within the teams such as identification, negotiability, engagement, imagination, alignment and participation. However, through economies of meaning they have an opportunity to externally influence these processes. With properly designed assessment tasks lecturers can encourage positive processes such as the development of identities of participation through active engagement, and discourage negative ones such as marginalisation. For that purpose we believe 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 assignments as voluntary, or for bonus marks.

**Inside leadership and outside nurturing**

Communities of practice are self-organising systems which can form spontaneously or through seeding and nurturing. However, they develop only through internal leadership. To support development in a relatively short time, lecturers can only teach students about the importance and role of leadership inside the group and encourage members to take leadership roles by setting a task for each group to dedicate different leadership roles to different members. As defined by Wenger 1998a, the leadership roles that students need to take up are:

- "Inspirational leadership – to inspire the members"
- "Day-to-day leadership – to organise activities"
- "Classificatory leadership – to collect and organise information in order to document practices"
- **Interpersonal leadership** – to weave the social fabric
- **Boundary leadership** – to connect the community to other communities
- **Institutional leadership** – to maintain the links with lecturers
- **Cutting-edge leadership** – to provide "out of the box" initiatives.

Although these can be formal or informal roles, we have suggested students are asked 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 would take up more than one role. Students may divide these roles into two groups: major and minor, and then each student would be assigned one major and one or two or no minor roles. The group should also be able to decide that some roles are not as relevant and to exclude them or substitute them with other roles. Providing students with a list and guidance on each leadership role would give them ideas of what is expected from them and may also inspire them to undertake more active roles in their community. This can also serve as a starting point in negotiating roles and reflecting on each of the members' skills and aspirations.

As lecturers can not provide leadership from inside of the communities, they should nurture the communities from the outside. Wenger 1998a, gives examples of how organisations can nurture communities of practice from the outside. The examples that we have suggested to be applied in the case of building students’ international capability in the context of community of practice include:

- **Legitimising participation** – is the obvious one as the project already adopted the concept of communities of practice.
- **Negotiating their strategic context** – It is important that students understand how intercultural communication is related to their future profession. On the other hand, it is important for the lecturers to pay attention to the feedback related to strategic directions from the members of communities of practice as this may be crucial in sustaining them in the future.
- **Being attuned to real practices** - Appropriately, the design practice domain should be flexible enough to allow students to express themselves through participation as cultural entities. Still, it is important to be based on an engineering discipline task; otherwise students may not see it as relevant and may not take it seriously or may choose not to participate.
- **Fine-tuning the organisation** – Although it is not easy to design a reward system that will manipulate students’ behaviour, lecturers should design assessment schemes that reward students’ participation and their contribution to creating positive learning environment.
- **Providing support** – Communities of practice benefit when provided with relevant resources, such as meeting facilities, help from external experts, communication technology, etc. In our project, students are provided with online access to the remote laboratory that includes video communication facilities. Lecturers are available to provide both online and off-line help with all issues related to the project, in particular, when students are not sure how to balance engineering content and intercultural content of the work.

Consequently, lecturers should seed and nurture the development of communities where students collaborate online with students from other countries, by providing resources and support, but should refrain from attempting to organise and manage them as this may hinder students’ participation.
Intercultural capability

Intercultural capability (ICC), sometimes referred to as *cultural intelligence* with an indicator CQ (cultural quotient), analogue to IQ (intelligence quotient) for general intelligence, is an indication of how well a person deals with people from different cultures. There are various definitions of *culture*. For the purpose of our project we adopted the definition that the “*culture of a group is a set of practices, beliefs and values which are accepted relatively unthinkingly by members of the group*” (Corder & Meyerhoff 2008). In most cases when talking about the culture of a person, people assume nationality or ethnicity of the person. However, the definition of culture that we adopted includes a much broader concept to emphasise that a person’s behaviour is multifaceted and caution should be exercised in what we attribute to a person’s culture in terms of nationality or ethnicity to avoid the risk of stereotyping.

Most literature deals with the development of ICC in connection with teaching languages where students commonly work on tasks dealing with cultural issues through which they also learn a foreign language. In our project, learning intercultural communication is situated within the teaching of engineering skills. Students develop ICC while doing what engineers do: setting up equipment, performing experiments, analysing measurement data and comparing them with model simulation results. Nevertheless, the language is the most prominent side of the communication as in our project voice communication is the main means of communication. Thus the linguistic theories of intercultural communication are very much applicable in our case. However, we do not focus on learning a language, but rather on the use of language in the particular situation. This puts emphasis on the social aspect of learning and communication which prompted us to adopt the concept of the community of practice as a tool for analysing and developing ICC.

 Probably the most important indicator of ICC is the development of the capacity to be flexible in dealing with unfamiliar cultural situations and contexts, and to avoid developing stereotypes which commonly arise due to our selective attention that makes us notice and reinforce what we “already know”. To develop this capacity it has been suggested to encourage students to reflect on the differences between how they perceive themselves (both as individuals and as members of a group/culture) and the way they are perceived by others. This can be aided by analysing four sides of messages as defined by Schulz von Thun 1981, (cited in Grünhage-Monetti, Holland & Szablewski-Çavuş 2005), represented diagrammatically in Figure 6.

![Figure 6. Four sides of a message (Schulz von Thun 1981, cited in Grünhage-Monetti, Holland & Szablewski-Çavuş 2005).](image-url)
The diagram shows that in communication, a message passed from one person to another is much more than just passing factual information as it may also reveal the relationship between communication partners (Relationship); it may reveal some knowledge of or about the sender (Self-revelation) and it may reveal a sender’s desire for a response (Appeal). This model also shows how the online collaborative environment can be a rich learning environment for the development of intercultural capability, if students are perceptive of the concepts represented in Figure 6. This certainly requires preparation of students before engaging in collaborative activities. However, this is a delicate task as preconditioning students may take away their attention from the technical focus. Thus, we have suggested that the induction of students for online international collaboration prepares students to establish a balance between discipline and cultural competencies.

Corder & Meyerhoff 2008, define intercultural communication as a "situation in which people"...from different cultures..." find themselves in a position where they need to communicate with each other, and the differences and similarities between"... their learnt behaviours..."may facilitate or impede their interactions." In our project students find themselves in a position of having to communicate with students from other cultures within a discipline specific professional environment. Consequently, we have situated students’ activities within the context of the community of practice as the most suitable learning environment for the development of intercultural capability. We would certainly like students to successfully collaborate, but as the definition above indicates, cultural similarities and differences may impede their interaction. However, the experience would still be valuable if the students are able to reflect on the observed interactions and develop strategies for improvement in their future interactions. This means acquiring skills that will aid students in developing ICC in a lifelong process. Development of these skills and strategies is what we expect to result from this project in the long term.

However, the question is not only how to develop these skills and knowledge, but also how to assess their development by assessing the level of students’ ICC. A number of researchers attempted to develop methods for assessment of ICC (Koester & Olebe 1988; Wiseman 2002) and showed that adaptability is a common factor in ICC. Their research pointed out that methods should take into account the multidimensional nature of ICC (Abe 1983; Gudykunst & William 1984) and also that oversimplification should be avoided.

Spitzberg & Changnon 2009, give a comprehensive review and classification of intercultural competence theories and models. In Figure 7 we show a model developed by Deardorff 2006, which we have adopted in the project and included in the support material for preparation of students (Student Guide). The model is considered suitable for a number of reasons:

- It includes all three important components in ICC: motivational (requisite attitudes), cognitive (knowledge and comprehension) and behavioral (skills).
- It figuratively shows the progression pathway (from the bottom of the pyramid towards the top) moving from the individual level (attitudes) towards the interaction level (desirable external (visible) outcomes) resulting in “the effective and appropriate communication and behaviour in intercultural situations” (Spitzberg & Changnon 2009).
- The model also suggests the recursive (feedforward-feedback) nature of the process of the development of ICC through the constant development of attitudes, knowledge and skills after the assessment of desired external outcomes.

The pyramid model of intercultural competence shown in Figure 7 and the related
Enriching student learning experiences through international collaboration in remote laboratories

process model, also suggested by Deardorff 2006, are used as a basis for the development of the framework for our project.

Assessing development of ICC

If culture and ICC are difficult concepts, assessment of ICC is even more difficult particularly when we try to implement it in practice. However, assessment has to fit the purpose of the assessment; e.g. assessment of ICC of international aid workers will be quite different from assessment of progress in development of ICC of students as a first step in their preparation for work as members of international distributed engineering team. On the other hand, there are some fundamental commonalities in requirements regardless of the aim, e.g. respect for other cultures.

Assessment of ICC certainly needs planning. Deardorff 2009, suggests a list of important questions to be considered and a template that can be used for planning the ICC assessment activities. In her PhD research, Deardorff 2004, investigated appropriate methods for assessment of intercultural competence of graduating students. One of important outcomes of her investigation is a list of assessment methods that most of the top 20 intercultural experts agree as the most suitable. The list and the statistical data of the survey are shown in Table 2.
Table 2. Ways to assess intercultural competence (Deardorff 2004)

<table>
<thead>
<tr>
<th>ACCEPT</th>
<th>REJECT</th>
<th>MEAN</th>
<th>SD</th>
<th>ITEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>3</td>
<td>3.7</td>
<td>0.8</td>
<td>Mix of quantitative and qualitative measures</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>3.4</td>
<td>0.7</td>
<td>Qualitative measures</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>3.2</td>
<td>0.9</td>
<td>Case studies</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>3.2</td>
<td>0.9</td>
<td>Analysis of narrative diaries</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>3.2</td>
<td>0.9</td>
<td>Self-report instruments</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>3.2</td>
<td>0.9</td>
<td>Observation by others/host culture</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td>3.2</td>
<td>1.0</td>
<td>Quantitative measures</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td>3.1</td>
<td>0.9</td>
<td>Critical incidents</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td>3.1</td>
<td>0.9</td>
<td>Critical essays</td>
</tr>
<tr>
<td>14</td>
<td>6</td>
<td>3.1</td>
<td>1.0</td>
<td>Other-report measures</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>3.1</td>
<td>1.0</td>
<td>Judgment by self and others</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>3.1</td>
<td>1.1</td>
<td>Developing specific indicators for each component/dimension of ICC and evidence of each indicator</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>3.1</td>
<td>1.1</td>
<td>Inventory combined with qualitative measure</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>3.0</td>
<td>1.2</td>
<td>Triangulation (use of multiple data-collection efforts as corroborative evidence for validity of qualitative research findings)</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>2.9</td>
<td>1.0</td>
<td>Interviews</td>
</tr>
<tr>
<td>14</td>
<td>6</td>
<td>2.9</td>
<td>1.0</td>
<td>Bottom-up approach (focus groups, workshops, dialogues, open-ended surveys)</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>2.7</td>
<td>1.0</td>
<td>Satisfaction ratings with all involved in the interaction</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td>2.6</td>
<td>1.0</td>
<td>Pre/post test</td>
</tr>
</tbody>
</table>

In our project we have used the information provided in Table 2 as a guide for the selection of methods with the highest agreement scores as the most suitable ones. These include: case studies, interviews, analysis of narrative diaries, observation and judgment by self and others, and self-report instruments. Table 2 also guided us in avoiding assessment methods considered unsuitable (with the lowest scores), despite our initial intentions to use some of them, e.g. pre/post tests and critical incidents.

Contribution of the project

In this project a framework has been developed with structured activities to support students in online international collaboration in RLs and developing their intercultural capability through induction, practice and reflection on their experiences.

As shown in Figure 8, the framework addresses three general aspects that affect this collaboration:

- discipline knowledge
- enabling technology
- cultural intelligence also referred to as intercultural capability.

For successful collaboration a member of a distributed international engineering team should be highly competent in all three aspects of the framework which can be represented by positioning this member and his/her skills in the centre of the framework. The question is how to encourage and how to facilitate the development of these competences in students.
Framework for development and assessment of ICC

Our framework is based on creating opportunities, followed by induction, inspiration and guidance, practice and reflection. Students are not given prescribed conversations 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 students focusing only on discipline tasks and failing to take a full advantage of the opportunities to learn about other cultures. All our observations come from recorded collaborative sessions between students who volunteered to participate in this project. The recorded sessions included students from Singapore, Sweden and Australia, both from Mawson Lakes and Whyalla campuses of UniSA.

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

1. Remote laboratory NetLab as a collaborative experimentation environment with open access (anyone can create an account and access NetLab and perform experiments free of charge).
2. Supporting the communication environment in the form of a chat window within NetLab itself as well as video communication integrated with NetLab which also supports whiteboarding to enable online 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 online community of practice may facilitate the group activities and their development of ICC. It also includes questions that encourage intercultural curiosity and support the development of the dynamics of group intercultural communication.
4. Instruction sheets with specific discipline tasks including experiments to be performed online in collaboration with students from other countries (cultures).
5. Samples of assessment tasks specific to the assessment of the development of ICC. These include self-reflection questions like:
   a. 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 the other culture that both sides agreed on and statements that you did not agree on.

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

c. Explain mutual alteration of actions, attitudes, and understandings based on interaction with members of another culture (based on adaptational model where adaptation itself is taken as a criterion of competence (Spitzberg & Changnon 2009).

The philosophy of the framework developed is to induct students into a fundamental theoretical background of what intercultural capability is and how it can be developed through a collaborative, discipline specific practice in an online environment within the context of diverse communities. 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 not intended 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.

The contribution of this project is reflected in the developed framework that resulted from implementation of modern concepts of social theory of situated learning within the context of application of new technologies that pave the path towards the education paradigms of the 21st century aiming to prepare students for a globalised international work environment.

The project has also considerably raised awareness of the potential intrinsic in collaborative remote laboratories. It has pioneered notions that international and intercultural collaboration along with the concept of communities of practice are inextricably interwoven in the practice of RLS. As has been observed elsewhere in this report, despite the innate ability of remote laboratories by virtue of spanning over national and cultural boundaries through the use of the Internet, so far there has been little progress in terms of enhancing the collaborative and intercultural aspects of RLS. This is evidenced by the fact that there are but a few RLS worldwide which practice collaborative approaches.

**Project outcomes**

**Students’ experiences**

Opportunity to work on this project gave us exceptional experience and insight in how modern technology can be used to expand the traditional curricula to include teaching new skills that were almost impossible to teach in the past. We enjoyed observing the enthusiasm of students who voluntarily participated in the project and are happy to report their positive perception of the experience.

The analysis of the initial trials discovered that students spend minimal or almost no time learning even basic facts about other cultures. This certainly limits students’ opportunities to broaden their cultural experience and take the full advantage of the international collaboration with students from different countries. This prompted the intervention in the follow-up trials between Australian and Swedish students. The intervention included requirement for students to find out a number of facts about their collaborating partners, their countries, and programmes and courses they
Some of the questions and answers are shown in Table 3.

<table>
<thead>
<tr>
<th>Questions that encourage cultural curiosity</th>
<th>Responses by Australian students</th>
<th>Responses by Swedish students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. What have you learnt about the foreign country from this collaborative exercise?</td>
<td>In Sweden they have polar bears that are dangerous. They like to eat them :) They are 7.5 hours behind us &amp; they have cool accents. They have to learn 3 languages before they leave school &amp; they have an excellent sense of humor.</td>
<td>They have small bears that fall out of trees then they eat em for lunch :) Koala bears sleep for 19 hrs a day. The only time people from Australia isn’t watching out for koalas is when they go shark diving...</td>
</tr>
<tr>
<td>Q2. What have you learned about programs that your colleagues from foreign countries are doing (include differences and similarities)?</td>
<td>They have to learn programming languages too… Lucky b (we swear a lot down here ;)) – MATLAB…….! - can be a very frustrating program to use .D. …</td>
<td>Matlab is a part of the toolbox in the course, for our course we can use it if we have it but its not necessary nice to be a Lucky b :) =&gt; graph is a very good program that gives us a lot (recommend)... Link to the webpage for Graph 4.3 (<a href="http://www.padowan.dk/graph/">http://www.padowan.dk/graph/</a>) the web page is even in English :-).</td>
</tr>
<tr>
<td>Q3. What have you learned about the course that your colleagues from foreign countries are doing (include differences and similarities in structure of the course, theory approach, simulation software used, etc)?</td>
<td>We second that :)</td>
<td>Only familiar with this lab and it seems quite similar in the approach and theoretical prep.</td>
</tr>
<tr>
<td>Q4. What is your perception of foreign partners’ knowledge background (i.e. is it at a similar level as yours, if not, is it higher or lower, or in some area higher and in other lower)?</td>
<td>…although you guys are much better at dealing with graphs than some of us here :)</td>
<td>Impossible to know after a few hours but its like in all courses we all have specialities and it would be better to be prepared for that before the experiment. In that way we could divide the task between us to get the exp more efficient.</td>
</tr>
<tr>
<td>Q5. Comment on cultural and behavioural differences that you have observed.</td>
<td>I haven’t noticed any … other than accents - especially ours (the Australian accent is the worst on the planet I rekn :) We dive with sharks - you eat polar bears :) what’s different :)</td>
<td>we are all human and not that different and its always nice to see that it works :) I quite like your accent its comfortable</td>
</tr>
<tr>
<td>Q6. Do you think that you have enriched your collaborative learning by using different practices and knowledge?</td>
<td>Absolutely but the importance of planning the experiment and prepare the conditions in advance is a critical point. We use the BTH labb… in a way like yours but we have for example a br eadbord that we place components on. Its not java based</td>
<td>Yes - it would have been much more helpful to you guys if you had the NetLab info last week &amp; we had a less laggy way of utilising laboratory environments….if we could have just used NetLab itself instead of ShareApps we all could have participated more in the actual prac. What is the laboratory environment that you guys use and how do you find it?</td>
</tr>
<tr>
<td>Q7. List what you consider as desirable attributes of an international group member.</td>
<td>A GOOD SENSE OF HUMOUR - we had a GREAT time :)</td>
<td>Humour is a tool the best one :) if all are prepared and the experiment are well coordinated in time and what tools we are supposed to use =&gt; well its just a matter of communication skills to get the job done</td>
</tr>
</tbody>
</table>

From the evidence collected, including responses as shown in Table 3, we believe that students gained a valuable international collaboration experience including...
intercultural communication skills, but a lot more can be done to take the full
advantage of this experience.

It is not clear why students do not naturally show more interest in other cultures;
maybe engineering students are too focused on technical issues and feel outside
their comfort zone when involved in cultural interactions. To find answers this would
need a more thorough investigation of this topic. However, this also shows a clear
need to involve students in international collaborative activities to gain confidence in
intercultural communication as their future career may very much benefit from this
experience.

Introducing a set of questions that encourage cultural curiosity helped students
broaden their experience. However, we have realised that we cannot fully control
students' interactions. We have to accept that sometimes it will not be "perfect" and
that we can only encourage students to embark on this activity and provide support
for them to make the experience more successful and enjoyable.

Encouraged by the students’ positive attitude towards this experience and our
perceptions of gaps in students’ skills and the importance of filling in these gaps, our
team is committed to continue this work hoping that it will eventuate in commitment
of more partner universities and the development of high quality materials to support
students’ and lecturers’ activities. We hope to win another teaching and learning
grant to support this work.

We are also committed to keep open access to modern educational environments
such as RL NetLab and to advocate collaboration and sharing resources between
universities as the best way to teach students how to build communities of practice
as a modern working environment that nurtures learning and supports fast progress
of the society.

All materials developed in the course of this project are available to be downloaded
from the project web site. We also intend to continue revising and improving the
materials based on feedback that we will receive in the future through the open
forum also available on the project web site.

**Deliverable outcomes**

The key deliverable is the development of a framework with support material to be
used both by remote laboratory developers and by university educators to support
student learning experience through structured collaborative activities in RLs.

All materials are available on the project web site:

Materials that are available for downloading form the framework and include:

- *Guide for Students*
- open access to UniSA remote laboratory NetLab at [http://netlab.unisa.edu.au/](http://netlab.unisa.edu.au/)
- instructions for using the remote laboratory NetLab and examples of practical exercises
- samples of collaborative tasks/experiments including intercultural activities and assessment tasks.
Dissemination of materials

The dissemination of the project progress and the outcomes has been very active and multifaceted through the engagement of partner institutions, through publications, a web site and through conferences and workshops for national and international audience.

The project team has published 3 book chapters, 6 journals papers and 17 conferences papers, all fully peer refereed. The team has staged 10 ALTC specific workshop/session dissemination events during conferences and meetings in 2009-2011.

Although this project targets the engineering disciplines, the developed framework and the dissemination strategy can serve as a model for implementation in other engineering and non-engineering disciplines.

Links with other ALTC projects

We have been collaborating with two 2010 ALTC project leaders at The University of New South Wales: Professor Brynn Hibbert, School of Chemistry working on project ‘Extending the science curriculum: teaching instrumental science at a distance in a global laboratory using a collaborative electronic laboratory notebook’ and Associate Professor Gangadhara Prusty, School of Mechanical & Manufacturing Engineering and conducting a project on ‘An adaptive e-learning community of practice for mechanics courses in engineering’. We have exchanged project materials and relevant publications. We have also jointly attended the 21st Annual Australasian Association of Engineering Education (AaeE) Conference in Sydney at UTS, 5-8 December 2010.

Representatives of several ALTC projects attended a workshop organised with our contribution during the conference on “LabShare – using Remote Laboratories to share expertise and share resources” on 6 December 2010 and a whole day post-conference workshop on 8 December 2010 on LabShare covering designing, developing and using remote inter-institutional remote laboratories. Both workshops took place at University of Technology, Sydney.

The project is also linked to ALTC project, coordinated by the University Technology Sydney, completed in 2008 with the title: Remotely Accessible Laboratories – Enhancing Learning Outcomes.

Analysis of the critical factors

Factors critical for the success of the approach

The major factor conditioning the success of the intercultural international remote laboratory sharing was the commitment of the international student teams to the online collaboration. By giving the students detailed guidelines of technical and communication nature, and debriefing, the laboratory project outcomes have been greatly improved.

The involvement of all members of the multidisciplinary project team including engineers both from Australia and the international partners from Portugal and Sweden, as well as the intercultural experts was also very crucial to the success of the project.

One of further critical factors required for the project success was a necessity of
Finding and accommodating common or equivalent courses in collaborating institutions and ensuring that academic year and program structures are parallel in those institutions. Difficulties of meeting these conditions in courses on microcontroller programming at UniSA and the University of Porto led us to choose not to proceed with collaborative sessions for these courses.

In the case of collaboration between on-campus UniSA students and those in Singapore doing the same course offshore, the initial plan was to have four collaborating teams: two teams composed of two students from Adelaide and two students from Singapore (2x (2+2)); and two teams with one student from Adelaide and one student from Singapore (2x(1+1)). However, none of the students wanted to work alone with student(s) from another country, so we ended up forming 4 groups of 2+2 students. This appeared to be a critical factor of student participation in collaborative remote experiments.

Factors for scalability and extensibility

From our experience the implementation of the project on large scale is not a simple task. Factors that contribute to this include the reluctance of a large number of students to participate in this activity especially from disciplines like engineering, partially because the benefits are not so obvious and immediate, and partially because of the novelty of the project tasks and lack of confidence in success. There may also be additional reasons, which need to be further investigated.

Also, a significant factor is the time difference between geographically distant regions. In the case of Sweden this amounts to 7.5 hours (daylight saving) and 9.5 hours (standard time). This significantly reduces students' opportunities to meet at a mutually convenient time.

Time difference has been a significant factor even in the case of Singapore, a country in the region. That was mainly due to the specificity of the cohort of students in Singapore who work full time and are available only in the evening after 7pm Singapore time. Adding 2.5 hours (Australian daylight saving) or 3.5 hours (Central Australian Standard time respectively, making it rather late for students in Adelaide, limiting the sessions almost exclusively to weekends.

However, learning and practicing intercultural communication does not have to be limited by collaboration with students from other countries. The majority of concepts that we considered are applicable, and the implementation of our framework is strongly encouraged for the collaboration of local and international students on campus and off campus, although on-campus students may select not to collaborate online as supervised face to face collaboration is a mode preferred by the majority of students. However, this may change in a near future with the current rapid development of communication technologies and students developing skills in using it.

As previously mentioned, the framework can be directly used in engineering disciplines. The materials can be also modified to include different discipline specific tasks and intercultural assessment tasks. In disciplines other than engineering the same concept can be used. The framework can serve as a model for the development of a discipline specific collaborative and intercultural tasks.
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Enriching student learning experiences through international collaboration in remote laboratories


List of publications linked to the project

**Book Chapters**


**Journal Papers**


**Conference Papers**


Posters

Newsletters

* Most of the listed publications can be downloaded from the project web site: http://resource.unisa.edu.au/course/view.php?id=1411.
Melbourne, 31st March 2011

Independent Evaluation Report
on the ALTC Competitive Grant CG8-697 project
“Enriching Student Learning Experience through International Collaboration in Remote Laboratories”

Introduction
I have accepted the task of writing this report as the topic of the project matches well my research expertise and interests. My PhD focused on research into the curriculum development for English and communication studies in engineering and technology courses. I have also published a significant number of papers related to professional communication in engineering and technology education. As an Associate Editor of the two scholarly journals published by the World Institute for Engineering and Technology Education: the Global Journal of Engineering and Technology Education and the World Transactions of Engineering Education (both ERA listed), I am familiar with the publications of the project team. They have also published intensively in journals and conference proceedings of the UNESCO International Centre for Engineering Education (UICCE) at Monash University in Melbourne, with which I have been affiliated since 2006.

The background
Remote laboratories where students experiment on real equipment controlled from any location with the Internet availability, offer unsurpassed flexibility of 24/7 access, also for disadvantaged students, allow for collaboration between team members, either sharing the same computer or being physically relocated. The investment, maintenance and personnel costs are vastly reduced in remote laboratories as compared with ‘real’ or proximal laboratories. By resource sharing between academic and industrial establishments, students (and staff) can have access to unique, expensive and otherwise inaccessible equipment and software. The increasing trend of developing and using remote laboratories in education is clearly visible. The world-wide education, both in developed and developing countries, is greatly benefiting from the developments of remote laboratories. Remote laboratories give an opportunity for collaboration between team members consisting of international students that can contribute to the development of skills required in distributed international professional networks.

The project
Surprisingly there is only a handful of collaborative remote laboratories world-wide, whereas in real laboratories teams of 2-3 students working on the same experiment are a common practice. NetLab – a remote laboratory developed at the University of South Australia (UniSA) and implemented in teaching, is a collaborative experiment environment allowing a team of students controlling, recording and downloading experiment results in Electrical Circuit Theory and Signal and Systems courses. It has been designed from the onset as a collaborative setup; students communicating through a chat window; audio and video means integrated with the GUI. A camera adds to the telepresence in the laboratory, as students sometimes question whether what is on the screen is real or a simulated environment. The project has investigated international collaboration and intercultural issues in online remote laboratory setups, the scenarios never tackled before in the world-wide research.

Evaluation of processes and milestones
I have been provided with the project application and a draft of the final project report, parts 1 and 2. I am satisfied with the project management and processes during its duration. There have been regular meetings of the Project Management
Team, including international members, often using the joint attendance of international conferences which I also attended. The major milestones have been accomplished leading to the development of the framework with structured activities to support students in practising online international collaboration and developing intercultural capability.

**Dissemination**
The dissemination of the project progress and the outcomes has been remarkable. The project team has published 3 book chapters, 6 journals papers, 17 conferences papers, all fully peer refereed. The team has staged 10 ALTC specific workshop/session dissemination events during 2009-2011 conference and meeting calendar. For details refer to the part 2, of the final report.

**Evaluation of project outcomes**
The main outcome of the project –the framework for international collaboration in remote laboratories based on communities of practice has not been developed before. Frameworks for collaboration and development of student intercultural capacity in proximal and online communities of practice are most frequently used in teaching languages and are quite rare in engineering.

Another important outcome of the project is the UniSA remote laboratory NetLab accessible to anyone with the Internet access. NetLab’s open access and its collaborative environment is very unique in existing remote laboratories.

Other project outcomes are resources such as Guide for Students (orientation to collaboration), Guidelines for Experiments including instructions on how to communicate and collaborate, Staff and Student Survey Questionnaires.

**Conclusions and recommendations**
I think that the evaluated ALTC project was very successful and, explored untested territory of student collaboration in international teams working in remote laboratory, and the development of their collaborative and intercultural skills. After initial trials it became obvious that students enjoyed working with their colleagues overseas but they needed training. The project team has developed educational materials to support these activities.

This project raises profound and far-reaching implications for those involved in improvement of engineering education. This is a great example of how technology can support the delivery of tertiary engineering education in providing students (who usually combine their studies with part-time work) with learning opportunities 24/7. Apart from the obvious flexibility, the challenges that the students may experience while completing the group assignments provide them with the real industry insight, considering that the companies increasingly operate on an international level.

The framework and other deliverables are of great value for other educational institutions in engineering and non-engineering disciplines. In fact, the project provides a coherent and detailed set of solutions (presented in various publications) for various stakeholders involved in modernising engineering education for the benefit of students. I personally believe that remote laboratories like NetLab have to become an essential part of learning experience for the engineering students before entering the work force. It will be interesting to see the evaluation of learning outcomes when the framework is implemented and tested on a larger scale.

Dr Elena Danilova
School of Applied Media and Social Sciences Monash University