International collaboration framework for remote laboratories

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ABSTRACT: If not already, in the near future employers of engineering graduates will be regarding international collaborative skills very highly. To enhance graduates' intercultural competence skills and their readiness to work collaboratively in a global international environment, the researchers have conducted a project funded by the Australian Learning and Teaching Council (ALTC) aimed at enriching students' learning experience through international collaboration in remote laboratories. Remote laboratories are chosen as a medium of collaboration because they offer an on-line hands-on laboratory environment where students can access and perform experiments on real equipment via the Internet. Unfortunately, there are not many remote laboratories that offer a collaborative learning environment, which is a drawback of these state-of-the-art technologies for which there is an increasing demand from universities worldwide. In this article, a case study of an international collaboration framework is presented, developed as part of the ALTC project, and which has specific focus on intercultural communication within the context of on-line communities.

INTRODUCTION

In the researchers' previous work [1], the community of practice concept [2][3] was presented as a model of situated learning for the development of international collaborative skills in undergraduate engineering programmes, where students perform experiments jointly with students from other countries. The remote laboratory NetLab developed at the University of South Australia (UniSA) was utilised as a collaborative on-line environment. NetLab allows multiuser interactive synchronous access to real equipment placed at the Mawson Lakes Campus of UniSA in Adelaide, Australia. NetLab is one of the very few remote laboratories where all students, who are logged on, have full control over all equipment [4-6]. The fact that only three from numerous remote laboratories worldwide are collaborative learning environments comes as a surprise because in real laboratories, also referred to as proximal laboratories, students perform experiments in small teams of 2-3 students. Consequently, it is suggested that in future and whenever possible, developers should design remote laboratories as collaborative tools. This will also transform training sessions into collaborative sessions between students, as well as provide an opportunity for lecturers to log on and help students remotely in real time.

As a collaborative on-line laboratory, NetLab gave a unique opportunity to investigate how it can be used for learning international collaborative skills. With globalisation of the world economy, being able to communicate and work with people from other cultures is becoming more important. For some people it seems to come naturally, while others require more training. This is often referred to as intercultural competence, and is becoming very important for engineering graduates with increasing requirements to work as members of internationally distributed teams.

In this project, sponsored by the Australian Learning and Teaching Council (ALTC), the researchers embarked on teaching students international on-line collaboration skills, including intercultural communication skills. This is a life-long learning process, and there is no single moment when someone becomes interculturally competent. Thus, it is certainly not considered that this project is about making students interculturally competent. Rather, it is just a first step in this life-long process of becoming a professional engineer. Students should be aware of the importance of intercultural competence in their future professional career. However, just to be aware is not sufficient, so a framework for teaching intercultural communication skills was developed through experience within the context of on-line collaboration with students from other countries. Building intercultural competence within the set framework is discussed in this article.

INTERCULTURAL COMPETENCE

Intercultural competence (ICC), sometimes referred to as cultural intelligence with an indicator CQ (cultural quotient), an analogue to IQ (intelligence quotient) for general intelligence, is an indication of how good a person is in dealing

with people from different cultures. There are various definitions of culture. For the purpose of this project, the definition was adopted that the *culture of a group is a set of practices, beliefs and values which are accepted relatively unthinkingly by members of the group* [7]. In most cases, when talking about the culture of a person people assume nationality or ethnicity of the person. However, the definition of culture adopted here includes a much broader concept, which emphasises that a person's behaviour is multifaceted and to avoid the risk of stereotyping, caution should be exercised in attribution given to a person's culture, in terms of nationality or ethnicity.

Most literature deals with the teaching of intercultural competence in connection with teaching languages, where students commonly work on tasks dealing with cultural issues through which they also learn a foreign language. In this project's learning, intercultural communication is situated within the teaching of engineering skills. Students acquire intercultural competence while doing what engineers do: setting up equipment, performing experiments, analysing measurement data, comparing them with model simulation results and writing reports. Nevertheless, the language is the most prominent side of the communication; as in this project, voice communication is the main means of communication. Thus, the linguistic theories of intercultural communication are very much applicable in this case. However, the researchers of this study have not focused on learning language but rather on the use of language in a particular situation. This emphasises the social aspect of learning and communication, which prompted the researchers 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 development of the capacity to be flexible in dealing with unfamiliar cultural situations and contexts and to avoid developing stereotypes that commonly arise due to selective attention that makes people notice and reinforce what is *already known*. To develop this capacity, it has been suggested that students are encouraged 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 the others. This can be aided by analysing four aspects of messages as defined by Schulz von Thun ([8], cited in [9]), and represented diagrammatically in Figure 1. The diagram shows that in communication, a message passed from one person to another is much more than just passing factual information. 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).

Using this model for analysis of intercultural communication shows how rich the learning environment can be if students collaborating on-line with students from other countries are open to these issues. This would certainly require preparation for students before engaging in collaborative activities. However, this is a delicate task as pre-conditioning the students may take their attention away from a technical focus. Thus, in this project, the researchers suggest an induction of students for on-line international collaboration that prepares students to establish a balance in their attention between discipline and cultural competencies focus.
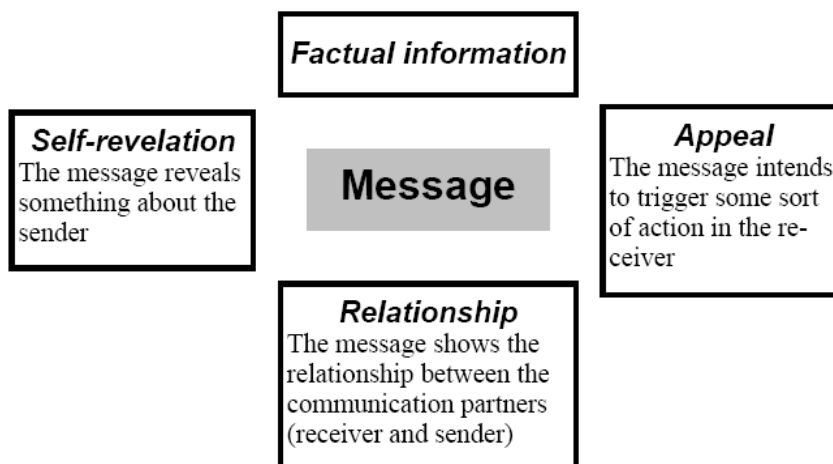

Figure 1: Four sides of a message (source [8], cited in [9]).

Corder and Meyerhof 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* [7]. In this project, students have found themselves in a position to communicate with students from other cultures within a discipline-specific professional environment. Today's technology allows people to communicate with others within a number of social networks synchronously or asynchronously. However, the important aspect of this project is that the intercultural communication is situated within the discipline's specific professional environment. Consequently, the researchers were able to situate students' activities within the concept of the community of practice; and they would certainly like students to collaborate successfully, but as the definition above indicates, cultural similarities and differences may also impede that interaction. The experience is still valuable if students are able to reflect on the observed interactions and develop strategies for improvement in their future interactions. In other words, this means development of skills that will aid

students in developing ICC in a life-long process. Development of these skills and strategies is expected to be the outcome of this project.

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 student intercultural competence. A number of researchers attempted to develop methods for assessment of ICC and showed that adaptability is a key factor in ICC [10][11]. Their research pointed out that methods should take into account the multi-dimensional nature of ICC and that oversimplification should be avoided [12][13].

Spitzberg and Changnon give a comprehensive review and classification of intercultural competence theories and models [14]. In Figure 2 is a model developed by Deardorff, which was adopted in this project with the intention of including it in the support material for preparation of students (student guide) [15]. The model is considered suitable for this project for a number of reasons:

- it includes all three important components in ICC: motivational (requisite attitudes), cognitive (knowledge and comprehension) and behavioural (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* [14];
- 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 assessment of desired external outcomes.

DESIRED EXTERNAL OUTCOME:
Behaving and communicating effectively and appropriately (based on one's intercultural knowledge, skills, and attitudes) to achieve one's goals to some degree

DESIRED INTERNAL OUTCOME:
Informed frame of reference/filter shift:
Adaptability (to different communication styles & behaviors; adjustment to new cultural environments);
Flexibility (selecting and using appropriate communication styles and behaviors; cognitive flexibility);
Ethnorelative view;
Empathy

Knowledge & Comprehension:
Cultural self-awareness;
Deep understanding and knowledge of culture (including contexts, role and impact of culture & others' world views);
Culture-specific information;
Sociolinguistic awareness

Skills:
To listen, observe, and interpret
To analyze, evaluate, and relate

Requisite Attitudes:
Respect (valuing other cultures, cultural diversity)
Openness (to intercultural learning and to people from other cultures, withholding judgment)
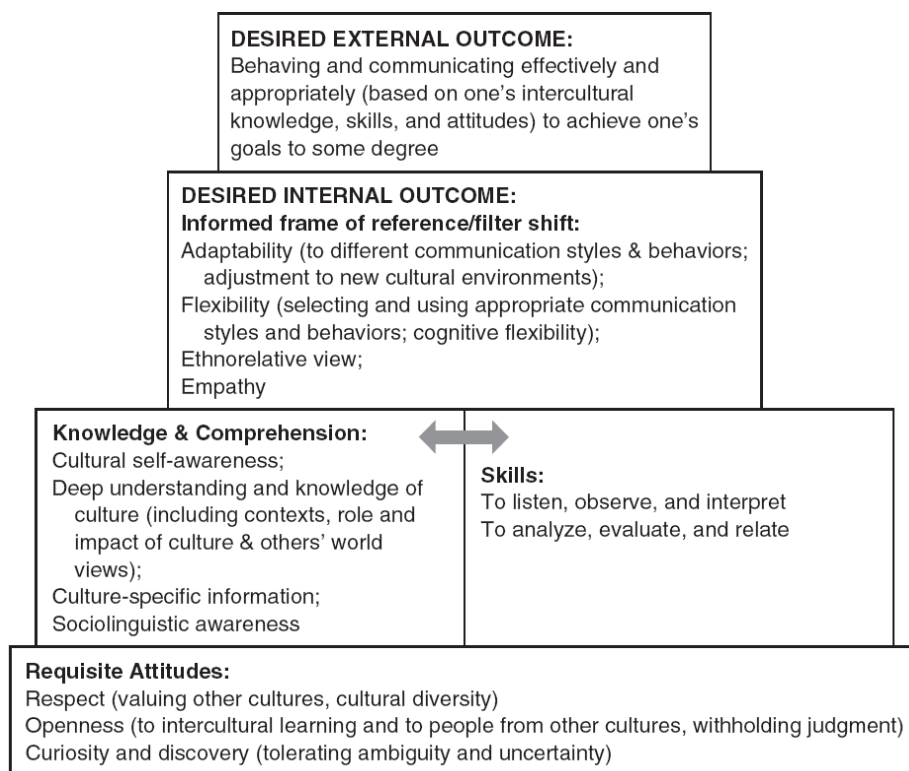Curiosity and discovery (tolerating ambiguity and uncertainty)

Figure 2: Pyramid model of intercultural competence [15].

The pyramid model of intercultural competence shown in Figure 2 and the related process model suggested, are used as a basis for the development of the framework for this project, described in the following section.

ASSESSING DEVELOPMENT OF ICC

If culture and ICC are difficult concepts, assessment of ICC is even more difficult, particularly when implementation is tried 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 internationally distributed engineering teams. 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 suggests a list of important questions to be considered and a template that can be used for planning the ICC assessment activities [16]. In her PhD research, Deardorf investigated appropriate methods for assessment of intercultural competences of graduating students [17]. One of the important outcomes of her investigation is a list of assessment methods that most of the top 20 intercultural experts agree are the most suitable. The list and the statistical data of the survey are shown in Table 1.

Table 1: List of assessment methods and the statistical data of the survey [17].

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

In this project, the researchers have used Table 1 as a guide for the selection of methods with the highest agreement scores, i.e. considered as the most suitable methods by most of the top intercultural experts. These include: case studies, interviews, analysis of narrative diaries, observation and judgment by self and others and self-report instruments. Table 1 also guided the researchers in avoiding assessment methods considered unsuitable (with the lowest scores), despite the initial intentions to use some of them, e.g. pre/post tests and critical incidents.

FRAMEWORK FOR DEVELOPMENT AND ASSESSMENT OF ICC

The framework used by the researchers was based on creating opportunities, followed by induction, inspiration and guidance, practice and reflection. Students are not given a prescribed conversation that would make the whole experience very artificial. Rather, they are given *discipline tasks* to perform collaboratively and a set of questions they need to discuss with students from foreign countries. These questions are introduced in order to encourage students' intercultural curiosity in the context of engineering practice. This was done as an intervention measure after the researchers noticed students focusing only on discipline tasks and failing to take a full advantage of the opportunities to learn about other cultures. All the observations come from recorded collaborative sessions between students who volunteered to participate in this project. The recorded sessions include students from Singapore, Sweden and Australia, both from Mawson Lakes and Whyalla campuses of the UniSA. Details on programmes and courses in which these students were enrolled and the technology used can be found in the researchers' previous publications [18-23].

The framework that the researchers developed for students to develop their ICC includes:

1. Remote laboratory (NetLab) as a collaborative experimentation environment with open access.
2. Supportive communication environment in a form of a chat within NetLab itself and video communication integrated with NetLab that also supports whiteboarding, for drawing as an important communication tool in engineering disciplines.
3. An induction guide that explains to students what ICC is, and how their participation in the context of an on-line community of practice may facilitate the group activities and their development of ICC. It also includes questions that encourage intercultural curiosity and supports development of the dynamics of the group intercultural communication.
4. Experiment instruction sheets with specific discipline tasks including experiments to be performed on-line in collaboration with students from other countries (cultures).
5. Samples of assessment tasks specific to assessment of the development of ICC. These include self-reflection questions, such as:

   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 culture and another 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 an adaptation model where adaptation itself is taken as a criterion of competence [14].

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

CONCLUSIONS

In this article, the researchers discussed some issues and models for the development and assessment of intercultural competencies of engineering students within the framework of international on-line collaboration in remote laboratories.

Derived from the experiments in this study is the fact that students attempt to minimise the divides between cultures, which agrees with findings by Montgomery in [24]. However, this may suppress their attention to differences and jeopardise their opportunities in developing ICC, including intercultural curiosity.

Analysis of recordings of the pilot collaborative sessions showed students practised politeness, which is natural behaviour in establishing and maintaining relationships, including intercultural relationship. However, this may have negative consequences in professional collaborative environments, because politeness often induces a considerable amount of ambiguity, uncertainty and indirectness. On the other hand, caution should be exercised when encouraging directness in communication as it should not appear to encourage people to be rude to each other, and to be more tolerant to directness, but less tolerant to misunderstandings and ambiguity in communication within the professional collaborative environment, when it could have serious consequences to the outcomes of joint international projects.

Consequently, students need to learn to balance clarity and ambiguity, understanding and misunderstanding, directness and indirectness in their communication. They also need to learn to balance their discipline's task focus and intercultural learning focus to maximise their learning opportunities in the development of ICC in the context of professional intercultural collaboration.

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