Observing cultural interactions in engineering design projects

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***Abstract**: The University of Wollongong and partner institutions UTAS, UTS, and QUT have engaged in an ALTC funded project to address issues of intercultural competence in engineering. As a major component of this project, observational research techniques are being employed to assess the current state of intercultural competence in first and second year engineering students. The research described in this paper is a process employed by the authors to observe cultural interactions between students in first or second year design subjects. The process involves simple video recordings of the groups' interactions over the course of a normal project team meeting, which are then coded and analysed using NVivo 8. To identify cultural diversity within the observed groups and perceived intercultural competency, the observation session is followed by a brief survey which incorporates dimensions of self and peer evaluation. This research will be conducted at all four participating institutions over the teaching semesters of 2011. As well as establishing an overview of the current state of intercultural intelligence amongst engineering cohorts, these research outcomes will be used to develop packaged teaching modules for developing intercultural intelligence amongst both engineering students and teaching staff.*

Introduction

As evident in accreditation criteria for engineering programs in many countries including Australia (Australia, 2011, Standards 1.5, 3.2, 3.6) and the US (Commission, 2011, Criteria 3c, 3g, 3h), the need for engineers to have the ability to work effectively in multidisciplinary, multicultural and multinational settings is now widely accepted. Inherent in the various 'multi' scenarios is the need for engineers to recognise, appreciate and value perspectives or priorities that differ from their own. Ang and Van Dyne (2008, pp.3) define cultural competence succinctly as *an individual's capability to function and manage effectively in culturally diverse settings*. A culturally competent engineer should be able to identify the emergence of a differing view or opinion, appreciate that this could influenced by differing cultural and societal norms, and that these views may be strongly held by others and as

equally valid as their own. The competent engineer would then consider the situation, discuss the issues at hand and develop a solution that leads to continued productivity and subsequent success of the project.

Defining levels of intercultural competence, measuring it and creating education that fosters the development of this competence in undergraduate engineering programs is the focus of an ALTC funded project currently under way at UoW and project partners UTAS, UTS and QUT. This paper concerns the development and implementation of an observational research process aimed at establishing a baseline level of competence of undergraduate engineering students. Rather than a simple quantitative and/or qualitative competence level in a traditional sense, the observation process intends to establish a set of behaviours and challenges that commonly appear in the undergraduate engineering education setting to inform the development of educational resources and practices that can help students (and staff) move forward.

Method

The abilities described in the definition of intercultural competence are most readily observed in students working in a group setting. The context of the group work for each subject involved in the research is described later in the paper. The observation process used here incorporates three dimensions: self perception of intercultural competence; peer assessment of group process and external assessment of group process (Figure 1). The process draws on two main frameworks, both adapted to paper based questionnaire format, and is informed by a definition of culture.

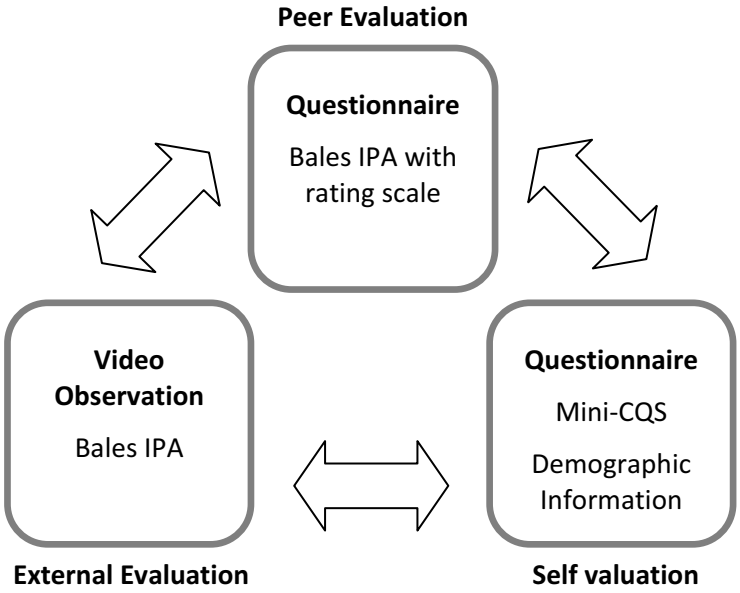

Figure 1 Three components of the observation research measures

Bales (1950) developed an Interaction Process Analysis (IPA) framework for analysing interactions between individuals in a group, or team setting which has been widely applied in group observation research, particularly in multi cultural contexts (Lingham, Richley, & Serlavos, 2009; Nam, Lyons, Hwang, & Kim, 2009; Vallaster, 2005). The IPA framework as used in this study is presented accessibly by Carney (1976, p. 160), see Table 1.

Table 1: Bales Interaction Process Analysis

Interaction type	Demonstrated behaviour
Group maintenance - Positive	1. Shows solidarity: raises other's status, gives help, brings others in, praises 2. Releases tension: eases over difficulties, jokes, laughs, shows satisfaction

	3.	Agrees: accepts, understands, concurs
Task orientation – Positive	1.	Gives ideas: suggests alternatives, outlines options, opens up horizons, non-directive
	2.	Gives evaluations: offers opinions, analyses; expresses feelings, wishes
	3.	Gives direction: clarifies, orients, informs, recalls, confirms, sums up, watches time
Task orientation – Negative	1.	Asks for direction: clarification, orientation, information, repeats of information, summaries, prodigal of time
	2.	Asks for or challenges evaluations: questions analyses, assessments, feelings, opinions, wishes
	3.	Asks for ideas: indicates lacks alternatives, options, direction, possible ways of action
Group maintenance - Negative	1.	Disagrees: silent disagreement, insists on formalities, withholds help
	2.	Contributes to tension: unhelpful, freeloads, shows discomfort, demands help, promotes misunderstanding
	3.	Shows antagonism: imputes motives, judges in value-laden terms, uses irony and sarcasm, plays power games, verbal duelling

Bales IPA has its faults, in particular, the differentiation between positive and negative interactions can be interpreted as showing bias towards some Western cultures at the expense of Eastern cultures. However, the application of this framework to observation of group interactions still provides a useful starting point.

The IPA framework is adapted for peer evaluation in the Templaar (2005) Tutorial Group Evaluation scale, which asks students to rate interaction in their project group. Using a rating scale of 1-7, students rate the common behaviour in their project group from ostensibly negative interactions (one) to positive interactions (seven), based on the behavioural indicators in Table 1.

For self evaluation, a lightly modified cultural intelligence scale (Mini-CQS) (Ang & Van Dyne, 2008) was included on the reverse side of the questionnaire to capture students' experience of, and self rated competence in, dealing with cultural interactions. There are nine items on the Mini-CQS which are rated in terms of agreement with the statement on a scale of 1-7:

1. I frequently interact with people from different cultures
2. I am sure I could deal with the stresses of adjusting to a culture that is new to me
3. I know the cultural values and religious beliefs of other cultures
4. I know the legal and economic systems of other cultures
5. I know the rules (e.g., vocabulary, grammar) of other languages
6. I am conscious of the cultural knowledge I use when interacting with people with different cultural backgrounds
7. I check the accuracy of my cultural knowledge as I interact with people from different cultures
8. I change my verbal behaviour (e.g., accent, tone) when a cross-cultural interaction requires it
9. I change my non-verbal behaviour when a cross-cultural situation requires it

Coupled with this are demographic questions on gender, educational background and the type of area in which the individual grew up, i.e. urban, rural or remote.

The external observation of students' behaviour is conducted using video recordings of project groups working in a tutorial class setting, and in an out-of-class single project group setting. The questionnaire containing self and peer assessment measures is distributed to participants following the video observation session.

In terms of data analysis, the video recordings are analysed using NVivo 8 (a qualitative data analysis tool), with group interactions coded against the Bales IPA. The peer evaluation questionnaire allows

the researchers to create a link between self evaluation and external observation, enabling the triangulation of findings from each of the three dimensions. Individuals' ratings on the Templaar (2005) Tutorial Group Evaluation scale are then compared with observed behaviour to establish the likely reliability of students' self ratings of intercultural competence.

Following this process, the researchers then turn to individual items within the Mini-CQS. These self ratings are compared with each other to identify conflicting statements. For instance, students who indicate they change their verbal behaviour when interacting across cultures, but also indicate they are unfamiliar with the cultural values and religious beliefs of other cultures, may not be changing their behaviour appropriately or consciously. Several items in the Mini-CQS also lend themselves to external validation. Observation of students' interactions within groups where one or more members have English as a second language are be compared against their self ratings of items 5, 8, and 9. Once likely cultural differences within a group are identified, other Mini-CQS items are compared against actual behaviour in the group setting.

Finally when considering cultural issues as a focus of research such as this, it is crucial to distinguish culture from nationality. Matsumoto (2004, p. 276) defines culture as a catch-all term representing influences from multiple sources such as the natural environment, 'sociopolitical factors (e.g. sociocultural history, government and laws, religion, etc.) as well as familial and communal customs, norms, beliefs, opinions and rituals'. The researchers apply this broad frame of reference to the observation of group interactions to avoid assigning responsibility for behaviour and attitudes completely to a cultural group, or to the individual.

Implementation

A pilot study using this process was conducted in a first year subject at the lead institution, Foundations of Engineering. This is a subject which has been running since 2005 and introduces concepts of engineering mechanics through an enquiry based learning approach (Dwight, McCarthy, Carew, & Ferry, 2006). Students are allocated to teams of three to work on a number of engineering research and design tasks. Team selection is based on mixing academic abilities (based on High School Performance, ATAR etc), Engineering Major, gender and domestic/international. The cohort is male dominated (85%) and approximately 75% Australian and 25% international. Both groups that took part in the classroom observation were 100% male and approximately 75% domestic. It should be noted that the domestic cohort is quite ethnically mixed with a range of countries of birth.

The observations were conducted for two tutorial classes and one project group (three members) at the end of the term when the teams of three were required to modify a design they had been working on, taking into account some last minute modifications to the design criteria. Following the revision of their calculations, they constructed a working model and tested it during the class. The 10 or so teams in each tutorial group quickly forgot about the video cameras and became engaged with their task. Questionnaire return rates were close to 100%.

Future repetitions of this observation process are planned for four other subjects across the participating institutions in second semester 2011. The subjects selected for the research cover a broad spectrum of content focus and design project formats.

The first subject, at the Australian Maritime College @UTAS, incorporates a project where students design, build and test an electricity generation system using ocean wave power. This project is undertaken by the first year cohort in the unit Electrical Fundamentals. Additional observations may be made as students design, construct and test an underwater vehicle as part of the second year unit Fluid Mechanics. At this institution, observations will be conducted on small groups working outside class, using the same process applied in Foundations of Engineering in the pilot study.

In the second subject, conducted at UTAS, the researchers will conduct observations of students working in teams as part of Engineering Design and Project Management, a second year unit common to all engineering disciplines that features a major multidisciplinary design and build project. Additional observations may be made of third year engineering students working in teams on laboratory assignments as part of Fluid Mechanics to provide a contextual contrast to the design and management subject.

The third subject, from UoW, will repeat this observation process in a first year design subject that centres around the 2011 EWB Challenge. The point of difference in this subject is that the lecture and tutorial content includes learning activities focused specifically on intercultural competence and its relationship to engineering design. The student cohort undertaking this subject will be largely the same as that of the Foundations of Engineering subject from first semester. Here the researchers will be looking for any clear differences in students approach to group work from the first semester and from the two other subjects outlined above that may be a result of learning activities within the subject.

The final subject, run at UTS, is constructed around an institutional learning model that states that students should be exposed to *Professional practice situated in a global workplace, with international mobility and international and cultural engagement".* Various activities in the Faculty contribute to this exposure and the research will specifically focus on the first subject in the Professional Practice Program. One of the assessment tasks for this subject requires students to research one of the following topics: professional ethics, industrial relations, health and safety or culture and diversity. The aim of this assessment is to enable the students to formulate sensible questions to ask a professional engineer about that topic. Students then interview their chosen professional engineer and report their reflections on any differences between what they though the engineer would say and what they actually did say. The research conducted on this subject will differ from the observation process described above as students work individually. For this subject, analysis of these reports will be conducted in Nvivo 8 to identify evidence of intercultural competence from the reflections of students who selected culture and diversity as their topic of research and questioning. The document analysis will form a counterpoint to the observations of group interaction carried out at the other institutions and provide a small snapshot of perspectives of practising professionals in relation to the issue of culture.

The three subjects selected for the research observations will provide the researchers with data from a range of contexts to create a more broad assessment of students' current levels of intercultural competency. The contrast with written reports from UTS will be used to compare typical issues observed in students' actual behavior with those that students reflect upon when interviewing practicing engineers.

Results and Discussion

Since the focus of this paper is on a research method, this discussion will focus on the outcomes of the method in terms of the analysis of the gathered data.

External evaluation v. peer evaluation: Preliminary results from the pilot study indicate an interesting contrast between students' perceptions of group process, and observed group interactions. Students rating of their team process on the Templaar Tutorial Group Evaluation scale are almost universally strongly positive, ranging between group averages of 5.3 and 6.2 (maximum positive rating is 7) for all six items on the scale. However, initial review of the video observations show several incidents of strongly negative group interaction. Assuming the students peer evaluations recorded on the survey are accurate, this could indicate that the single, one hour observation is not capturing the normal working relationship between the students. However, assuming the observational period is representative of how the group operates; the research process may have identified self reflection and social metacognition (Jost, Kruglanski, & Nelson, 1998) as potential barriers to advancing competency in intercultural and even monocultural interactions. Further analysis is needed to determine whether this is the case and how others have dealt with it in education previously.

Self evaluation: The miniCQS results show statistically significant positive correlations between all individual scale items (Pearson correlations ranging from 0.360 to 0.846, significant at the 0.01 level), covering a wide range of scale responses (unlike the Templaar scale). This internal consistency, along with the range of responses indicates that students self perceptions of their preparedness to work across cultures can differ greatly. Further analysis of individual items and their relationship to each other is still to be carried out, but the absence of any negative or statistically insignificant correlations indicates that the miniCQS is understood by students and there are no major misinterpretations of

individual questions. It is apparent that the the miniCQS is potentially an effective tool for monitoring changes in self perception of intercultural competence if administered as a pre/post intervention evaluation mechanism. This will be explored in detail as the miniCQS is currently being administered to the same cohort of UoW students after the EWB challenge in second semester 2011.

Self evaluation v peer and external evaluation: The usefulness of the miniCQS data in relation to the Bales' IPA based scales, both in peer and external observation format is also yet to be determined. Analysing the behavior of those who tended to rate themselves low on the miniCQS compared to those who rated high may provide insight on the reasons for students' self assessment of their ability to work interculturally.

External evaluation: The definition of culture used here poses some challenges. It has been difficult to establish whether negative or positive interactions have anything at all to do with fundamental cultural differences. Present in the group situation are language barriers, differences in academic goals, and even personality traits which can not necessarily be categorized as having a particular cultural derivation. As culture defines common traits of a collective, from which individuals may deviate, making judgements on the cultural background of an individual is problematic. There is a real risk that when considering individuals, making judgments informed by a cultural norm is simply a form of stereotyping. For the purposes of this observational research, the authors argue that distinguishing different cultures within a group is less important than understanding how students respond to and manage differing views and opinions, whether they are a product of cultural differences or not. From this point of view, Bales' IPA is an appropriate and well recognized tool for analyzing this type of group interactions. Full results of this work when completed will be reported to the engineering education community over 2012-13.

Conclusion

In this paper the authors have presented the design, implementation, and reflections of a research process that combines video observations with a multi dimensional paper based questionnaire. The process has proved to be effective in collecting data to develop a picture of the current state of intercultural competency in engineering. Some interesting challenges have arisen, particularly around the usefulness of defining cultural differences when observing group interactions. Further analysis of this data will be used to identify the issues to be addressed in the development of educational practices and materials aimed at improving students' ability to take into account potential differences in the cultural backgrounds of those they are working with. The authors invite those interested to become involved in the project and share the educational resources that will be produced from this research.

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