Intercultural competence in engineering education: who are we teaching?

Goldfinch, Thomas[a]; Abuodha, Pamela[a]; Hampton, Greg[a]; Hill, Frances[b]; Dawes, Les[c]; Thomas, Giles[d]
University of Wollongong[a], University of Manchester[b], Queensland University of Technology[c], University of Tasmania[d]
Corresponding Author Email: tom_goldfinch@uow.edu.au

BACKGROUND

There is little doubt that our engineering graduates' ability to identify cultural differences and their potential to impact on engineering projects, and to work effectively with these differences is of key importance in the modern engineering practice. Within engineering degree programs themselves there is also a significant need to recognise the impact of changing student and staff profiles on what happens in the classroom. The research described in this paper forms part of a larger project exploring issues of intercultural competence in engineering.

PURPOSE

This paper presents an observational and survey study of undergraduate and postgraduate engineering students from four institutions working in groups on tasks with a purely technical focus, or with a cultural and humanitarian element. The study sought to explore how students rate their own intercultural competence and team process and whether any differences exist depending on the nature of the task they are working on. The study also investigated whether any differences were evident between groups of first year, second year and postgraduate students.

DESIGN/METHOD

The study used the miniCQS survey instrument (Ang & Van Dyne, 2008) and a Bales Interaction Process Analysis based scale (Bales, 1950; Carney, 1976) to collect students self ratings of group process, task management, and cultural experience and behaviour. The Bales IPA was also used for coding video observations of students working in groups. Survey data were used to form descriptive variables to compare outcomes across the different tasks and contexts. Observations analysed in Nvivo were used to provide commentary and additional detail on the quantitative data.

RESULTS

The results of the survey indicated consistent mean scores on each survey item for each group of students, despite vastly different tasks, student backgrounds and educational contexts. Some small, statistically significant mean differences existed, offering some basic insights into how task and student group composition could affect self ratings. Overall though, the results suggest minimal shift in how students view group function and their intercultural experience, irrespective of differing educational experience.

CONCLUSIONS

The survey results indicate that either students are not translating their experience in the group tasks into critical self assessment of their cultural competence and teamwork, or that they become more critical of team performance and cultural competence as their competence in these areas grows, so their ratings remain consistent. Both outcomes indicate that students need more intensive guidance to build their critical self and peer assessment skills in these areas irrespective of their year level of study.

KEYWORDS

Teamwork, self assessment, intercultural competence

Introduction

There is little doubt that our engineering graduates ability to identify cultural differences and their potential to impact on engineering projects, and to work effectively with these differences is of key importance in modern engineering practice (Engineers Australia, 1996; Bradley, 2006). Within engineering degree programs themselves there is also a significant need to recognise the impact of changing student and staff profiles on what happens in the classroom (King, 2008, p.34).

The ever expanding uptake of programs such as the Engineers Without Borders (EWB) Challenge in undergraduate education is evidence of engineering academics' appreciation of these new dimensions of engineering education. The research question is, *when it comes to educating students on intercultural issues in engineering, what, or who are we as engineering educators working with?*

We sought answers to this question through the use of an observational study and paper-based survey that explored how students assess their own knowledge and experience of other cultures and what these look like in practice. The research described in the current paper forms one component of an Office for Learning and Teaching (OLT, formerly ALTC) funded project exploring intercultural competency in engineering. In developing strategies and resources for addressing intercultural competency in engineering, we needed to understand more about where the students are at in terms of their knowledge and experience of different cultures. We also sought to understand more about how the makeup of the student cohort and the nature of the tasks they are working on in class might impact on this. It was intended that from this point, we could develop competency targets for graduates, and develop learning resources to guide students towards these.

Method

The thinking behind the research method used here has been published elsewhere (Goldfinch & Layton, 2011), but for ease of reading they are described here in brief.

The study used a paper-based survey to collect students self ratings of group process, task management, and cultural experience and behaviour, and video observations of self selected groups to identify any points of interest for further insight on the survey. The questionnaire was based on the miniCQS instrument (Ang & Van Dyne, 2008) for cultural experience and behaviour and Bales' Interaction Process Analysis based scale (Bales, 1950; Carney, 1976) for group interactions.

When looking for a survey instrument relating to intercultural competencies, the Authors considered several options but settled on the miniCQS as a simple instrument that focussed on intercultural experience and behaviour. A number of other scales utilised indicators of 'positive' intercultural interactions, and we had concerns these would lend themselves to participant responses that may be indicating what they see as the 'correct' answer, rather than an honest response. It was believed the focus of the miniCQS on simple statements of personal experience and knowledge would encourage more genuine participant responses.

Bales' interaction process analysis (IPA) is a popular methodology for coding "the function (as opposed to the topical content) of communication during group discussion" (Keyton, 1997, P.240, in Nam et al, 2009). The framework has been widely applied in group observation research, particularly in multi cultural contexts (Lingham, Richley, & Serlavos, 2009; Nam, Lyons, Hwang, & Kim, 2009; Vallaster, 2005) and was a useful starting point for this research.

On both scales, students were asked to rate themselves (miniCQS) and their group (Bales IPA) from 1 to 7. The questionnaire is described in detail in (insert after blind review).

Video observations were conducted with student groups working on tasks set as part of the normal course content. The aim was to observe students working as they normally would without providing additional stimulus or an artificial focus for the students.

Both the survey and observations were conducted at four different institutions with student groups working on quite different tasks. The points below provide a general overview of the makeup of the class for context:

- First year undergraduates at the University of Wollongong (UoW): This cohort was predominantly domestic school leavers with approximately 16% international student enrolments. The survey and observation sessions were conducted in Autumn and Spring semesters with largely the same cohort. In Autumn semester students were given a technical design task focussing on flow properties and projectile motion, the task also had a strong underpinning teamwork component. In Spring session the groups focus was on their EWB Challenge design. The survey was conducted in tutorial classes, and observations were conducted on self selecting participants – student groups working on projects outside normal class times, in a self directed manner.

- Second year undergraduates at the Australian Maritime College (AMC), University of Tasmania: The survey and observations were carried out in semester 2 on students studying in the second year unit Fluid Mechanics. This cohort was a mix of Tasmanian (18%), Mainland (60%) and International (22%) students. The technical task in the unit which this work focussed on was the design, build and testing of an underwater vehicle, which was an activity undertaken in teams. These students were observed in a meeting to review their performance on the project over semester. Again, the students were self directed.

- First year undergraduates at the Queensland University of Technology (QUT): This cohort was predominantly domestic school leavers with approximately 15% international student enrolment. The survey and observation sessions were conducted in Autumn semester where the groups focus was on the EWB Challenge design. These students were observed in class working on an activity developed as part of ALTC project to identify differences in engineering requirements across a range of cultures and explain the impact of such requirements on cultural issues and society. Again, the students were self directed.

- Postgraduate students at the University of Manchester, UK (UoM): These students were all international, working on a Management of Projects MSc within the Engineering Faculty. A variety of first degrees were represented, including various engineering disciplines, architecture, events management. A number of the students were completing a MSc in Project management, within the Business School rather than engineering. For the observation sessions, the students were focused on tutorial activities developing groundwork for humanitarian aid projects in Northern Ghana and Haiti. For these observations, the students were working in class time, with occasional intervention from the tutor to keep them on task.

Bales' IPA was used for coding video observations of students working in groups in QSR Nvivo 8 (Nvivo 9 at the University of Manchester). Observations analysed in Nvivo were used to provide commentary and additional detail on the quantitative data. Coding involved identifying and highlighting instances of positive or negative group process and task management, as described by Bales (1950), and Carney (1976). This coding process produced summaries of the percentage of the observation session (by time) for which a particular type of event occurred such as "creating tension by being unhelpful", or summarising a count of the number of times particular events occurred. This allowed us to produce an overall picture of what happened in each group's session in terms of how the students interacted.

Results

The Survey

The survey results for the miniCQS scale revealed that, on a scale of 1 to 7, one being low cultural knowledge/experience and 7 being high, the mean results were in the range 3-5 for most of the nine scale items with most data points clustered around this range. There was a general trend towards students from AMC and Manchester rating more confidently on the miniCQS scale than the first year students at UoW and QUT, with some statistically significant mean differences to confirm this.

A Multivariate Analysis of Variance was conducted on the scales for the mini CQS and the scales representing the self-assessment of the Bales IPA with the student group (or cohort) as the independent variable. A significant multivariate effect was detected due to student group (Wilks =.74, $F_{(60, 1243)} = 1.69$, $p < .01$). Univariate Analysis of Variance indicated that this effect pertained to the scale "I frequently interact with people from different cultures" ($F_{(4, 332)} = 3.39$, $p < .01$); for the scale "I know the legal and economic systems" ($F_{(4, 332)} = 2.60$, $p < .03$); and for the scale "I know the rules (e.g., vocabulary, grammar) of other languages" ($F_{(4, 332)} = 3.95$, $p < .004$). For the self ratings of the Bales IPA the significant effect pertained to group process – opting out or assisting one another ($F_{(4, 332)} = 5.01$, $p < .001$) and group process – creating tension by being unhelpful or friendly, easing over difficulties ($F_{(4, 332)} = 5.55$, $p < .001$). Significant multiple comparisons of means are as follows:

For student ratings of "I frequently interact with people from different cultures",

- AMC students ($M = 5.76$, SD$= .23$) agreed more ($t = 3.12$, $p < .025$) with this statement than QUT students ($M = 4.57$, SD $= .30$);
- AMC students ($M = 5.76$, SD$= .23$) agreed more ($t = 2.49$, $p < .025$) with this statement than UoW students ($M = 4.98$, SD$= .21$).

For student ratings of "I know the legal and economic systems",

- UoM students ($M = 4.53$, SD$= .23$) agreed more ($t = 2.11$, $p < .08$) with this statement than QUT students ($M = 3.73$, SD$=.28$).

For student ratings of "I know the rules (e.g., vocabulary, grammar) of other languages",

- UoM students ($M = 4.23$, SD$=.29$) agreed more ($t = 2.69$, $p < .02$) with this statement than QUT students ($M = 3.07$, SD$=.32$);
- UoM students ($M = 4.23$, SD$=.29$) agreed more ($t = 3.18$, $p < .01$) with this statement than UoW students ($M = 3.22$, SD$=.29$).

These results are in line with what could be reasonably expected, that the students at UoM who have had more experience working with people of different nationalities rated themselves higher on the miniCQS. The same could also be true for the AMC students, where the campus has a very high proportion of international students and staff. However, despite their more diverse life experience, students at the University of Manchester still tended to rate their own competence conservatively. This issue is far more pronounced for the first year undergraduate students at UoW and QUT, where high ratings on any given scale item were rare.

On the Bales IPA scale, means for participant groups from each institution were almost identical. In contrast to the miniCQS scale, students rated the performance of their group much more confidently with mean ratings in each of the 6 scale items in the 5-6 range, 7 being the most positive elements of group process and productive elements of task management. Given the consistency in ratings between sample groups, there were less statistically significant differences evident:

For student ratings of "group process – opting out (1) or assisting one another (7)",

- UoW students (M = 6.02, SD=.07) rated themselves as assisting one another more (t = 4.28, p< .01) than AMC students (M = 5.35, SD=.17).

For student ratings of "group process –creating tension by being unhelpful (1) or friendly, easing over difficulties (7)",

- UoW students (M = 5.94, SD=.13) rated themselves as being more friendly (t = 3.82, p< .01) than AMC Students (M = 5.04, SD=.17).

Although it is difficult to draw specific conclusions on these differences, it looks as though the student groups from AMC were judging their teammates more harshly. This could also be an artefact of when the survey was conducted. At AMC it was at the conclusion of a semester-long group project, while all other groups were in the middle-to-later stages of their group project.

Overall though, despite the differences in group composition and size, task focus, and year level, students self ratings of group process and task management were remarkably similar.

Video observations

In total, six small group observations have been analysed so far, two each from UoW, AMC, and Manchester. In observing the students working together, we found it impossible to identify any differences in culture other than to link culture with nationality. This is something we are trying to avoid, but even on this basis there was no clear evidence of any culture clashes in any of the groups. In addition, since culture is normally applied as a collective term, it will inevitably be difficult to observe cultural traits in individuals working in mixed groups. For these reasons, we opted to focus the video analysis only on the Bales IPA framework with the intention of identifying any particular challenges students face working in groups on a variety of different tasks.

This analysis was conducted in QSR Nvivo 8 (UoW and AMC groups) and QSR Nvivo 9 (UoM groups). Because of compatibility issues between the two versions of Nvivo, it has not been possible to conduct a multiple reviewer analysis of each video thus far. Further complicating the analysis of results, the groups at UoM were analysed by a different researcher to the groups at UoW and AMC. Thus it is difficult to make inferences on differences observed and recorded between AMC/UoW and UoM groups. Figures 1 below shows a summary of the coding results for all six groups. On the whole, all six groups appeared to be working well together, although their productivity (task management) on set tasks varied according the reviewers. The figure clearly illustrates that the proportion of time coded for the UoM groups is skewed towards task management (TM+ & TM-), while the UoW and AMC coding is focused more on group process (GP+ & GP-). Looking at the task for each group, UoM students were focused on an in class activity that required an outcome by the end of class, while the other four group were observed in out of class project meetings and self directed. This could indicate that the groups at UoM were more task oriented and productive than the other groups, given the nature of the task that was set. However, without comparative coding from different reviewers, it is not possible to say this definitively.
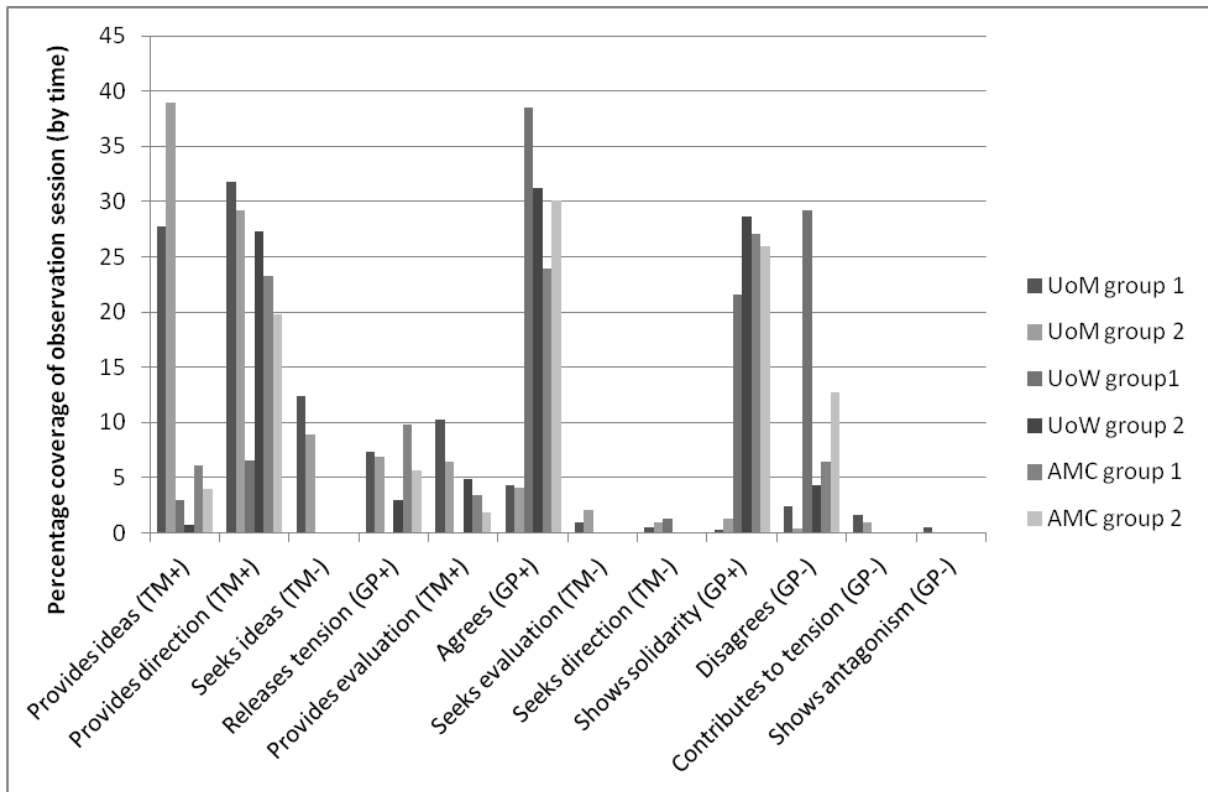
Figure 1 Bales IPA Coding results for six groups.

Discussion

There are some interesting points to be drawn from this research. Firstly, for students to develop an awareness of their own level of intercultural competency, the results suggest interaction with other students from different backgrounds is helpful. We have shown here that student groups who are less likely to have experienced a diverse range of cultures, first year undergraduates, rate their own competence conservatively (3-5), if not negatively (<3). Although students may be uncertain as to how to rate their own level of experience and knowledge of other cultures, the self ratings and observations against the bales IPA framework are encouraging. Students generally report a positive view of groupwork, a view supported by our observations. Keeping in mind some remaining uncertainty around the analysis of the observations, the results of this also indicate that students are also more positively task focused when working in class with a firm deadline, as was the case for UoM students.

In response to our initial question: when it comes to educating students on intercultural issues in engineering, what, or who are we as engineering educators working with? This research suggests that in the case of undergraduates, we are dealing with people who may or may not have a high level of intercultural competency, but are not likely to be critically aware of what they do and don't know about working with different cultures. In the case of more diverse groups, particularly at postgraduate level, these students have had greater opportunity to progress in their awareness of different cultures and their self reported competence suggests they are aware of this.

This is helpful because it highlights some challenges and opportunities in our efforts to improve students' intercultural competence. The biggest challenge will be improving students' critical self awareness of what they know about other cultures and their ability to identify cultural differences. This will involve far more than a content driven approach to learning about intercultural competence.

An opportunity evident from this research is that students can develop this knowledge and ability through frequent and meaningful interaction with people from different backgrounds. Deardorff (2011) makes a case for well supported overseas placements as an ideal context for students to develop their intercultural competence, but that this can also be facilitated with on campus education. So while increasing rates of study abroad participation (in-bound and outbound) are desirable, there is also the option to make the most of increasing international enrolments and the diversifying engineering academic staff profile.

Students' reported level of optimism about group work in this study creates another opportunity for doing this through well supported group projects such as the EWB challenge, and in class simulations.

In terms of the research process used here, there are a number of limitations that need to be addressed to improve the reliability of the data and the insight it provides us with in students' intercultural competency. One key drawback has been the task focus. Observing students working on pre-existing projects that have a low or zero level of difficulty in regards to intercultural issues in engineering has limited the insights we have been able to draw on students' ability to deal with these issues. Observing different groups working on different tasks also creates limitations on the comparability of results. In running observation sessions in the future, we would like to observe groups twice working on different tasks, one technical, one with a challenging intercultural focus. This will enable us to create a baseline for how well the group works together on a familiar technical challenge to compare with any group interaction issues that surface when challenged by a complex human oriented task.

We would also like to use the miniCQS scale differently. At present, it only represents a snapshot of how students rate their own competence. This does not take into account how different people may interpret the scale items. It would be useful to use the scale in a pre/post test format, with students completing the questionnaire once, participating in a learning activity where students discuss and clarify the meaning of the scale items, then repeat the questionnaire to identify any different ratings. From here it would be possible to draw more definite conclusions about students' self assessments.

Conclusion

Improving engineering student cultural awareness and subsequent intercultural competence is an issue of ongoing importance, not only for their professional success, but for the people whose lives are impacted by engineering projects in the future. The survey results, contrasted with group observations, indicate that either students are not translating their experience (in the group tasks) into critical self assessment of their cultural competence and teamwork, or that they become more critical of team performance and cultural competence as their competence in these areas grows, so their ratings remain consistent. In trying to capture and analyse this data on students' levels of intercultural competency, we have identified several ways to improve the rigour of the research and validity of outcomes. These will be employed in future research in the area.

Outcomes thus far suggest that students need more intensive guidance to build their critical self and peer assessment skills in these areas irrespective of what year level of their course. This needs to be coupled with more effective strategies for measuring and monitoring students' development of these skills. In a companion paper (Goldfinch, Leigh, Gardner, Dawes, & McCarthy, 2012) we propose some strategies and learning resources for achieving this that aim to simulate the intercultural experience and consideration that this research suggests will benefit students. While this work continues, we invite the engineering education community to provide comment, share strategies, or become involved in this work to increase the profile of intercultural competency as a key learning outcome of engineering degree programs.

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