Strategies for promoting cultural diversity within student laboratory groups in an engineering degree course at an Australian university

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STRUCTURED ABSTRACT

CONTEXT
Engineering graduates (Stage 1 Professional Engineers) must be able to demonstrate effective team membership and team leadership. Australasian engineering degrees include this competency as a course learning outcome. Students work in small groups in laboratory sessions, design classes or for oral presentations to gain this competency. Students tend to form groups with little cultural diversity if allowed to self-select. Mandating cultural diversity within groups is resisted by domestic students. A further issue is individual assessment within groups.

PURPOSE
What strategies are effective in promoting cultural diversity within groups of engineering students?

APPROACH
Ethics approval will be sought to conduct semi-structured interviews with a culturally diverse selection of students and teaching staff. Qualitative data will be analysed (with NVIVO) on students' and staff experience with group work.

RESULTS
Analysis of the structured interviews is expected to provide an insight into the factors limiting the effectiveness of group-work to deliver the required team-work competencies. Acceptable methods for group formation and individual assessment within groups may emerge. Strategies which assure harmony within culturally diverse groups will be sought. These strategies will be presented to a workshop at AAEE2018.

CONCLUSIONS
The structured interview results, together with the literature review, will inform further research leading to the identification of effective strategies to promote cultural diversity within groups.

KEYWORDS
Group-work; Cultural diversity; Engineering graduate competency.

Introduction

It is mandatory for engineering graduates (Stage 1 Professional Engineers) to demonstrate effective team membership and team leadership (Engineers Australia, 2011). Therefore, Australasian engineering degrees are typically organised to incorporate this competency as part of course learning-outcomes. Instructional activities are developed for students to achieve this competency, for example laboratory and design studio sessions, with group reports and presentations typically used to assess the level of competency attained.

Many studies, meanwhile, have shown that culturally diverse groups are more creative and better at problem solving (Zhou & Shi, 2015); besides, it is one of the requirements of a graduate engineer that he or she is an effective team member and "Functions as an effective member or leader of diverse engineering teams, including those with multi-level, multi-disciplinary and multi-cultural dimensions." (Engineers Australia, 2011, p6). In the context of Australasian engineering degrees, cultural diversity manifests primarily via a student body which consists of both a large domestic cohort and a large international cohort. Thus, there is usually ample opportunity for cultural diversity within teams, particularly during laboratory activities. Unfortunately, however, students tend to form groups with little cultural diversity if allowed to self-select. That is, groups mostly consist only of domestic students or only of international students. Indeed, domestic students have on occasions been observed to actively resist lecturers' attempts to mandate cultural diversity within groups (Henderson, A., personal communication, 10 December 2017).

What usually happens, when self-selection for group formation is followed, is that students form groups with their friends. Generally, this method facilitates harmony between group members, but the various advantages afforded by cultural diversity are then largely foregone. The most common alternative is some means of random selection, which increases the likelihood of cultural diversity within groups, but which may potentially do so at the expense of harmonious team-work.

The aim and challenge for this research is to develop a group formation process which assures cultural diversity while also realising effective team membership harmony. Overall group performance should also be "maximized".

Literature Review

Group work

The benefits of group work are well documented: creativity, cross-cultural sharing, communication, critical thinking, leadership skills, collaborative learning. When students work together in groups they have the opportunity to collaborate, communicate, and explore concepts at a deeper level, resulting in greater understanding and retention than the conventional method of lecturers' delivery of content to a whole class mode. Group work has the potential to improve project quality and performance (Dillenbourg, 1999; Davis, 2009). Macgregor, Cooper, Smith & Robinson (2000) articulated that small group learning in large classes promoted cognitive collaboration; enhanced critical thinking; provided feedback; promoted social and emotional development; appreciated diversity; and reduced the student attrition rate.

The focus of much of the published research on group work and selection has been to maximise the overall effectiveness of teams selected from a given cohort. The reality, for engineering laboratory and project groups, is that some groups will out-perform others. At UTAS there was a significant difference in the quality of final year project reports from self-selected homogeneous domestic and international groups (León de la Barra, B., personal communication, 22 June 2018). Other co-investigators have trialled assigning students to laboratory groups to provide a mix of domestic and international students (Henderson, A., personal communication, 10 December 2017). There have been reported complaints from domestic students that having international students in their group resulted in a lower mark than if international students had not been involved (Lyden, S., personal communication, 22 June 2018).

Cultural diversity

Cultural diversity is usually defined as a 'variety of cultural and ethnic groups'. Arkoudis, Watty, Baik, Yu, Borland, Chang, Lang, Lang & Pearce (2010) commented on the lack of interaction between domestic and international students studying in Australia. They developed 'The Interaction for Learning Framework' to inform ways to enhance interaction between diverse student groups. Colvin, Volet and

Fozda (2014) also articulated that meaningful interactions between students from different cultural backgrounds in Australia are limited. Cruickshank, Chen & Warren (2012) explore the use of group work strategies to increase student interaction and learning.

Cox and Blake (1991) were interested in cultural diversity but as a competitive advantage in organisations; they concluded that cultural diversity enhanced creativity, problem solving and flexible adaptation to change. These findings were confirmed for student groups by McLeod, Lobel and Cox (1996) in a problem-solving exercise at a mid-western US university (N=135). Su and Harrison (2016), in a qualitative study of 20 international students from six countries at Ohio University reported high student numbers from one country impeded their integration. Another US study (N=850) reported very minimal contact between Asian Americans and other cultural groups (Halualani, Chitgopekar, Morrison & Dodge, 2004).

Students' own views on cultural mix have been examined. Summers & Volet (2008) surveyed 233 students in culturally mixed group-work business study projects at Murdoch University. They reported students' attitudes to culturally mixed group work did not change significantly from the beginning to the end of the project, although afterwards they were not inclined to seek another mixed-work project. Goldfinch, Layton and McCarthy (2010) developed learning activities to engender cultural awareness.

Group formation

Bacon, Stewart and Anderson (2001) reviewed methods of assigning players to teams. They cited Decker's (1995) report that a study of 40 instructors in business schools found 52% used self-selection into groups, 18% were teacher assigned, 10% were randomly assigned and other methods were used for the remaining 20%. Researchers, such as Millhiser, Cohen & Solow (2011) and Dias & Borges (2017), have developed computer-based simulations to investigate strategies for forming culturally diverse teams.

Lu, Chin, Yao, Xu & Xiao (2010) probed students' opinions (N = 1000) from five Australian universities on learning methods, language and culture-based teaching, and learning concepts. Examples of questions explored were: Do international students have the confidence to take part in asking questions as well as in-class discussion? Do students prefer working with others from the same cultural background in assignments? But these questions did not address the issue of group formation. Liu, Joy and Griffiths (2013) explored group formation through similar and diverse learning styles of their students. Findings indicated more meaningful interactions, and less negative social emotional reactions in showing disagreements as compared to similar learning styles group.

Hussein, Mohammed, Hasan, & Murtuza (2017) proposed a framework for forming groups for engineering project work based on group formation taking onto account personality type, gender, and other demographic information. The framework sought to maximise team effectiveness, product quality, team member satisfaction and personal skills whilst limiting team member frustration. Hübsher (2010) proposed and tested an algorithmic method of assigning students to groups using a search algorithm to ensure diversity while in addition providing for context-specific criteria. Other criteria for group formation are learning styles (Kyprianidou, Demetriadis, Tsiatsos & Pombortsis, 2012), and maximising diversity while minimising differences (Baker & Powell, 2002). The contribution of group formation choices on academic performance was studied by Seethamraju & Borman (2009) at Sydney University applied to business studies. Their study concluded that whilst group formation influences students' ultimate academic performance the operation of the group is also important.

Research questions

The research questions to be probed, through a series of semi-structured interviews, are:
1. What strategies are most effective for forming culturally diverse engineering laboratory and project groups?
2. What factors in group-formation assure harmony within culturally diverse groups?

Methodology

The methodological approach for this study focuses on qualitative research design. Data collection was achieved via semi-structured interviews with both teaching staff and students, conducted one-on-one by the first author on the University of Tasmania's Sandy Bay campus, between 20 July and 1 August 2018. Each interview was recorded on an iPhone 7. Each (de-identified) interview recording was subsequently transferred to the 'Listen N Write' software on a secure personal computer. The interviews

were transcribed and emailed to the interviewee for member checking then imported to the NVIVO software for coding and analysis. The data was kept secure at all times.

Participants

Participants comprised three cohorts: teaching staff and tutors; domestic students; and international students. Each cohort consisted of a diverse range of nationality, ethnicity and inter-cultural experience. Participants were recruited through advertisement placed in strategic locations for a one-month period in the University of Tasmania's School of Engineering building. The advertisement included a summary of the aims of the research and the names of the researchers. All respondents who agreed to participate in the interview were sent an invitation sheet, consent form, and the list of semi-structured interview questions. The possibility of a skewed sample through this recruitment process cannot be discounted.

Semi-structured interviews

The questions put to student interviewees in semi-structured interviews were:
1. *What is your understanding of cultural diversity?*
2. *Do you think it is important for laboratory and design groups to be culturally diverse? Why?*
3. *Is a culturally diverse group an advantage or disadvantage?*
4. *Do you have an opinion on how students should be allocated to a group?*
5. *How often and where do you interact with other group members?*
6. *Some students will contribute more than others in a group – is this an issue?*

The questions 1,2 and 3 were also put to the teaching staff but questions 4, 5 and 6 were changed to:
4. *What are the important criteria in the selection of members in laboratory and design groups?*
5. *How are laboratory and/or design groups formed in your classes at present?*
6. *Can you suggest a better method of forming groups to assure cultural diversity?*

Analysis

The protocol for the proposed in-depth NVIVO analysis of the interview responses followed the methodology of Bazeley & Jackson, 2013. All co-investigators read the photocopied transcripts to highlight the important themes and categories of the de-identified corrected transcripts. Nodes were created in NVIVO according to the concepts and identified themes in the semi-structured interviews. This is the first level of interpretation (open coding) where each component code is reviewed independently, creating a re-contextualized perspective on each concept or topic as all the coded text relating to it are brought together. Open coding was followed by axial coding using the constant comparative method which is the process of finding similarities and differences, making connections between codes and data segments. Questions of the text (such as: who, what, why, how, how much, how long, what for, what if or with what results) were asked. Selective coding followed. This is a refinement process for all the categories and involved deliberately selecting specific data segments to fit into a previously generated category.

Results

At the date of submission of this paper (3 August 2018) a total of 11 interviews (4 from international students, 4 from domestic students and 3 from lecturing staff) had been recorded and transcribed. Further interviews will be conducted, transcribed, checked, analysed and reported to the AAEE2018 conference in Hamilton, New Zealand on 11 December 2018.

The key to the unidentified responses below is: A = International Students; B = Domestic students; C = Lecturers.

The meaning of cultural diversity

All interviewees were confident of the meaning of cultural diversity. One of the international students answered:
> A1: There are several kinds of meaning of cultural diversity. Like we have Asia, we have Europe, we have America and we have Australia. All these countries have different forms of culture. So the cultures are different. That is why we say there is cultural diversity.

Culturally diverse groups.

Nine of the eleven interviewees were of the opinion engineering laboratory and design groups should be culturally diverse. A typical positive response came from a domestic student:

B2: Right. So you can get different perspectives on whatever the work is you are doing and so you can come up with different solutions and you can get different ways of solving the work and also presenting the work.

Both negative responses were from domestic students, one being:

B3: Not really. I believe it is probably best to have the best team available. If you choose a team that you know will perform. I suppose its knowing people so if you initially know people from different cultures, yes, but putting people together you don't know for cultural diversity because it is hard to communicate, and that's a big part of the group, I believe, like you see some things that work or don't work.

One of the international students gave a constructive comment:

A4: I think we need a leader, we also need a smart guy, really, who can think ideas and we need people who are hard working and can do various things for us and we also need people who can communicate with other groups to get more ideas for us.

Group formation.

This question elicited responses across the spectrum from student self-selection to lecturer-mandated cultural diversity.

B3: I'd like to choose my own group, self select, but that would be biased because I'd pick my friends who would be domestic students. You wouldn't get that diversity, initially anyway.

B2: So, as a student, I guess the normal way for a group to form would be through people who are friends. That means a group will have good cohesion; you are not going to have people arguing all the time. I can see the benefit in meeting new people especially at university.

B1: Undergraduate students are in part seeking direction but at tertiary level they are also seeking to develop their own initiative as well, so I don't think you can prescribe too much top down.

C2: Mainly in the laboratory setting I just let the students self-select. They form their own groups without any intervention from me. I guess I have been doing that for a long time probably when I had an issue many years ago when I did the selection for the students. They were not happy with that so I decided to take my hands off that process.

A1: For last semester and the semester before last initially we formed groups by ourselves but later from cultural difference considerations we design, we adapt, different groups with different members. We got three international students and two domestic students. We have at least two or three different cultures in one group.

A3: I think it is a good way to force them to make a group with people that they did not know before.

There were two similar responses proposing a mechanism for group formation:

C1: I'm thinking around an instrument, an expression of interest type instrument where perhaps students would write two paragraphs about themselves. I'm picturing a whole lot of sticky notes on a pin board. On the right-hand side there will be sticky notes from international students saying what they know and what they have done. On the left hand side there will be domestic students' sticky notes. I haven't really thought through this but perhaps you could get two domestic students to choose two international students (take it in turns, toss up) so it will be random.

C3: In one of the units I taught last semester they did a significant project where they worked as a group of four. I allowed them to choose a partner and then my tutor put the partners together to deliberately form cross-cultural groups. That worked quite well. There was some cynicism from students because we randomly selected into groups and they were aware that what we were basically doing was mixing from cultural backgrounds.

Students contributing more than others in a group

There was universal acceptance that some students will contribute more than others when working in a group. An insightful response was from one of the international students:

> A3: I think it's normal. Because everyone has a different level of ability so they can't make the same contribution in the group. Because, in our group we need to help each other. So as long as the guy who made the lower contribution, as long as he didn't mean that, I can accept that he makes a lower contribution.

Discussion

It seems to be mostly recognised by students and lecturers that cultural diversity is a positive thing; and also that current 'default' methods of group selection generally prevents that. UTAS lecturers are actively pursuing/trialling methods to achieve diversity, but with mixed results and clearly with knowledge of some disharmony being apparent. A probable failing of many groups is that they simply divide the work up piecemeal and then join it together at the end, often resulting in a poor final product, rather than realising for that one person in the group is better at writing, one better at organisation and managing tasks, one better at data analysis, one better at maths; there is a need to provide students with training on how to work in a group.

The literature review and the results of this preliminary study will inform the workshop on cultural diversity in engineering laboratory and project group work at the AAEE2018 conference. This research and the workshop outcome is expected to contribute to the peer-reviewed literature and could potentially extend to different types of impact say on students, on teaching staff, and on learning outcomes.

Conclusions

Cultural diversity in groups has value, but it is not generally yet being taken full advantage of. Group formation should only be considered the first part of the process, and that to ensure that culturally diverse groups lead to positive outcomes and experience it is likely necessary for teaching staff to provide support and suggested structure for those groups, for example to help the members recognise the differences and individual strengths within a group and thus capitalise on them.

Further analysis of the structured interviews is expected to provide a deeper insight into the methods for group formation and individual assessment within groups. Strategies, which assure harmony within culturally diverse groups, will also be sought.

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