BEYOND 'GLOBALLY COMPETENT': PREPARING ENGINEERS FOR 'WICKED COMPETENCIES' AND 'SUPERDIVERSITY'.

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Structured Abstract

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CONTEXT
Preparing 21st century engineering graduates means developing interpersonal skills including the "wicked competencies" needed to work effectively in "superdiverse" teams. In 2011, the Dean Teaching and Learning in the Division of ITEE at the University of South Australia asked an academic adviser with experience in transformative engineering education to work with the course coordinator of large first year engineering courses, to turn negative student attitudes to teamwork around and improve their communication skills. A Student Counsellor introduced Rank theory to explain the power dynamics within teams. This new approach receives essential senior management support as well as commitment from the course coordinators and tutors on the front-line.

PURPOSE OR GOAL
Engineers need more skills than ever before but helping students to develop these skills is not easy. Although the team apply this work in discrete courses across all year levels, we report on sustained work with the first year engineering cohorts and their teaching staff.

APPROACH
Our transdisciplinary, iterative approach to professional development (Learning for Change) embeds teamwork skills, intercultural awareness, sensitivity and other communication skills, supported by learning journals. We applied Kelly's learnings from previous research while Collett introduced the concept of Rank to create 'third space learning, for students to experience inclusive teamwork.

ACTUAL OR ANTICIPATED OUTCOMES
Evaluations show quantitative and qualitative evidence of attitude and skills changes in positive directions. The outcomes for both local and international students include more effective and inclusive teamwork, improved critical thinking and writing and developing understanding of what it means to be an ethical, responsible professional engineer. In 2013 the shift in students' perceived inclusivity within their teams was rated as highly significant.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY
- Intercultural engagement is not intuitive but students learn to embrace differences when provided with transformative conceptual frameworks and opportunities to engage inclusively.
- Tinkering does not do it. Personal change and professional skill development are best supported through a suite of activities that build across a semester and ideally, across a program.
- Merging expertise within a transdisciplinary team develops everyone's teaching skills and global competencies.

Engineering faculty in Australia and internationally face similar challenges. Our sustained, embedded approach improves communication skills and helps to bridge perceived cultural gaps between international and local students. The conclusions are thus seen as useful to international colleagues.

KEYWORDS

Global competence, intercultural team-skills, communication skills, 'wicked competencies'.

Introduction

Industry civil engineers report it takes 3 years on a building site before university graduates of engineering... learn skills to interact and empathise. They lack employability skills when they start" (Goodwin, McDonald, Perkins et al., 2012, p.7)

Undergraduate engineering educators, in Australia and internationally, are required to help develop the complex interpersonal competencies 21st century engineering graduates need to meet the 'perfect storm' of global challenges ahead (Beddington, in Jowitt, 2010, p.6). These include the expanded "wicked competencies" to work effectively in "superdiverse" teams and societies (Cousin, 2012) as well as shifting students' mindsets to integrate ethics, sustainability and systems thinking into their professional practice. This paper offers one approach to what it takes, both in the classroom and beyond, to build 'wicked competencies', reporting on four years of sustained work with large, diverse first year engineering cohorts and associated teaching staff. We are extending into later years in three Schools, Civil, Mechanical and IT, with positive feedback and have used our approach successfully with diverse post-graduate international teams at the International Space University Summer School in Montreal, Canada, 2014.

The need to improve engineering students' communication skills and the associated challenges, has been documented since at least the 1970s (McCulley & Soper, 1986; Selfe & Arbabi, 1986). Students need interpersonal skills that are both effective and interculturally relevant. Given that India and China, graduating hundreds of thousands of engineers per year, are finding "unemployability a bigger problem than unemployment" (Nair, 2012), the conclusions are seen as useful to transnational education and to international colleagues facing similar challenges (Wu, 2013). Growing levels of cultural diversity make labelling or generalising on the grounds of ethnicity increasingly unhelpful (Cousin, 2012). Our transdisciplinary team (course coordinators, support staff) has developed an iterative approach to professional development *Learning for Change* (LFC) which works progressively to embed teamwork skills, intercultural awareness, sensitivity and allied oral and written communication skills. Graham (2012, p.3) notes that innovative programs tend to vanish or revert to previous approaches if a 'lone champion' moves on or gives up the struggle. In line with her advice for successful engineering curriculum change, this team is fortunate in having essential supports: senior management commitment and encouragement, collaborative course coordinators and tutors, as well as the contemporary theories that underpin our teaching methods. Many of the concepts and strategies are new to both students and teaching staff, who also develop their competencies as inclusive educators for professional communication skills.

The LFC approach began in 2011 in response to concern about first year engineering students' antagonism to teamwork and their poor communication skills. The Dean of Teaching and Learning in the Division of ITEE at the University of South Australia (UniSA) asked Kelly, an academic adviser with experience in transformative engineering education, to work with the course coordinator of several large first year engineering courses, to turn this situation around. Collett, a student counsellor, contributed experience in inclusive teamwork by introducing the concept of Rank to explain power dynamics within communication. Effectively, the team is promoting a new vision of what it means to be an engineer in a global environment. The LFC approach builds student competencies incrementally, recognising that successful learning (particularly for minority or vulnerable students) comes through embedding a "*continuum* of interventions rather than discrete interventions" (Gandara, 2010, np).

Embedding transformational learning approaches requires planning to give students time and opportunity to 'productively struggle' with the threshold concepts that promote sustained personal change (Shulman, 2014). Greater input is needed early, when students first learn academic expectations and engineering culture. A first semester course, Sustainable

Engineering Practice (SEP), foregrounds Indigenous culture through a culture forum, guided by Indigenous tutors and integrated into content and assessment, including Learning Journals. Students develop and apply their understandings through an Engineers Without Borders project, set in a developing country. The activities and process support students to move beyond their comfort zones and make the relevant changes in attitudes and behaviours to become inclusive professional communicators. The following key terms and concepts underpin the *LFC* approach: competencies, transdisciplinary, iterative, transformative, Rank and inclusive communication. We explain these and then explore how we integrate them and evaluate their effectiveness in practice, before summarising lessons learnt.

Key terms and concepts

We accept competencies as "an interplay of knowledge capacities and skill, motives and affective dispositions" (Reickmann, 2012, p.129). Knight uses 'wicked competencies" to spell out the complexity of 21st century communication and group work. He urges professional practice programs to assess "developing supportive relationships; emotional intelligence; group work; listening and assimilating; oral communication; professional subject knowledge; relating to clients; self-management (confidence and effectiveness) and; taking it onwards…" (2007, in Crisp, 2012, p. 34). These all involve 'empathy,' identified by transnational focus groups as crucial to effective communication (Walther, Kelham, Sochacka et al., 2011, p.730).

Our teaching team is developing a transdisciplinary response, growing "between, across and beyond any one discipline" (Ramadier, 2004, p.400). This complements Sheppard, Macatangay et al.'s (2008, p.8) iterative or 'spiral' approach to revising engineering education, in which all components of an integrated curriculum are "revisited at increasing levels of sophistication and interconnection" with professional practice providing the "spine". We lay the foundations for such a process but its sustainability depends on it being reinforced and "carefully interlinked with existing courses" (Graham, 2012, p.65). We built on Kelly's research into what engineering students find difficult about change and communication, as well as how to support transformative learning (Mezirow, 2000). This theory underpins change because it involves reflecting and "…reassessing the presuppositions on which our beliefs are based and then acting" on the insights arising from this process (Mezirow, 1990, p.18). For students, this often entails not just learning but 'unlearning,' as they correct distorted assumptions about culture, ethics and sustainability.

Power is a critical aspect of our daily interactions and relationships (Diamond, 1996). Knowing how we express our personal power, or 'Rank', and how this affects others, prepares us for building relationships. Collett introduced the concept of Rank, "a conscious or unconscious, social or personal ability or power…" (Mindell, 1992 p.43) from Process Oriented Psychology, to explore the behaviours and attitudes associated with both high and low rank (Camastral, 2000). This gives students a framework and language for analysing their own interactions and acts as a catalyst for enhancing intercultural engagement. It is not tinkering, or shallow cultural work based on 'dealing with' or 'managing' differences, but "Third Space" learning" (Bhabha, 1994). Third Spaces are intercultural spaces in which students can struggle with difficult and challenging cultural discontinuities, question meanings and co-create new understandings. This work motivates engagement, but students also need time to practise new professional, oral and written conventions for effective intercultural interactions. Having established the context, the next section details the key curriculum elements we have used to create active learning spaces for practice.

Learning for Change: creating active spaces

We create active spaces that enable students to engage with differences through four common curriculum elements, scaffolded or guided to suit each context and level: 1)

Creating a safe environment, 2) Building intercultural capacity, 3) Providing appropriate resources and 4) Providing Feedback and Feed-forward.

1) Creating a safe environment: Theory, content and expertise combine in the "Teamwork Foundations" tutorial, with structured opportunities for team members to share strengths, concerns, goals and hopes. We must include students with no previous teambuilding experience since as many as 45% of students in a later course self-identified in this category, through alternative entry, recognition of prior learning or as transnational students. A common staff assumption is that students will know each other after one Ice-breaker. They don't. Ice-breakers are essential, but we quickly move into Focused Group Discussions, with a template to help them begin, e.g. (1st year, 1st semester) "*Choose a spokesperson/scribe who will present for you. Then share information under the following headings: Your preferred name, education and work background; your aims and concerns in studying this course; Something interesting about you; One strength you bring; The engineering field you hope to enter. Spokesperson presents to tutorial (I minute).* Focused discussions evolve to reflect course aims and student maturity, but all retain a common aspect in which a volunteer spokesperson summarises and presents the group. Presenting has many benefits. It makes students visible and valued, establishing a collective culture that incorporates all members and it takes the fear out of presenting from day one. Students hear and receive positive feedback, which lays the foundations for all students to develop confidence and presentation skills.

Having established an environment which encourages and supports participation, and with increased familiarity between the students, we move to a *Negative Brainstorm* activity, using humour to identify behaviours and attitudes which can impact badly on groups, allowing students to identify how they impact on others, but without identifying anyone. This makes overt what are often hidden or 'taboo' issues. The critical aspect is the feedback and response to students' input, which requires skill, tact and practice to do well, particularly if any of the 'isms' emerge (sexism, ageism, racism, able-bodyism). We do not leave students with negatives but guide them to take responsibility for their own behaviours. We ask them to reflect on and complete a Personal Learning Agreement (PLA) template, stating five things they will do to help their teams succeed. They use these PLAs to negotiate a Collective Team Agreement (CTA) to guide their team work throughout the semester.

2) Building intercultural capacity. On this foundation, Collett introduces Rank, asking students to reflect on and discuss situations when they have had both high and low rank. Rank provides students with a common language for evaluating team performance. Those with more rank may be unaware of their impact on others, while those with less rank may feel marginalised and ignored. We further support group inclusiveness by incrementally introducing professional communication skills, building on prior knowledge. In 1st semester, 1st year, we provide a consensus decision making model before teams negotiate their CTA. In Engineering Design and Innovation (EDI, 2nd semester, 1st year) a focused discussion of leadership styles explores previous teamwork experiences, before teams create a CTA. A 2013 EDI tutor focus group reported students voluntarily asking to create new agreements for their second project. These Third Space activities help to bridge perceived social and cultural differences, develop responsibility and build confidence. Shifting attitudes toward cultural difference is sustained by exploring cultural identity and awareness in 1st year, culture, inclusive communication in 2nd year and culture in the workplace in subsequent years. Typical journal reflections include*:*

> *"Before my first tutorial I was unsure about communicating and working in teams with other students specially students that I never met before. The first tutorial came as a good influence as it encouraged me and gave me more confidence in meeting new students and working with them in teams" (Male, EAL, 1st yr, 1st sem. 2012).*

3) Providing appropriate resources: Clear written aims and instructions are particularly useful for international students but there is an associated need for staff development.

> *…[I]f national priorities and community expectations around graduate employability are to be met, academic teaching staff must be properly prepared to identify, model and assess key attributes and skills in a curriculum specifically designed to ensure graduates achieve the 'required mix' of knowledge and skills (Oliver et al. 2011, p.7).*

Our tutors also come from varied cultural and educational traditions, so the student and tutor guides help them integrate and apply different approaches. Learning journals (5 x 250 words) develop students' written communication skills and reflection. Templates scaffold each entry with a topic focus and open-ended sentences to help them begin, while marking rubrics and formative feedback help students overcome writing fears and move towards critical reflection. Journal labels indicate growing professionalism, moving from Learning Journals (Sem. 1) to Development Journals (Sem. 2.) to Individual Portfolios (2nd year), for which the course coordinator encourages students to use video entries. We encourage students to collect all professional skills resources and writing across their programs in a PReP (Professional Resource Portfolio), as evidence for future employers and of their personal development.

4) Feedback/ Feed-forward: Minute evaluations (Angelo & Cross, 1993) are an effective early intervention. These anonymous worksheets seek pre and post responses to "Things I Have Learnt from today's lecture/tutorial …" and "One Unanswered question or comment I am leaving with is…". They benefit staff and students. Since they are informal, vulnerable teaching staff can identify any 'burning issues' early and try to address them. No-one else has to see the results, but the process can reassure staff (and students) that things aren't as bad as vocal student critics may claim. Teachers can also use them as evidence that they are working to improve their teaching and are responding to student needs. We refined this strategy, using reciprocal feedback to create 'feed-forward'. **All** collated evaluations and our responses to 'unanswered questions' were available online and in lectures, within a week. This takes time but saves more, because students receive answers they need and these answers can form the basis of a web-based Frequently Answered Questions. Many course coordinators also integrate the on-line peer assessment tool SPARK, with guidance provided on constructive feedback.

Outcomes

We have used a range of evaluation strategies in a 1st year 1st semester course to assess the students' responses to change. We summarise the main findings below as *What students valued, Attitudinal change* and *Sustained change.*

1) What students valued: Data from pre and post Minute Evaluations is collected for each cohort. Week 3 feedback captures student responses to Tutorial 1 & 2 activities. Later comments respond to teamwork experiences throughout the project. The 2013 EDI Week 3 minute paper listed LFC concepts and activities and students (n=159) ticked those they found "new and useful". Table 1 shows that most students valued the dedicated time for meeting others and learning concepts that explain group dynamics.

Table 1: New useful activities/concepts, EDI, 2013

Meeting Other Class Members	*89%*	*Consensus Decision Making*	*70%*
Rank and communication	*87%*	*What Works /Doesn't Work In Team*	*70%*
Behavioural Indicators of Rank	*72%*	*PLA & Team Agreement*	*69%*

2) Attitudinal change: We know from the 2012 paired survey of student attitudinal change toward culture in SEP that some highly significant' and 'significant' changes occurred, with local students increasing their understanding of cultural identity, empathy for other cultures and appreciation for interdisciplinarity (Kelly, Smith & Ford, 2012). Willingness to change was also measured. Not all students are prepared to challenge their attitudes and behaviours.

Improving written and oral skills requires a readiness to engage with new and different ways of communicating and the self-confidence to practise them. Kelly analysed the tone of journal entries in her 2000- 2005 study. Using her framework, students in the 2012, first semester cohort were identified as those willingly or grudgingly accepting new concepts and activities (Accepters), those who were initially sceptical but later valued them (Converts) and students who remained antagonistic (Resisting change). Converts write things like the following, with attitude change markers underlined:

> *…i did not expect to learn anything new. <u>However</u> the idea of rank within a group was a completely new concept to me… <u>I can now</u> see its importance; … at university I face a far greater degree of cultural diversity than I did at school. If the concept of rank is not given the attention it deserves, it would then be easy for subordinate group members to be left out, and any valuable contributions they may be able to give will be ignored. <u>Now that I realise</u> this I can see times where I may have failed in past to properly use my rank…" (Male, ESB)*

Kelly typically found 65% acceptors, 25% converts and 7-10% resisting change (for reasons such as fear, not seeing the relevance). In the 2012 SEP journals, acceptance reached 95% with only 2-3 % presenting as mildly resisting, a considerable increase. Contextual changes possibly contributing to increased 'willingness to change' include the fact that team work and intercultural work is built into the entire course content and process (rather than being a small part of it) and there is strong senior staff support. We also built on the findings, addressing the problem of relevance by showing students that their profession and employers value professional and personal skills. Students may also be less resistant to attitudinal and behavioural change when they understand communication dynamics and the intended outcomes of using alternative desirable behaviours. Personal development is progressive, with students benefiting from repeated exposure to new concepts (Sheppard et al, 2009, p.9). In the second semester course's journal entries, students continued referring to rank and teambuilding concepts, with some acknowledging they had not understood the full value of LFC material until working in teams in this course. This supports an iterative approach.

3) Sustained change: One measure of change in student attitudes and behaviours was their comments in minute evaluations. In 2013, EDI student comments about 'one useful thing they had learnt' were coded as Reflective, Reflexive or Neither for both Week 3 and Week 9 evaluations. Reflective statements refer to the nature of an experience, while reflexive statements relate to personal beliefs, attitudes or behaviours. Reflective comments, like 'teamwork can make or break a project' or 'different team members do different jobs in a team', show objective understanding, whereas reflexive comments such as 'need to respect and trust members of team', show insight and are used to "guide, reflect on and deconstruct the assumptions and beliefs that underpin their own everyday experiences" (Segal, 1999, p.730). In the 2013 Week 3 evaluation', 149 responses (N=174) about a 'useful thing I have learnt' were collated and coded as reflective, reflexive or neither. The same prompt in Week 9 yielded 101 comments, similarly coded and collated. Table 2 shows percentages of reflective and reflexive comments across the two evaluations.

Table 2 SEP 2013 Weeks 3 & 9 Comments

Evaluation	Reflective	Reflexive	Neither
Wk3 Comments n= 149	70% (105)	23% (34)	7% (10)
Wk9 Comments n= 101	49% (49)	51% (52)	

The 70% Week 3 reflective comments show that many students were engaging with the material. The 23% making reflexive comments were already analysing their personal relationship to it. In the Week 9 evaluation the level of reflexivity more than doubled, with 51% of students making reflexive comments. This was a significant shift, with over half the

students showing sustained attitude change. A χ^2 (Chi Squared) test for homogeneity showed $\chi^2 = 18.5802$ (df =2), with a significance at P= <.001.

Challenges and benefits

Several challenges have emerged in embedding LFC in undergraduate courses.

Globally competent students imply globally competent teachers. Badley (2000) identified global competence as academic competence "knowing what", plus operational competence with the increasing pressure for academic staff to acquire formal teaching qualifications ("knowing how"). He added "socio-cultural" competence to this, based on, "the need for a transformatory and democratic approach to one's own teaching" (Ibid., p.245).

Differences in teaching and support staff expectations do emerge. For example, tutors in EDI 2013 were concerned when many teams chose to be 'leaderless' in their team agreements, resulting in organisational difficulties. "Some teams '…learned from their mistakes and later identified the need for leadership" (Tutor, focus group). Other groups continued as 'leaderless', even though tutors noticed leaders emerging. These teams were seen by tutors as disorganised and lacking appreciation for the leadership role. However the members continued to work together and '… at the end … they communicated and sorted it out themselves ...' (Tutor).The tutors had wanted teams to use a functional approach from the outset, whereas we valued them learning to negotiate how they would function. Staff need to appreciate that some activities are repeated every semester so students can use a familiar teambuilding process when meeting new team members. A comment we often hear from staff is "*They've done that before; students will be bored".* On the contrary, we find that repeating activities helps students build safe, comfortable working environments, from which they gain the confidence to engage more with one another and can take in more information.

There are also many benefits. Firstly, LFC educators and teaching staff relationships are also Third Space collaborations (Whitchurch, 2008, p.378). The differences in aims and teaching styles that emerge prompt us to negotiate our expectations and broaden our expertise, which recent internal and national teaching awards recognised and encourage. Secondly, early feedback enables course coordinators to respond quickly and appropriately. For example, in a 4th year civil engineering design course, student responses both raised and addressed the "why do we have to do this team-building stuff again" complaint, since the 'useful things' learnt included, (as written), *"Everyone is dfferent. eg diff strengths and weaknesses. What may be easy for one person isn't necessarily easy for someone else"* (Student evaluation, Week 4, 2014).

Table 3: Student evaluations EDI, 2010-2013

	2010	2011	2012	2013
Helpful Feedback	45%	63%	82%	82%
Overall satisfaction	61%	75%	79%	86%
Responses	31	8	33	74

Transparency assures students that we take their concerns seriously, models constructive criticism and encourages engagement. Table 3 summarises formal student evaluations from 2010 (the year before we began) through to 2013. There is significant improvement in measures of feedback and overall satisfaction as well as the response rate itself. We also evaluated teamwork competence and confidence in working inclusively. In 2013, we added a Likert scale teamwork inclusivity rater to first year, second semester (EDI) minute evaluations, comparing Weeks 3 & 13. We were pleased that 84% of respondents rated their team as inclusive or very inclusive in Week 3, but this improved to 93% by Week 13. More importantly, 53% rated their team as 'very inclusive' compared with 36% in Week 3, which a χ^2(Chi Squared) test for homogeneity showed as extremely statistically significant ($\chi^2 = 18.754$),(P= <.001), (df=3), (n=130). The students' journal entries reflect growing global competence and awareness.

The team itself is a multi-cultured corporation with more than half the team born internationally and speak more than one language. This has allowed me to network with different people and take in an alternative way of thinking or varying

method when applying knowledge instead of my straightforward way of thinking. (Male, ESB. 2013)

Conclusion

We have known for decades that intercultural engagement is not intuitive and doesn't 'just happen'. It can and needs to be developed in a thoughtful and systematic way across engineering courses and programs. Tinkering – adding one or two activities to introduce intercultural engagement or communication – may be a starting point, but does not support sustained change. Personal growth and professional skill development are best supported through a well-researched, designed and supported suite of activities that form a 'continuum' across a course and ideally across a program. This requires collaboration, planning and expert support for teaching staff. Merging content and process expertise within a transdisciplinary team develops everyone's teaching skills and global competency. It enables content experts to experiment with different processes, but with support and encouragement. It grounds process experts in discipline realities, so that their work is embedded, relevant and effective. Engineering faculty in Australia and internationally face similar challenges, with pressure to respond but few effective models for change. We document a sustained, iterative and embedded approach developed with large, diverse first year cohorts and extending into later years, which improves communication skills, including intercultural skills. It helps to bridge the perceived cultural gaps between international and local students and has proved useful in international settings. Building cultural bridges has never seemed so important.

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