Dancing at the Party: Educational Practices in Engineering Education that Foster Diversity & Inclusion

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STRUCTURED ABSTRACT

CONTEXT
Universities are strongly positioned to reproduce or reshape patterns of structural inequality (Outhred 2012). Given the "dynamic social context" (Armstrong & Cairnduff 2012, p. 926) of universities, one way reshaping can occur is through the inclusion of diverse groups of learners. Specifically, educational practices (by which we mean curriculum, teaching and broader learning experiences) that foster inclusion (Rolls, Northedge & Chambers 2018) have the potential to enable diverse learners to flourish and excel.

PURPOSE
Which strategies and educational practices might foster the inclusion of learners of diverse backgrounds and abilities in engineering education?

APPROACH
In this conceptual paper, we tease out approaches to diversity and inclusion, heeding Myers' (2012, para 1) call that: "Diversity is about being asked to the party; inclusion is being asked to dance." We begin with background strategies to support diversity, such as recruiting staff from diverse backgrounds, employing D&I specialists, and devising selection procedures to support diverse cohorts. We draw on frameworks to support the inclusion of diverse learners (Boud 2010; Buckridge & Guest 2007) including:

- Meaningful group formation (Kanter 2008) for women and gender-expansive learners in cohorts where men are over represented
- Use of a diversity snapshot, and inclusion plan
- Competency-based curriculum with formative feedback

RESULTS
We explore the example of the Bachelor of Engineering Practice (Honours) program at Swinburne University of Technology, including explicit educational practices to foster diversity and inclusion.

CONCLUSIONS
In conclusion, shifting educational practices to foster diversity and inclusion not only serves the educational experiences of individual learners, but also progresses institutional agendas for inclusion while preparing diverse, future-ready engineers. Put another way: there are many benefits, when we enable everyone to dance.

KEYWORDS
Inclusion, formative feedback, group formation

Introduction

Universities are strongly positioned to reproduce or reshape patterns of structural inequality (Outhred 2012). Given the "dynamic social context" (Armstrong & Cairnduff 2012, p. 926) of universities, one way reshaping can occur is by including learners from more diverse backgrounds and experiences. Specifically, educational practices (by which we mean curriculum, teaching and broader learning experiences) that foster inclusion (Rolls, Northedge & Chambers 2018) have the potential to enable diverse learners to flourish and excel.

In this conceptual paper, we explore the question: Which strategies and educational practices might foster the inclusion of learners of diverse backgrounds and abilities in engineering education? We discuss this with reference to implementations in the Bachelor of Engineering Practice (Honours) (or BEngPrac(Hons)). We begin with background strategies to support diversity and inclusion (D&I), such as employing D&I specialists, and implementing selection procedures to support diverse cohorts. We draw on frameworks for educational practices that support the inclusion of diverse learners (Boud 2010; Buckridge & Guest 2007) including:

- Meaningful group formation (Kanter 2008) for women and gender-expansive learners in cohorts where men are over represented
- Use of a diversity snapshot, and inclusion plan
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Background

The BEngPrac(Hons) is a four-year undergraduate, engineering degree program offered at a public institution (Swinburne University of Technology), in an urban Australian setting. The BEngPrac(Hons) program is located in the Engineering Practice Academy (the Academy) and utilises pedagogies from practice-based education (Higgs et al. 2013; Boud 2012), which both draws from, and extends, the rich tradition of problem-based learning (Kolmos, 1996; Holgaard, Guerra, Kolmos & Petersen, 2017). Description of the program are available elsewhere (Cook et al. 2017a; 2017b); however, for the purposes of this paper, the learning environment is closely aligned to innovative engineering working environments. Learners are called "Associates" and their program of study is known as the Associate Development Program, which is modelled on the graduate programs that many larger engineering firms offer to new graduate employees. Learning is contextualised in projects developed with industry and community partners, which occur in six-week terms called "sprints" (or terms). Associates engage with 4-5 projects in a calendar year. Aspects of learning are organised into short modules called "credentials" (involving online learning) that run alongside projects.

Diverse and inclusive practices begin with staff

The Engineering Practice Academy is a values-based organisation with a vision statement that notes: our "set of shared beliefs, practices and principles…. embrace and promote diversity and inclusion…" (Academy 2018, p. 2) among other values. Diversity refers to representation across learners and staff; while importantly, inclusion refers to the quality of those people's experiences in the context of the organisation. As Vernã Myers (2012, para 1) argues through the powerful metaphor: "Diversity is about being asked to the party; inclusion is being asked to dance." When viewed this way, bringing staff and learners in (to the "party") is only the first step in diversity and inclusion practices.

Senior leadership in the Academy recognised that this vital, first step in D&I involves a deliberate strategy for recruiting staff—especially to draw in the expertise that goes beyond the current homogeneity seen in the engineering industry (discussed further, below). While a full analysis of demographics among Academy staff is a matter for another paper, current staff include three women engineers-in-residence, people of colour, and people identifying as LGBTQI+ among others. In addition, building out from diverse hiring strategies to inclusive practices, three staff with diversity and inclusion specialisations where appointed. Of these, two staff (Dr Barbara Cosson & Dr Janine Pickering) were engaged for the initial design-phase of the program, and a third specialist (Dr Francesca Maclean) is engaged on a longer-term brief. In the role of engineer-in-residence, Dr Maclean leads the development of the Academy D&I strategy, systematic professional development for Academy staff, and the development and facilitation of D&I curriculum for Associates. It is through the appointment of both diverse staff and specialist staff that the vision of diversity and inclusion is enacted as a strategic priority, and in turn is able to be embedded in educational practices and the broader Academy culture.

Diverse and inclusive practices in selection and admission

Diversity is supported by policies and strategies that enable diverse cohorts (of learners and staff) to envision their success within engineering in general, and the Academy specifically. As Academy staff, we are engaging with the mission to foster diversity and inclusion by imagining richer conceptions of who is enabled to attend university (for example Tranter, 2012). We have approached this by altering admissions policies and practices.

Aggregated secondary school results (such as the ATAR in Australia) offer one indicator of prior learning, and are often used an admissions criteria. However, secondary education results do not provide a clear indicator of future attainment at tertiary level (Messinis & Sheehan, 2015). In the Academy, we are keen to support applicants who are likely to flourish in this environment, but who may not have enjoyed the full structural advantages of their peers. To this end, as a deliberate strategy to support more diverse cohorts, we have uncoupled the aggregated secondary school results from entrance requirements (ATARs). Instead we require the attainment of a high school certificate with specified scores in English and any mathematics at year 12 level, which in itself broadens the access for learners—given the gendered nature of rates in high school maths (Nosek et al. 2009). We have augmented the admissions process with a brief written application, where applicants respond to a position description, and attend an interview. The rationale behind this selection process is that it enables applicants from more diverse backgrounds (such as regional locations, lower socio-economic status (SES) backgrounds, people with disability, and neuro-diverse learners to name a few) who would succeed in the Academy if given the opportunity to contend for places, but where structural impediments might otherwise have discounted them under other application conditions. Returning to Myers' (2012, para 1) powerful metaphor: this selection process is equal to being asked to the party.

In the remainder of this article, we explore educational practices for D&I including three interventions in teaching practice, and competency-based curriculum with formative feedback. These approaches offer the human dignity of being first asked and then repeatedly included in the dance.

Diverse and inclusive groupwork design and practices

In the Academy, we are mindful that engineering faces a challenge with the homogeneity of both undergraduate learners and professionals in industry (86% and 88% men, respectively) (Engineers Australia, 2017). Historically this over-representation of men has been attributed to a "leaky pipeline", and attributed to poor attraction efforts. With a focus on outreach and attraction into the discipline, there has been attention given to the experience of women entering, and currently in, engineering undergraduate degrees and the profession (Mills, Ayre, & Gill, 2010; Mills, Franzway, Gill & Sharp, 2013; Male, Gardner, Figueroa & Bennett, 2018), which we are arguing is the key to retaining them in the industry. In the Academy, we strive for intersectional approaches to diversity and inclusion, which acknowledge that a person's experience is multifaceted. However, we have chosen to focus on our industry's most pervasive inequity—gender—as our starting point.

As a profession, engineering is heavily focused on groupwork to execute projects. This is mirrored in engineering education with project-based learning, and when implementing practice-based education, such as in the BEngPrac(Hons), groupwork is a dominant aspect of learners' experience. Whilst groupwork provides an authentic learning experience for future engineers, it also poses a risk to the quality of experience for learners who are not members of the dominant group (one example in our case is women).

We took the opportunity to design diverse and inclusive group environments for first-year Associates (learners) within the Academy. Designing diversity and inclusion into systems with behavioral nudges can potentially achieve tangible and impactful change within an environment (Bohnet, 2017). With this is mind, we designed a set of three interventions to nudge Associate behavior towards fostering a diverse and inclusive environment, as well as developing a set of diversity and inclusion credentials. The three interventions are:

1. Group formation for critical mass
2. Diversity snapshot
3. Inclusion plan

Group formation for critical mass

Without a critical mass, members of non-dominant groups are easily reduced to their demographic stereotypes and are likely to be treated as tokens (Katner 2008; Etzkowitz et. al. 1994; Torchia et. al. 2011). With this knowledge, we set out to design Associate groups to ensure a critical mass of more than 30% women in any one group. We stipulated that in groups of five or six, there must be at least two or three women (respectively). This would achieve a representation of at least 40% women in mixed-gender groups.

Given our initial cohort had 21% women, this did result in all male groups. Our approach was to design groups where women had a critical mass and introduce additional measures for groups with only men, so that they still interacted with women in their project experience. Additional measures included:

- Interacting with a client liaison or project principal identifying as a woman or non-binary, or,
- Engaging with external stakeholders at review points to ensure the group's thinking and outputs benefit from a greater diversity of thought.

Research has shown that among engineering undergraduates, women participated more in women-majority groups than in gender-parity or women-minority groups: first-year women felt less anxious and participated more actively in the groupwork (Dasgupta, et. al. 2015). Interestingly this effect was not seen in gender-parity groups (two women and two men), which is in contrast to the existing research on critical mass, suggesting 30% in relative terms, or three in absolute terms (Bohnet 2017; Kanter 1977). Differences in research contexts (ie educational compared to professional contexts), and age (first-year undergraduates compared to professionals) could account for this difference.

In our first project sprint, we had at least two of our women Associates together in the same group. Due to cohort numbers, we were unable to create a women-majority (75%) group aligning with the positive research findings of Dasgupta, et al. (2015). We could have created an all-women group, however we were hesitant to design gender-segregation into our practice-based course.

With changing cohort numbers and future intakes, we will look to create women-majority groups and evaluate the experience of the women. There are two important considerations when balancing opportunities for learners of all genders to interact with diverse genders: 1) not compromising the experience of women learners on the one hand, whilst 2) giving men the opportunities to work with women and people who are non-binary, in an environment already dominated by men. Alternatively, reaching our 40/40/20 gender target (meaning 40% women, 40% men, and 20% not specified) would alleviate the latter concern. This target is aligned with the Australian Human Rights Commission's target for gender balance on Australian government boards as an articulation of best practice (Broderick, 2015).

We note that diversity in engineering is not limited to gender, and that we strive for an authentic diversity and inclusion approach that is intersectional. While we have reported on activities relating to gender, here, our future work will focus on the equity and empowerment of other non-dominant groups within engineering, including but not limited to Aboriginal and Torres Strait Islander peoples, socio-economic status, and cultural background.

Developing diversity and inclusion capabilities among engineering undergraduates

Whilst there is a focus on gender equity for many Australian universities at the staff level through the Science in Engineering Gender Equity pilot (SAGE, 2018), developing D&I-capable undergraduates has been a missed opportunity. Many engineering companies and firms are investing time and money into diversity and inclusion, and so we have created interventions and bespoke course material to develop D&I-capable engineering graduates.

Once groups have been formed to achieve critical mass of women, project groups complete a **diversity snapshot**. This snapshot guides learners in exploring their diversity as a group – covering age, gender pronouns, birthplaces, languages and cultural holidays. This snapshot is then accompanied by an **inclusion plan**, where learners explore their preferred working styles, external commitments, communication preferences, group bonding activities, and how to identify off-track/on-track behaviors. These small interventions at the start of the project sprint are designed to place diversity and inclusion front-of-mind for learners, and foster communication to bridge differences in creating an inclusive group.

Few effective diversity and inclusion curriculum interventions exist within undergraduate engineering education at present. An early example is the introduction of unconscious bias training for learners

within the Department of Earth Sciences and Engineering at Imperial College London (ICL) in 2016 (Narcross 2016). Recognising the need for learners to be D&I-capable given their early involvement in start-ups and leadership positions, ICL noted that unconscious bias training could help their learners; nevertheless, many similar diversity programs have been shown ineffective (Dobbin & Kalev, 2016).

At the Academy, the curriculum includes dedicated credentials on diversity and inclusion, which learners complete throughout their degree. These credentials are designed to embed a sustainable approach for developing D&I-capable learners, and eventually, graduates. We are conscious of the risk of the "moral licensing effects" of curriculum activities such as unconscious bias training. In this sense, Merrit et al. (2010, p. 344) define moral licensing the phenomenon where "past moral behavior makes people more likely to do potentially immoral things without worrying about feeling or appearing immoral." In short, if not handled delicately, D&I-capability training might have unintended negative effects on learners' behavior.

In terms of curriculum, in the later half of 2018, we will deliver the first six-hour credential, "Embracing and Valuing Differences" to the Associates, where learners will be introduced to diversity and inclusion; explore the social justice and business case; and develop personal inclusion commitments to foster an inclusive environment within the Academy. The credentials are described further in the next section of the paper. Embedding diversity and inclusion within their education as an expected capability is designed to develop graduates who are further along their D&I journey than previous cohorts. Combining this knowledge, with the skills and experience of this innovative practice-based course, we anticipate that our graduates to be change-makers for inclusive engineering once they join the workforce.

Building a competency-based curriculum with formative feedback

In the Academy, D&I-focused curriculum and teaching practices—discussed above—are complimented by broader curriculum and feedback practices that are intended to foster the inclusion of cohorts of diverse learners. Learners engage in curriculum for D&I-capability, and we also use approaches across curriculum that support learners in their diversity. The design and implementation of a collection of short modules called credentials represent a powerful example. Credentials are core to practice-based education in the Academy, and integral to our program. Each credential represents approximately six hours of work, and the Associates are asked to complete them at their own time and pace. Each sprint, completion of the credentials accounts for 50% of the Associate's grade, and represents the learning of capabilities within specified domains of knowledge that are foundational to professional engineering (i.e., Discipline, Process, Work, Self and Thinking). They make up the baseline of knowledge, skills, and experiences that we require all graduates to achieve. Our learners engage with the credentials through a blended learning approach (e.g., Procter 2003) where experiences occur in the workplace and are supported online through readings and supplementary resources. These are "evidenced" by the Associate and submitted through an online learning management system.

Several key features support diverse learners. The credentials are:

- **Self-paced** and **self-directed**
- **Competency-based** (e.g., Frank, 2010; Nguyen & Losee, 2016)
- Able to be achieved through **multiple attempts**
- Supported through **formative feedback** (e.g., Nicol and McFarlane-Dick 2006)

Self-paced and self-directed

Learners (Associates) may choose the order, timing and time spent on each credential. This allows them to be strategic with those that they find more or less challenging, letting them spend more time on specific areas to ensure mastery. We argue that success for all learners is improved by letting them take control of when and for how long they engage in parts of the curriculum. It also allows them to "level the playing field" early in the program, rather than being appraised, by themselves and their teachers as a "low achiever". Essentially, they work through at their own pace, define their own success, and learn how they learn.

Competency-based

Each credential is assessed by a detailed rubric and given a status of "achieved" or "not achieved". No grades are given, and the standards and benchmarks for achievement are the same for all learners

(guided by the rubric). The rubric is provided to them, ahead of their submissions and this increases transparency in what is expected for proficiency in a topic area. This reduces the "hidden curriculum" which is commonly a barrier for underrepresented learners (Hafferty & Gaufberg, 2013). In this way, the focus becomes not on grades but on learning. We (as instructors) can give learners the attention that they need, where they need it.

Multiple attempts

Learners submit their work and we assess it with standards defined in a rubric, which is always provided to them. If they have not met all standards, they are given additional attempts to review their work, revise and resubmit. At present, the curriculum has no set limits to the number of attempts that a learner may try to achieve a given credential for completion of the degree program. This feedback loop ensures that standards are met. In addition, topics that the learner may struggle with are less like to provoke an "all or nothing" mindset. In turn, multiple attempts may decrease the anxiety that typically accompanies other summative assessments such as exams.

Formative feedback

As noted above, learners have multiple attempts to achieve a credential. To improve and learn, learners are given formative feedback against each item in a rubric (against a standard) and instructors provide "on-paper" annotations to bodies of work submitted. The rich, customised and inquiry-focussed feedback allows the learner to question and revisit areas of their work. It also scaffolds learning through our program and provide support to learners, as they need it and to what degree they need it.

We chose to design the credential system in this way to embrace a diversity of learners and their abilities, and to support them in individual learning journeys. We feel that it supports learners across a range of ability levels (i.e., low to high achievers), neurodiversity (Pollak 2009) and first-in-family learners (McKay & Devlin 2014). However, in this system, progression through the program relies on achievement of the credentials, so by setting standards that all learners must achieve to pass, we provide the learners who require more time, more support, and more feedback-loops with more opportunities to succeed. However, because progression through the credential system is self-regulated (Zimmerman 1990), learners must organised their time and manage their progress by taking control of their learning. This means that some learners may delay graduation until their core learning has been achieved (DeLorenzo, et. al., 2009; Silva, et al., 2015). This requires additional skills that some learners will not have, when entering the degree program. To avoid a scenario where learners fall behind we have engineered and scaffolded goal-setting and learning plans throughout the four-year degree which supports self-regulation and self-paced learning opportunities.

Conclusion

This paper has presented ways of embedding practices within engineering education that foster diversity and inclusion among the cohort of learners. To return to Myers' metaphor (2012, para 1), we have thought deeply about asking learners to the "party" of engineering education, inviting them to dance, and importantly, ensuring that they continue to be included in the dance. While the descriptions presented here are specific to the BEngPrac(Hons) in the Academy, we argue that the approaches are applicable to any engineering course that wants to increase the diversity and strengthen the inclusion for its cohort, while acknowledging some are easier to embed than others. We argue that a fundamental shift is needed in the diversity of graduates to cope with the challenges facing the engineering profession now and into the future. Universities are uniquely placed to facilitate this shift, however a transformation is needed not only in approaches and practices in engineering education to foster diversity, but also in mindsets about how imperative this shift is for the future of engineering practice. This shift is not just a nice to have, not just a business opportunity, but an obligation we have to address the structural inequity in the systems we work within.

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