Scoping the opportunities to aid recruitment and retention of indigenous students in engineering

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Abstract: Indigenous Australians are grossly under-represented in engineering education and the engineering workforce. The reasons for this are complex and multifaceted. There are no magic bullet solutions to increase their participation. Rather, this will be a long term task that will require commitment from a wide range of contributors at all levels of the education pipeline, including indigenous educators and representatives of indigenous communities and organizations. University providers of engineering programs can have significant roles to play in assisting growth in participation. This paper reports on findings that formed part of a wider project investigating opportunities for flexible and alternate pathways into engineering degrees.

After examining perceived barriers to, and potential opportunities for, growth in indigenous participation, recommendations and guidelines are proposed for implementation by providers of higher education engineering qualifications.

Background

The 2008 Review of Engineering Education sponsored by the Australian Learning and Teaching Council and undertaken on behalf of the Australian Council of Engineering Deans (King, 2008) identified that engineering classrooms are often highly culturally diverse, but within that diversity indigenous Australian students are grossly under-represented. There is no doubt that indigenous participation in engineering studies and in the engineering workforce at all levels, but more particularly at the professional engineering degree level, are so low that the use of percentages relative to the general population becomes inappropriate. To illustrate, the higher education statistics for 2009 (DEEWR, 2009) state that across Australia there were more than 53,000 applicants for university degrees in Science, Technology, Engineering and Mathematics (STEM) fields in 2009. Only 282 applicants who identified as indigenous applied to a STEM field. Of these, 213 were offered a university place in a STEM field and 184 accepted. (STEM fields include all the natural and physical sciences, ICT, engineering, mathematics, architecture and building, and environmental studies.).It is evident that indigenous participation in engineering at any individual institution is likely to be in single digits.

Participation in higher education is very dependent on school performance. Current performance gaps between indigenous and non-indigenous student outcomes indicate that much remains to be achieved on every aspect of school performance. The Human Resources Commission (2008) reported that in 2006:

> *"For secondary education: The proportion of Indigenous peoples over 15 years who had completed Year 10 was 33% in major cities and 24% in remote areas. The proportion of Indigenous peoples who had completed Year 12 was 29% in major cities and 13% in remote areas."*

Indigenous students clearly lack engagement and connection with mathematics and the physical sciences at school level, It is all too easy to blame the gross under-representation of indigenous students in engineering as a consequence of school performance and their choice of school subjects,

and thereby absolve higher education engineering providers from further action. Whilst schooling may well be a major factor, the slow but steady rise in indigenous participation in higher education as a whole, has not been matched in engineering.

In engineering, educators recognise that engineering students undergo an enculturation into an engineering "way of thinking" as they progress through their study (Godfrey & Parker, 2010), without ever questioning our assumptions about the way knowledge is constructed and valued. Research over the last 15 years, particularly within science education has highlighted the privileging of different epistemologies of "Western" scientific knowledge relative to indigenous ways of knowing (Rigney, 2001). It has been suggested that indigenous students' access, retention and engagement depends on the recognition of indigenous knowledge and experiences which indigenous students bring with them to the university environment (Syron & McLaughlin, 2010). At secondary school level, culturally appropriate curriculum development models have been proposed for teaching Western science to indigenous students in Australia (Michie & Linkson, 1999) and New Zealand (McKinley, 1996). Although understanding and adoption of social and environmental responsibility are graduate attributes for accreditation of professional engineering degrees, little evidence exists of consideration of culturally appropriate curricula in tertiary engineering institutions. Thus indigenous knowledge and practice remain, at best, "add on extras" sprinkled lightly in subjects addressing consultation, environmental and sustainability issues.

We would argue that greater retention and successful completion of university degrees by indigenous students will depend on their academic performance, and their ability to assimilate into the academy, and find a personal sense of belonging that reconciles Western concepts of knowledge and their chosen profession with indigenous frameworks and perspectives.

Concerns with the lack of participation by indigenous students in engineering study can be viewed as driven from two perspectives:

Firstly, students, their families and communities need to understand the pervasive influence engineering has on their daily lives and value their potential to harness that influence for their personal and community benefits. Assisting students to recognize, and personally identify with, good employment opportunities at a range of levels in engineering is the first step to them engaging in engineering study.

Secondly, the profession and practice of engineering in Australia needs to serve the interests of all sections of Australian society, and deliver economic, environmental and social outcomes for all. We face many complex challenges in mining and mineral rights, water management, climate change, access to telecommunications and information technology, transport and energy infrastructure. We need informed voices, including those of more indigenous engineers, to ensure the future well being of this country and the prosperity of its people.

Methodology

The recommendations from the 2008 review included the need to "address shortages by attracting people from non-traditional backgrounds" and "embrace concepts of inclusivity in the curriculum". An Australian Learning and Teaching Council project has been funded that picks up on the first point, with one of its aims being to "investigate educational pathways that attract, train and retrain people from under-represented groups, taking into account their special requirements" . Recognising the magnitude and complexity of the issues concerning indigenous participation, not only in engineering but in higher education in general, the present project has limited its scope to investigating actions that could be undertaken by engineering schools in collaboration with other sections of their institution, the community or external organisations.

The project has built on the findings of relevant literature and reports, and discussions with persons identified as key informants from university indigenous support units, staff and students from five universities with a background in indigenous support activities, companies with indigenous engineering recruitment initiatives and representatives of the Australian Indigenous Engineering Summer School, and the Australian Indigenous Mentoring Experience. A draft position paper was

prepared that aimed to scope opportunities for new curricula and support systems to contribute to affirmative action initiatives to aid recruitment and retention of indigenous students in engineering. The paper was circulated amongst those who had earlier taken part in discussions, and a feedback forum was conducted. This conference paper is a brief summary of the findings that will be conveyed as outcomes of the project.

Barriers

The two major barriers to the growth of indigenous participation in engineering (and ICT) education were identified as:

- the lack of engagement and sense of connection to engineering with little awareness of the relevance of engineering to the individual and community;
- the lack of a pool of suitably qualified Year 12 students.

The first barrier requires wider thinking than a "show them engineering – how exciting it is and they will come" approach. Several informants suggested that engineering (and other professions) is seen by the majority of indigenous students and their families as a "pie in sky" target – not achievable or accessible. In engineering particularly there is a dearth of role models who can demonstrate its career and community possibilities.

There are two aspects to the second barrier, the lack of a qualified pool of applicants:

- high school completion rates are not high; for a significant proportion of indigenous students, retention to Year 12 is itself a major triumph;

- the pool of indigenous university applicants who have studied mathematics and physical sciences beyond Year 10 is not growing appreciably.

Students who had made it through to studying engineering spoke of not being able to take some Year 12 subjects because of limited school resources and being advised to take only lower level mathematics, to either attain a higher overall ATAR score or because they had sought additional help with the higher level mathematics. Lack of encouragement from family who do not have experience of the demands of higher education study and issues around self-perception and self-belief were also discussed as challenges even for a well motivated student.

It has been suggested that higher proportions of indigenous students undertake VET study – initially at Certificate level. This has not been verified, although industry sponsored indigenous cadetships and back to work training has appeared to target vocational study at AQF Certificates 3 and 4. Students have been encouraged (or recommended) by family and teachers to take up vocational opportunities eg a job rather than a career, particularly when immediate earnings are in prospect.

Clear articulated pathways to engineering study and explicit guidance through them are not uniformly and nationally available. In the Northern Territory, for example, there are no providers of TAFE Diplomas or Advanced Diplomas in Engineering.

Although our principal concern here is recruitment of more indigenous students, the attrition theme of the ALTC project has also provided evidence that individual indigenous students are not strongly retained post-entry. Issues of isolation, personal confidence, and growth of identity with their area of study are thought to be critical. When numbers are so small, one student dropping out is a major catastrophe.

Opportunities and Best Practice

Recruitment and retention of indigenous students into engineering education at tertiary level are complex tasks involving many separate systems and sequential activities by a number of sectors and agencies. The engineering faculties and schools can play important positive roles, particularly if they operate in partnership with other units and organisations. Valuable sources of background reading for appropriate strategies for curriculum and support systems involving indigenous participation were found from work in other academic disciplines (Drysdale, Faulkner & Chesters, 2006; Dyson, Hendriks & Grant, 2007).

The current project has had a specific interest in recommendations for curriculum design and delivery. Inclusive curricula, project based learning and bridging and transition courses provide three opportunities for engineering institutions to demonstrate their commitment to equity of access and outcomes.

Inclusive curricula

Indigenous students are all but invisible in engineering classrooms, but 'Inclusivity' is an approach that aims to recognise and build on the knowledge, skills and experiences of ALL students regardless of their proportions in our classrooms. The naming of inclusive curricula implicitly recognizes that for some groups of students there has been, and often still is, a marginalization, or lack of fit for them in the dominant culture of the classroom, disciplinary content and pedagogy. For indigenous students in Australia, regardless of their level of urbanization, their isolation in courses such as engineering is likely to see them struggle for authentic self-identity as prospective engineers.

'Inclusivity' can be addressed through the choice of teaching methods, the process of curriculum design, the selection of assessment processes, the establishment of productive classroom environments, and departmental and institutional factors such as staff selection and promotion.

A considerable bank of resources and research has been compiled at secondary school level for inclusive curricula addressing inclusion of diversity and equity categories of gender, race, and disability. Projects such as the Australian Research Council (ARC) research project "Indigenous knowledge and Western science pedagogy: a comparative approach" which aims to determine the most effective ways of incorporating Indigenous knowledge within the NSW secondary school science curricula provides an excellent reading list at http://livingknowledge.anu.edu.au/html/background/suggested_reading.htm.

An ALTC project primarily targeting inclusivity in engineering education from a gender perspective is expected to provide recommendations and guidelines which will be transferable to other marginalised groups in engineering education (Mills, et al, 2010).

Project based learning

Engineering curricula have many opportunities to incorporate topics relevant to indigenous knowledge, practices, current and future needs into project based learning across the curriculum. A requirement of such projects should be to ensure that students consider a variety of perspectives when considering the "problem" and its possible solutions. The Engineers Without Borders organisation (http://www.ewb.org.au/) has relationships in place with indigenous communities and an Undergraduate Research Co-ordinator who could provide suggestions for working in this area. The EWB challenge for 2010, requires students to use their problem solving and design skills to support the development of the Kooma Traditional Owners community in South-western Queensland by means of a wide range of suggested projects. The development of these projects has involved considerable consultation with the aboriginal community, exemplifying best practice.

Bridging and Transition programs

Where Bridging or Enabling programs and courses exist within a university, engineering faculties should maintain a pro-active relationship with their staff and Indigenous support units to ensure that the courses offered are appropriate and encouraged to be seen as pathways with clearly defined criteria to engineering degrees. The bridging programs at Charles Darwin University (http://www.cdu.edu.au/community/indigenous_alternative_entry.html) and the University of Southern Queensland (http://www.usq.edu.au/caik/programs/ihepp) were identified as exemplars.

Moving beyond curriculum based initiatives and internal support systems, to outreach, opportunities exist for engineering institutions to play meaningful roles in raising the profile of engineering in indigenous communities and assisting in raising the personal goals of their youth.

Mentoring

Personal and academic mentoring has long been seen as a strategy for encouraging students at all levels and from all backgrounds to aim high, and increase their self-perception of worth and ability. A

personal relationship with a mentor has been shown to be a decisive factor in high school completion and retention within higher education for indigenous students (AIME, 2009). Rather than mentoring being seen largely as a remedial strategy targeting at-risk students, some "best practice" initiatives shift perceptions from remedial to "readiness, recruitment, retention, and role modelling" (Murray and Morgan, 2009), thereby promoting excellence rather than academic survival. In engineering, where numbers are so very small, indigenous students are likely to need support from outside the discipline or from a non-indigenous mentor.

There are several opportunities for engineering institutions to pro-actively take part in mentoring – using in-house programs in conjunction with their own Indigenous Support units, or working with external organizations such as the Australian Indigenous Mentoring Experience (AIME), or the Smith Family.

Seven universities, across three states, are now acting as AIME host-institutions. The AIME program uses a unique style of structured education mentoring to link university students in a one-on-one relationship with high school indigenous students. AIME's objectives are to increase Year 10 and Year 12 progression rates, and university admission rates for all Indigenous Australian students who participate in the program. AIME has reported that for AIME schools the Year 10 to Year 11 progression rate was 81%, compared to the NSW rate of 59% and the Year 12 completion rate was 73%, compared to a NSW rate of 60% (AIME, 2009). The potential for this program to continue to expand and influence the next generation of university students is enormous. Whilst the program does not target any particular field of study, there is potential for engineering providers to ensure that their students are represented amongst the mentors and seek other ways of interacting with a motivated group of school students.

Outreach opportunities

Outreach opportunities abound, to communities and through relationships with schools. The practical nature of engineering, utilizing science and mathematics in real-life contexts, provides a plethora of opportunities for university students and staff to work with teachers and school students –by making expensive and scarce equipment available, and by explaining and demonstrating the application of scientific theory and concepts in engineering. Some suggestions are provided in the next section.

Pre-university taster programs have a special role for indigenous students, the majority of whom come from homes and communities where attendance at university is not a traditional progression. Providing a taste of university life and possibilities by way of positive experiences which promote self-confidence and belief in their personal potential has a special importance for these students. It is seen as necessary to introduce indigenous students to university life prior to Year 12. Indigenous units who organise the majority of targeted pre-university taster programs would welcome pro-active participation by engineering staff and students in these initiatives. The Australian Indigenous Engineering Summer School, now involving three universities is a proven exemplar that has resulted in increased enrolment into university engineering.

Recommendations and Ideas for Action

One theme that came strongly from our consultation with indigenous academics was the vital importance of building Relationships. Trusted relationships take time: they must build and value mutual respect. In particular, three guiding principles, bluntly expressed, in making and applying recommendations were seen as:

1. Success cannot be defined only in terms of "bums on seats": there is a need for university management to recognise the limitations of quantitative performance indicators. Outcomes cannot be guaranteed and results may be long term. Even "drop outs" will have gained personal skills and can take messages back to their community and family.

2. A broad range of initiatives is needed: there is no magic bullet: some initiatives will work and some won't, and acceptance that there will be disasters is necessary.

3. Some initiatives sound good in theory: how to do them must suit the community they are targeting. Consultation prior to the commitment of resources is a "must do"

One concern by the investigating team was the lack of a national strategy or commitment from an engineering perspective to the growth of participation by indigenous Australians in engineering education. On the other hand, most universities are working towards increasing their enrolments of indigenous and low SES students, as recommended by the 2008 National Review of Higher Education (Aust Govt, 2008). The question arises of whether a unified strategy would be preferable to each institution operating in isolation. Would it be feasible, or advantageous for indigenous engineering students to study in just a small number of the 30 plus engineering schools, so as to increase their critical mass at those institutions? Would recruitment activities be more efficient and effective, if driven by a national discipline based project? We envisage that these questions could be debated in future forums of engineering education leaders.

The consultations led to many ideas for initiatives that address the issues previously identified as barriers. An underlying principle of intent is to provide support and initiative to ensure that indigenous students attain the same standards of academic excellence as their non-indigenous peers. The ideas are summarised here to promote further discussion and future action.

- **Initiate and maintain a relationship with your institutional Indigenous Support Unit**
  You can help them, and they can help you through activities such as advertising scholarships; arranging pre-engineering programmes; Open Days; spotlighting success stories in indigenous media (not the Sydney Morning Herald!); ensuring students gain adequate information and support; building relationships with a community for project work with community ownership of the need and the proposed solution.

- **Outreach to Schools and Three-level Mentoring**
  Take university/faculty based initiatives in conjunction with Indigenous Support Units in areas such as: building relationships with school mentoring groups such as AIME, Smith Family; develop academic and industry mentors into university programs in a "reach up, reach in and reach down" concept.
  Build relationships with school subject teachers and career advisers; to provide engineering examples into school curricula; bring teachers into the university; develop a "teacher in residence" program; developing roadshows and summer and winter schools for Year 9 -10 students.

- **Increase engagement and connection of indigenous students and their families to engineering opportunities**
  Build a working and learning relationship with a local indigenous community: take time; be sensitive to negative views of engineering drawn from historical experience; locate indigenous engineers; and form a network between them to provide role models and be mentors for university students, and publicise them in community media.

- **Curriculum initiatives and Pathways**
  Develop bridging and enabling pathways, including first year engineering subjects. Support students on such pathways, noting that they might take 2 years to complete first year engineering with some courses classified as enabling subjects to ensure no extra HECS liability. Strengthen relationships with TAFE providers for students coming through this route.
  Develop inclusive curricula and assessment (and provide staff support)with explicit content on how cultural diversity can lead to different priorities, values and beliefs and ways of knowing; explicit clarification of the beliefs and assumptions underpinning the engineering way of knowing and practicing; project and problem-based learning; hands on involvement by engineering students working with communities to assist with their concerns such as housing, infrastructure or water management projects.

- **In-house Support**
  Appoint an indigenous staff member to a teaching role in a core course, or bring in a non-engineering indigenous graduate to team-teach.

> Provide indigenous engineering students with their own space, and identify a (willing) staff member with a liaison/mentoring role as first point of call, and develop a buddy system.
> Seek to provide portable scholarships with accommodation support.

- **Form relationships with local or national industry**
  Work with industry to sponsor a short documentary on indigenous cadet engineers particularly featuring their jobs as interesting, well-paid and secure, with leadership, responsibility, and opportunities for adventure and travel, and being about discovery and innovation, and "making a difference".
  Seek sponsorship for roadshows to primary and secondary schools in regional and rural areas particularly to "light the spark".
  Encourage industry to form a "Neighbourhood Engineers" type relationship with local schools – particularly where no university is close

Conclusions

The ultimate aim of growing the number of engineers with indigenous backgrounds is a long term task, and is one which will involve commitment from a wide range of contributors, not least of which are indigenous educators and representatives of indigenous communities and organizations. The constraints of our project limited its focus to strategies and actions that lie within the realm and influence of the university engineering schools. After summarizing what are seen as barriers to this growth, we have suggested examples of opportunities that might be available by way of internal changes in curriculum, pedagogy and support systems and external relationships with appropriate organizations. The recommendations provided in this paper and from the project will be taken to the Australian Council of Engineering Deans and disseminated to providers of higher education engineering degrees in the hope that we, as engineering educators, can work towards a more equitable representation of indigenous Australians in our student body and ultimately, the engineering workforce.

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