

Full Paper

Abstract

Engineering education programs make little mention of 'Aboriginal engineering' despite 40,000 years of active human engagement with this diverse Australian environment. Beginning from the premise that providing *Indigenous Student Support Through Indigenous Perspectives Embedded in Engineering Curricula* (Goldfinch, et al 2013) could encourage Aboriginal teenagers into an engineering career this project focused on curriculum-based change, including development of a model for inclusive teaching/learning spaces and study units. To identify barriers to inclusion, we explored the engineering principles and practices of pre-contact Aboriginal civilization. Since non-Aboriginal students would be engaging with such knowledge, they would need to understand at least something of the heritage of their Aboriginal peers - so finding ways to engage them in the process became important. Rather than identifying ways to attract Aboriginal engineering students, the project outcomes have shifted to establishing inclusive learning spaces through including knowledge about – and enact of - relevant Aboriginal practices and principles in engineering content. This paper introduces the resulting model, explores its potential influence on engineering curriculum development, and reports on implementation strategies.

Introduction

Histories of Engineering make little mention of the engineering activities of the Australian Aboriginal civilisation either before – or after – the arrival of European influences. Until Blainey's most recent volume [ref] Australian history texts also make no mention of engineering activities in the era prior to the arrival of European residents. Exploring why this is so is the province of History, Sociology, Anthropology and Archaeology, not Engineering. However, in the context of Engineering Education the issue came into focus as team members worked on developing a model for embedding Indigenous (see afterword for comment) perspectives into engineering curricula. The goal is to encourage educators and students to collaborate in building more inclusive learning spaces. Along the way it led to new insights into factors affecting broader social mores, and over time to the present model.

Background

The absence of Aboriginal and Torres Strait Islander students in Engineering classrooms has recently come into focus as a result of Engineering Industry and University participation agendas (Australia, 2011; Behrendt, Larkin, Griew, & Kelly, 2012; Billiton, 2012; Tinto, 2013). In recent times awareness of systemic disadvantage - and actions to correct it - created an environment in which understanding the reasons for the gap, and steps to reduce it, have both been gaining attention (Engineering, 2015; Rahilly, 2015). The total number of Aboriginal students in academic Engineering programs at this time is low. Similarly, there are few professional engineers with an Indigenous heritage. Reasons for this situation are multifaceted, and seeking to understand them was secondary to the projects' task and goals. However it is not a situation that could, or should, continue; and a number of efforts are being made to redress the balance (EAA, 2013). This project chose to address the issue at the level of direct engagement between Engineering Educators and their students - both Indigenous and non-Indigenous – proposing to *'develop an approach to indigenous student support that is integrated within existing engineering curricula'*. The proposal noted that -

In 2008, just 20 Aboriginal and Torres Strait Islander students graduated from engineering degree programs around Australia (Calma, 2009). This figure represents

a tiny fraction of engineering degree completions, and highlights the need for significant action to increase the number of indigenous students completing their studies.

The proposed actions included development of

- Guidelines detailing indigenous cultural values and their relationship to engineering education and engineering epistemology and design
- A model for the development and implementation of elective course content focusing on indigenous cultural appreciation that is applicable to other design oriented fields.
- An elective subject that links indigenous perspectives on country and connectedness to local engineering projects.

Increasing engagement and retention involves making Engineering classrooms more inclusive and more receptive to Aboriginal students' heritage and learning needs. The project began by exploring what is currently understood about Aboriginal approaches to learning (ref) with the intention of establishing how these could be incorporated into conventional academic teaching contexts. This led to an assessment that available strategies would be difficult to adapt to Engineering education contexts as they made it necessary for educators to learn how to apply new, and unfamiliar, teaching strategies to an already crowded teaching program. The team recognised that incorporating complex new teaching methods would not be a welcomed imposition, however worthy the goal, and searched for other strategies to increase inclusiveness without adding too much additional new effort.

During this phase we found we found that the question of 'what is Aboriginal engineering?' was emerging from discussions with interested observers of the project activity. They were intrigued by the idea of 'Aboriginal engineering' seeing it as a term that seemed to be part conundrum-part oxymoron. Their curiosity driven questions influenced our work both in regard to answering their question about '*what is Aboriginal Engineering?*' and shaping the model for embedding Indigenous perspectives in Engineering curricula. Gradually as we built up a body of knowledge, the component parts of the model began to emerge. When it was unveiled, via an exhibition and in workshop sessions as part of the National Indigenous Engineering Summit (June 2015) the model did not mention 'Aboriginal Engineering' as such but had been greatly influenced by the search for answers to the question of 'what is Aboriginal engineering?'

What is Aboriginal Engineering?

Other research has described how finding answers to such a question begins with asking '*what is engineering?*' To which a satisfactory answer is that it is

... a problem-based practically oriented discipline, whose practitioners are concerned with finding the most technically and economically effective solutions to practical challenges. [ref]

Described this way the practice of 'engineering' is as integral to Indigenous communities as in any other form of human society. A second question then emerges - '*what evidence is there for aboriginal engineering?*' It became clear that no one was asking this question, and the required evidence – if it existed – had to be sought outside the borders of engineering.

For this paper, three examples of Aboriginal engineering will suffice to indicate the scope of Aboriginal engineering activity pre-1788. Budge Bim (also known as Lake Condah, in the western region of Victoria is an extensive aquaculture site continuously occupied for thousands of years (McNiven, I & Bell, D 2010). The residents farmed eels, in a series of constructed dams and water channels, and smoked and traded their products over a wide region. Wilgie Mia, a deep and extensive mine in the Weld Range of Western Australia was also in continuous use for about 8,000 years (WA) producing an estimated 42,00 tons of

ochre over that period. Finally – in this list – is the materials science knowledge involved in such things as the making of woven baskets and deadly accurate spears and boomerangs [ref Brit Museum book]. As we collated this knowledge it was evident that this is a neglected area of engineering knowledge, and has potential to alter many other perspectives on aboriginal culture and civilisation.

Approach to Developing the Model

In the 1990's the Australian Tax office set out to devise and implement an entirely new approach to tax collection. Its intention was to shift thinking from a (paraphrased) stance of 'tax payers cheat, and our job is to prevent that' to 'tax payers are honest and as some make mistakes, our job is to help them.' In the course of that activity a cartoon emerged to become part of the educational materials used to introduce the new approach. It aptly describes our dilemma as this project temporarily morphed into a search for evidence of Aboriginal Engineering that could help address our intended goals.

Captioned "Lost at the Beginning" the cartoon depicted a group of fearful adults groping their way through a fog of 'unknowns'. The image reflects our own sense of fear, excitement and bewilderment. To resolve this we used – in no particular order – conversations with members of the local Aboriginal community, desktop research, discussions with academic peers, and analysis of notions of 'engineering' to help identify where to look, and how to look at, known artefacts of Aboriginal heritage. We also held several workshops to expose our thinking to the critique of academic peers.

We also had an opportunity to apply our emerging understanding to a first year engineering subject during Spring Semester 2013. The subject used the principles of the Engineers Without Borders Challenge [ref] and the decision was made to focus on a local site where an Aboriginal tent embassy has been in continuous occupation since 2000. The site was subject to a Management Plan of Action [ref] and was in urgent need of ideas to make it a more habitable location. Team members revised the project component of the subject and took students to the site, introducing them to traditional Aboriginal concepts of living and relationship with 'country'.

The student response was very positive and their projects produced some highly innovative ideas to meet the criteria for combining Aboriginal needs with conventional engineering solutions. This experience led to recognition that we were actually working across three domains of knowledge – now called 'Dominant', 'Aboriginal' and 'Disciplinary'. Although initially titled 'Western', 'Aboriginal' and 'Engineering' further analysis indicated that 'Western' did not define what we intended the classification to delineate. More recently, as we presented this aspect of the model to those in other disciplines it became evident that 'Engineering' - our focus of activity - equally well represents the fact that all disciplinary studies shape thinking and knowledge sets in particular ways. Discussion about the 'worldviews' led to collating them as a Venn diagram to highlight the 'Intersection' as the place where our work is operating.

The remaining elements of the model emerged in a similar fashion, through exploration, discussion, debate and analysis of our respective knowledges and understanding of the forces at work in the intersection. Each of the elements in the model, and factors influencing their emergence, are described next.

A Model for Incorporating Aboriginal Perspectives into Engineering Education

The model, presented in Figure 1, summarises diverse perspectives on its topic. Modes of Aboriginal thinking and knowledge generation were informed by local community input, as

well as the extraordinary text of Sveiby and Skuthorpe (2006) and we are continuing to research and refine the textual underpinning.

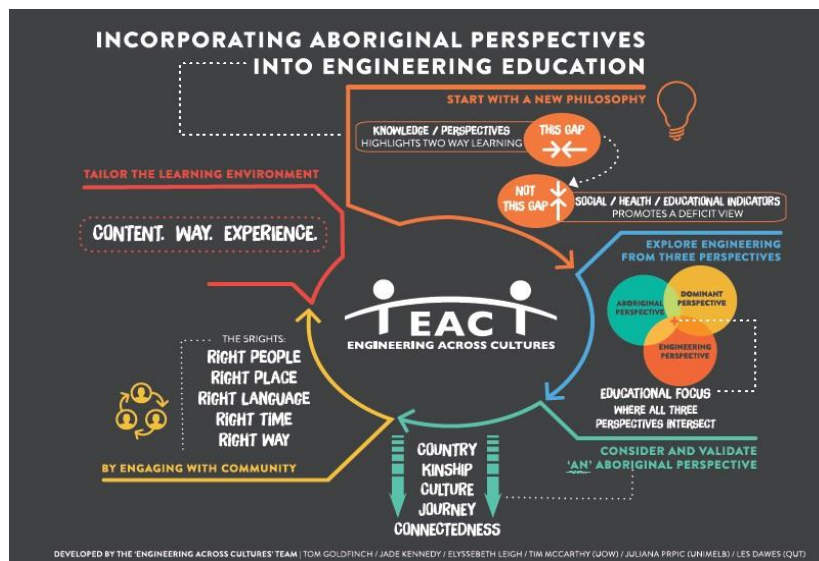


Figure 1 Model for embedding Indigenous perspectives in engineering education

Start With A New Philosophy

This concept was a late addition to the model, although, reflection indicates that it had been a behind-the-scenes factor, shaping our thinking for a long time, albeit without conscious awareness. The search for evidence of Aboriginal engineering uncovered a wealth of material and appreciation of a fact that now seems blindingly obvious – namely that Aboriginal engineering is informed and shaped by a set of social principles and philosophical propositions so different to Western equivalents as to render their engineering impact almost invisible to Westernised eyes. This ‘invisibility’ continues as politicians, and others ignorant of the truth, assert that

"As we look around this glorious city, as we see the extraordinary development, it's hard to think that back in 1788 it was nothing but bush," (Abbott quoted in Henderson, 2014)

Researchers such as Gammage (2011) and Pascoe (2014), demonstrate that such assertions are simply not true, while its existence contributes to the survival of the ‘deficit model’ of relative standings of Western and Aboriginal civilisations. The comment shows a belief that Aboriginal modes of living and engineering are primitive and therefore lesser than those of Western achievements, whereas we now understand that the difference lies in relationships with ‘Country’ which shape the working out of all interactions with it, in both cultures. Mary Graham describes Aboriginal thinking on this issue in this manner –

The Dreaming is a combination of meaning (about life and all reality), and an action guide to living. ... The land, and how we treat it, is what determines our human-ness. ... the relation between people and land becomes the template for society and social relations. Therefore all meaning comes from land. You are not alone in the world.

Comparing these two very different perspectives brought to light The GAP in our knowledge, which concerns continuing – or ceasing – to apply a ‘deficit view’ to Aboriginal people, both present and past. The GAP came into view during workshop conversations and was an essential factor in understanding the principles that shaped engineering on this continent during 40,000 years of continuous civilised occupation. Identifying The Gap created space

for the concept of *two-way learning* as the opening point for the model. Two-way learning provides engineers, from both domains, with opportunities to explore each other's work as equals. Neither one has 'the solution' to a problem - both have viable and effective solutions, based on different notions of ownership, relationship and *harm*. This emphasises the importance of a shift from a vertical, deficit view - commonly associated with modern social, health and educational indicators - to a horizontal view focusing on the meeting of knowledges and perspectives, opening possibilities for two-way learning.

Explore Engineering From Three Perspectives.

This was – as noted above – the beginning of the model and although the labels for each element have changed slightly, it encapsulates the approach that we used to develop early drafts of the promised elective subject. Taking the time to look at an engineering problem through three quite different lens takes longer, and can be seen (especially by those only familiar with the 'dominant' perspective) as time wasting and futile. However we consider that enabling students and teachers to learn to operate effectively in the 'Intersection' will – given time - contribute materially to a reduction in disputes arising in the later stages of projects. Adopting, and teaching, this approach allows for a depth of personal reflection that models an aspect of Aboriginal ways of learning. While we do expect that some non-Aboriginal students may consider this a mis-direction in regard to learning about how to manage technical projects (for example) trial subjects incorporating this approach are delivering evidence of positive student responses to the task of using three lens before making decisions or taking action.

Consider and Validate 'An' Aboriginal Perspective

The 'An' in this phrase is vital. We recognise the existence of hundreds of culturally different nations on this continent 200 ago. The mistaken assumption that they all share one view of the world has led to many unsatisfactory non-resolutions of engineering problems. The following summarises a philosophical stance informing aspects of Aboriginal civilisation, which is not complete. It originates in the Illawarra region of modern Australia and links to the traditions of that area. Users are urged to examine how closely it resembles principles informing Aboriginal communities in their own sphere of activity. This aspect of the model has the following background characteristics -

- It's a framework for understanding values informing decision making
- It was articulated by a Countryman from this region –adaptations will benefit from similar engagement with the local community
- This version has reasonable acceptance within the local community. All adapted versions will benefit from engagement with the local community
- As far as we can we have validated the principles, but accept that complete validation is unlikely – given the diversity of perspectives even within this one region. So choosing how to validate variations is always important.

This excerpt from the Project Blog summarises key aspects of this part of the model. Accepting that 'different' does not mean 'less than' or 'more than', means accepting diverse beliefs and cultures, and is essential for sustaining respectful attention to the goal of effective communication. But it does not extend to unquestioning acceptance of specific beliefs and values. With these in mind, non-Aboriginal parties involved in collaborative activities can become more adept at appreciating how Aboriginal participants engage with both people and the land.

The 5RIGHTS as a Framework for Engagement

The 5Rights are the key factors to be considered once a project, or other activity is emerging, and there are three key aspects of their usage. First all five are connected, and any one may be the start point for a project. Second, if any one is absent the only viable option is to stop. A car has five wheels (including) the steering wheel. Without any one wheel it is un-driveable. The Blog records that

People

It is vital to ensure that the people you are engaging with are the 'right people' – finding and working with them may be complex, difficult. A general focus is on 'elders' – however these are not always readily distinguishable from 'olders'. And each term and group members needs careful exploration. Key to success is transparent honesty about actions and intentions along with valuing the people on their own terms – which will need to be discovered.

Place

This has four components.

- 'meeting places' where discussions and negotiations occur
- an 'artefact place' – when the project is based on a physical location
- *intergroup connections* place/s – where multiple groups may meet safely
- *Place for the work of the project* -

The project itself may be a factor sensitising others to the importance of 'place'. It is vital to be alert to all these issues since your actions, and choices demonstrates your understanding (or not) of its importance and will influence all that follows.

Timing

It is important to know the needs and timeframes of all involved, and may include a lot of waiting and watching. Patience is the watchword. Knowing the needs and priorities of the people you are meeting is vital. Remember Tuckman's [ref] sequence of: Forming, Storming, Norming, Performing, and Mourning. In Aboriginal traditions the Forming phase carries particular weight. It can take a long time to get to the point.

Language

Elders are entitled to respect – their knowledge may have no parallels in western or engineering contexts but it is vital and valuable and must be treated as such. Your speech must be clear and concise, without condescension. If you are experiencing a sense of not being understood, do not impose meaning. Check for understanding – and wait for it to arrive. The referendum acknowledging that Aboriginals are

An Aboriginal Perspective

The items are listed in this order to indicate their cumulative impact on behaviours and relationships. However, even a superficial inspection shows they are a cycle wherein each one leads to the next, and back to the beginning. Connectedness leads back to country and country points in the direction of inter-connectedness. This is the most difficult word/concept of all. However paradoxical, it is true that there is, and is not, One Right Way. On many occasions it is simultaneously

• e to get things right and wrong. The perhaps because one deals with the possible surroundings, one's nature, group and got things 'right' only to find it is 'wrong' for another.

- *Kinship* – connection to people (family, kin, people of significance). There are roles and responsibilities/obligations that evolve with these relationships, over time shaping how they bind you to 'your' place.
- *Culture* – a core understanding that culture is a lived day-to-day expression of who and how to be. This is a reflection of the history (story) experienced within a place (country) and specific to that place and people.
- *Journey* – lived experiences (can be shared, and regularly are). One's experienced connections with time, place, people, day-to-day happenings.
- *Connectedness* – All things are inter-connected! And the harmonisation of concepts creates one's true sense of belongingness

Content. Way. Experience.

These three terms encapsulate our recommendations for applying the model as a whole. In academic contexts the key focus may be on information to be imparted, and 'knowledge' to be acquired. This is the 'content' of any learning activity and the work that produced this model demonstrates that both 'information' and 'knowledge' include far more than technical and scientific factors. If Aboriginal students are to feel included, and non-Aboriginal students are to improve their understanding of the first inhabitants' culture and knowledges, then the 'way' of delivery must reflect this. Lectures and written transmission modes will not be a sufficient means for ensuring knowledge has been absorbed and made personal. The role of first-hand 'experience' in enabling both teacher and learner to become comfortable with new knowledge and processes cannot be underestimated. In Aboriginal society practical experience is a primary learning tool. Western tendencies to limit 'learning' activities to passive transmission and receipt of information in abstracted forms will not allow students to engage with the 'experience' of being Aboriginal, and Aboriginal education modes suggest that without experience learning is not complete.

Discussion

The slow evolution of this model for embedding Indigenous perspectives in engineering education has somewhat paralleled what we have come to understand about Aboriginal society. Things take time, and allowing them to emerge naturalistically has enabled each project team member to evolve and develop our own perspectives on the wider agenda of engineering education and Aboriginal engagement in this, and many other aspects of Australian society. It has not prevented steady progress on the project, while enabling ideas to emerge and grow.

Taking the elements of the model through the process of trial via actual subjects during the last two years has contributed to the emergence of some essential components of the complete model. It has also clarified how the elements fit together and why each one belongs in its place on the model. We do not claim that this is a perfect or absolute model of how to engage with Aboriginal society in other contexts, although we are beginning to suspect that it

may have wider relevance than we first suspected.

The non-Aboriginal students who have trialled our approach report a much better understanding of both their own perspectives in engineering, and of Aboriginal culture in the 21st century.

As the project moves into its final phase we are aiming to make the model widely known and inviting readers to the Blog to extend their understanding of the issues we have addressed.

Conclusion

One clear and obvious outcome of the work to date is the acknowledgement of Aboriginal civilisation as having had viable engineering principles and practices extending back thousands of years. The implications of this for engineering education and eventually for the engineers who are being educated will be wide ranging and – we hope – lead to permanent changes in the general view of Aboriginal culture.

The learning, consultation, trial and discussion that has led to this model has emphasized one essential point: Engineering education that is inclusive of Indigenous perspectives cannot be achieved without sustained and productive relationships between Indigenous Communities and Engineering Schools. This is where the sector in Australia still has much ground to cover before real changes are seen.

AFTERWORD - The project title used the word 'Indigenous' – however as the project itself has proceeded we have become sensitised to the complexities of using the terms Aboriginal and Indigenous. Thus in this paper we chose to use the word Aboriginal unless there was a wider focus (e.g. Aboriginal and Torres Straits Islanders). Use of this word, in preference to Indigenous, has helped us concentrate on the Australian context and contributed to our own growing awareness of the complexities of the naming issues involved.

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