Manly, Sydney, Australia

Aboriginal Engineering for an enduring civilisation

Cat Kutay, Elyssebeth Leigh
University of Technology, Sydney
cat.kutay@uts.edu.au, elyssebeth.leigh@icloud.com

SESSION C4: The role and impact of engineers and the engineering profession in the wider community

CONTEXT Engineering is a set of practices and principles evidenced in the artefacts of human cultures. In the 21st century there is growing understanding of the implications of this for supporting innovation and sustainable practices. This paper specifically considers how Aboriginal cultures employed engineering principles prior to European arrival. Taking into account this combination of engineering principles, this paper introduces the next steps towards a framework for integrating Indigenous knowledge into the engineering curriculum. The aim is to provide a guide for engineering educators towards establishing and/or strengthening their engagement with local community knowledge holders to explore the principles and practices as well as teaching strategies of Indigenous technical knowledge.

PURPOSE Provide guidance in what is involved in developing processes for integrating Aboriginal/Indigenous engineering knowledge into engineering education, including provision of resources to contribute to revising our knowledge of Australia's technological history.

APPROACH Various approaches are being used to integrate indigenous and non-Indigenous engineering knowledges. These include locally sourced projects and encouragement of Indigenous students to become engineers. Integration of indigenous knowledge, frameworks and protocols into engineering education is increasing our understanding of the impact of engineering designed for specific cultures and values. This work provides engineering educators with an exploration of Indigenous engineering practices in pre-European times; and introductory work on assisting collaborative efforts between communities and engineering educators through:
- exploring how engineering education might be enhanced by incorporating knowledge about the civilisation occupying this continent prior to European arrival
- identifying sources of evidence for Aboriginal engineering, and relating this to engineering education to develop cultural sensitivity and sustainability knowledge in engineering education
- considering how such evidence as located in artefacts, concepts and physical contexts, can be used to expand the scope of engineering education programs across different disciplines

RESULTS These include protocols for engagement with Indigenous communities and suggestions for understanding Indigenous knowledge relating to Engineering and IT topics. We are in the process of developing an app to provide information to universities using location-based information. We also envisage this may also help tourist groups wishing to study aspects of indigenous knowledge and technology.

CONCLUSIONS Indigenous and non-indigenous engineering have many features in common, but until recently Indigenous knowledge has been ignored or denigrated. Developing ways to link awareness of similarities across engineering practices will provide practical and enjoyable experiences for students and educators, enabling them to expand their awareness of issues concerning sustainability, communication and cultural understanding in a diverse world.

Keywords Indigenous engineering, Sustainability, Community projects

Introduction

The tasks involved in integrating Indigenous engineering knowledge into engineering education are slowly being developed in a number of contexts: In-community projects; case studies in class; and indigenous approaches in teaching. Also the process of engaging Indigenous people in engineering studies includes: establishing scholarships for Aboriginal students; collecting archival and research material re-examining our knowledge of Australia's technological history; and exploration of protocols to connect with local communities on the basis of sharing knowledge as equals.

In particular the latter activity is integrating indigenous and non-Indigenous engineering knowledges, including locally sourced projects and encouragement of Indigenous students to become engineers. Such projects build on community collaboration, while also introducing and developing the concept of appropriate technologies. Integration of indigenous knowledge, frameworks and protocols into engineering is providing an opportunity to examine the impacts of engineering artefacts on various social and environmental conditions for which they were not designed.

The aim of the enduring Engineering project is to support engineers acquiring knowledge of Indigenous technology ether at university or through further study, with an app-based resource. This will, over time, link to indigenous community stories, records of local engineering knowledge, exploration of Indigenous engineering practices in pre-European times, and a framework for assisting collaborative efforts between communities, engineers and educators.

Background and Motivation

It is a troubling fact that many Australian government policies are based on a deficit view of Aboriginal civilisation, such as 'Closing the Gap' and the BasicCard to remove the control of finances. A direct impact of such positioning is to ignore the depth and scope of knowledge and capabilities embedded in the fabric of Aboriginal society and culture. This denies the longevity and complexity of the engineering history of Australia. Rather than considering knowledge as an opportunity for equal exchange and a meeting of minds, the deficit model is rooted in a belief that cultures occur as a hierarchy positioning some cultures as innately superior to others. Thus researchers position indigenous people as less than themselves (Craven et al, 2016) or than societies which developed the use of metals(Powell, 2008)

To redress the errors of such a belief involves establishing more valid method of engagement with Aboriginal knowledges. We consider in this paper some examples of what can be learned by adding Aboriginal perspectives to teaching and designing within the discipline of engineering. Valuing Aboriginal perspectives, and replacing out-dated perceptions of cultural inequity with a deeply respectful curiosity, positions Aboriginal knowledges as equal with, and simultaneously different from, other engineering knowledges, based on the observational processes used in knowledge gathering (Kutay, 2017).

Enacting this changed perspective helps to reveal that a key cause of the perception informing that deficit view, is a lack of knowledge exchange between Aboriginal and non-Aboriginal cultures. It resides in a general ignorance of Aboriginal beliefs and values, as well as a widespread lack of understanding of the practices, knowledges and principles underlying Aboriginal Australia's enduring civilization (Pascoe 2014, Gammage, 2011). One way to change this limiting perspective is to acknowledge the omission of Aboriginal engineering knowledge from current teaching practices, alongside the comparative absence of Aboriginal and Torres Strait Islander students from Engineering classrooms. One method for achieving sustained change in perspectives will be well informed learning strategies. It is clear that 17th century Aboriginal engineering knowledge paralleled the engineering known to Europeans in 1770, and that it was practiced across the entire continent in diverse, yet fundamentally similar, ways.

Enduring Engineering

What is now better understand is that when members of one culture are witnessing another culture in action, their interpretation of the actor's culture will be based on assumptions embedded in the observer's own culture. There can be no neutral analysis of what is being observed. It is in the moment of interpretation, when an author begins to interpret their observations, that tacit assumptions about superiority/inferiority begin to taint the description. Consider Pascoe's (p17, 2014) use of the following passage, written by a European observer in the late 1800's:

> As soon as the water began to run back to the river the blacks used to make a fence across these channels of thin sticks stuck upright, and close enough to prevent the fish going through, but leaving a space at one side, however, so that when the fish found they could not get through the fence, they naturally made for the opening. A black would sit near the opening and just behind him a tough stick about ten feet long was stuck in the ground with the thick end down. To the thin end of this rod was attached a line with a noose at the other end; a wooden peg was fixed under the water at the opening in the fence to which this noose was caught, and when the fish made a dart to go through the opening he was caught by the gills, his force undid the loop from the peg, and the spring of the stick threw the fish over the head of the black, who would then in a most lazy manner reach back his hand, undo the fish, and set the loop again on the peg.

> I have often heard of the indolence of the blacks and soon came to the conclusion after watching a blackfellow catch fish in such a lazy way, that what I had heard was perfectly true

In the 21st century more observant and enlightened thinking reveals the range of engineering concepts in action in what is being described. However the assumptions of this observer, presented here as accepted truth, demonstrate the absence of any comprehension of engineering principles. The constant repetition of such ideas helps explain the absence of more relevant and explicit records about, and respect for, Aboriginal engineering in Australian history.

Another, equally compelling reason for the low level of recognition of Aboriginal knowledges of engineering lies in the hardship facing Aboriginal communities in the face of loss of access to their country. Over time the knowledge went underground, and knowledge holders, those surviving disease or conflict, found it harder to ensure that what they knew could be safely passed on to future generations. People found many different ways of avoiding the demise of their vital knowledges (Skuthorpe and Sveiby, 2006), as Aboriginal Australia was a knowledge society long before the west recognised such a concept.

Available artefacts demonstrate clearly that the knowledge held in custody by generations of Aboriginal engineers was diverse, extensive and detailed. It was appropriate to the land and to the social structure and principles of the knowledge holders. Social and environmental conditions in Australia have changed with European settlement but this knowledge still can be applied as it is rooted in a deep understanding of how this country works. For instance when carp took over the Murray-Darling basin, it was Aborignal people who proposed the fish could be used as fertiliser (Duncan, 2017, pers. comm. October 6 2017)

Equal representation of ways of knowing

Bringing this enduring knowledge to general consciousness and achieving acceptance is clearly going to be a complex process. This paper is considering implications, suggested by the research summarised in Figure 1, of the overlapping segments in the Venn diagram, within which knowledge is common to various components. For example the overlap between the two forms of engineering - Aboriginal and Western (dominant) - proposes a

shared set of relationships in regard to engineering principles and practices. Both forms of engineering created buildings, constructed roads, excavating mines (DPI, 2007) and all the other visible and conceptual outcomes of technical processes that we employ, occupy and see around us today. While Western engineering examples are readily identifiable, Aboriginal engineered buildings, structures, transport routes and processes, designed on the principle of sufficiency and collective processes, are similar in function while quite unlike the products of Western thinking.

Figure 1 Aboriginal and non-Aboriginal knowledge intersect with engineering. Leigh et al 2015.

All human societies emerge from specific constructs having their roots in beliefs and values which created cultures and behavioural frameworks of immense variety and specificity. While conventional Australian history tells us a great deal about western principles and practices there is much less written about Aboriginal history and even less about the engineering. We are identifying and explicating Aboriginal engineering knowledge, to understand how this can have a minimal impact on both land and people at all times.

Representing this way of knowing, is not simple given the current broad social expectation that individuals can own and control property without any consideration of the long term effects on the surroundings. Consider, for example, the loss of water flow in the Snowy River and consequent damage to the land east of the dividing Range; and the current controversy and bitterness over efforts to manage the Murray-Darling basin to satisfy land owners who have different needs and priorities along the course of those rivers.

Knowledge Sharing Process

For student groups to work with community to design technology, we need to consider knowledge sharing processes and the kinds of engagement that is appropriate. If we want to share technology with Aboriginal people, we have to share the knowledge with the culture that is embedded (Mesthene, 1969). Either we are asking the community to enter the culture that created the technology, or we use engagement in design to change that technology to suit the culture. The first route involves assimilation and implies that cultural hierarchy of deficits of knowledge. The second route supports embedding of cultural knowledge in the new technology, and as the knowledge becomes part of the artefact, so will Aboriginal people begin to feel affinity with the product.

The protocols of knowledge sharing arise from the relationship between the researcher and the community. The procedures used in Aboriginal oral knowledge sharing reduce the potential for incorrect information being inserted into stories. The western concept of open format sharing of mainstream knowledge, too often creates the experience of invalid information being shared. Conversely, in functioning Aboriginal societies, information that should be private will not be shared publicly, and information that belongs to one person is rarely shared by another as claims of authority must be substantiated.

We need to understand the nature of traditional culture and how its processes remain relevant to today's values. To introduce students to this culture requires consideration of how and why processes will differ. What was each/any culture aiming to preserve and to create within the scope of its civilisation, and what is its understanding of the social and physical environment and how to live in it?

Aboriginal culture is based on an observational approach to science which makes full use of intuition and 'gut feeling' to gather information and understand the world. We consider how did such a knowledge gathering process maintains its integrity and what influenced and shapes those processes such that they remained constant and consistent, not changing at the whim of someone's vision or personal experience. That is, what ensured that the great range of such stories was worked into a coherent whole. Understanding these processes are crucial to understanding Aboriginal knowledge and how it is shared

What knowledge is valued

If western science tried to explain fire, the ripples and motion, where it will travel at any time, how much it will burn, how hot it will get, this would involve more non-linear equations than our present computer power could manage. An approach which operates by breaking science down into component parts and then build this up again into models of the whole system, tends to loose the picture of how things work. Use of the metaphors of clockwork mechanisms versus living organisms can help to explain the distinction between western and Aboriginal engineering.

When confronted with a complex problem, western trained engineers will approximate, reduce the variables, simplify the equations. The aim of such a process is to extract the patterns in the system, identify the main features and map how things generally interact. It in in this pattern matching that we start to approach the holistic methods used by Aboriginal teaching. This approach integrates sustainability from the start of any design or project (Kutay, 2017). If something is to be altered in any major way, the stories and knowledge sharing practises allow a long term consideration of consequences for everything involved, the people, land, flora and fauna.

Clearly if an Aboriginal approach had been applied to consideration of building coal-fired power stations in Australia, the outcome would have focused on developing clean energy and the present crisis in energy generation could well have been avoided. Aboriginal engineering values working with nature, the environment and the people.

How knowledge is taught

Aboriginal people used song cycles to provide contexts within which to remember and reinforce the knowledge that needs to be told in community meetings. Hence when sharing knowledge a very general moral story can be used for a context in perpetuity, but the individual aspects and histories that are provided within this theme will be those that apply to the present situation (e.g. the season) or the topic chosen (e.g. history at one place). These stories also retain a link to narratives that are not relevant in the present context, but will have to be re-told in the future as conditions change. By using existing Aboriginal stories and relating them to modern themes within the projects being developed with students, we provide more relevance to the information shared (Bodkin-Andrews et al, 2015).

When and by whom can knowledge be shared

In many Aboriginal languages there are 4th or 5th person pronouns, so if I talk about what we (you and I did) that is a different authority to talking about what we did (myself and someone else) or they did (when I did not witness). It is a way of expressing authority over the knowledge given. So when this knowledge comes over the internet, or on an app, whose is it and what is the relation to the source? The experience of Aborignal people online questions a lot of our assumptions about knowledge curation.

Who owns the knowledge

Aboriginal culture is based on relationships, to talk to someone you have to establish how you relate to them first. When you have a place in the knowledge network, the stories that relate to this position, such as relating to your totem, can be shared with you, while other

stories cannot be shared, since you are not positioned to be a recipient. This is a form of 'need to know' sharing, that ensures that information is not misinterpreted.

What will be told to you

Technology co-design activities with communities require knowledge be passed on to researchers. The experience in developing these projects with community has been that researchers would be told information based on what they able to understand. However, sometimes they would be also be told information simply because this provides an opportunity for its preservation, by passing it on to someone outside the community with no responsibility and links to the community, allow it to survive until the people are ready again to use it.

However, in general, sharing knowledge openly for all time is not considered suitable, and yet this is how modern teaching methods operate, meaning that information could be shared without assuring that pre-requisites have been covered. This is a concern not only in relation to Intellectual Property issues and Open Data, but also in relation to having a suitable process for sharing that also preserves the integrity of the knowledge.

How will knowledge come

An understanding of matters relating to a culture other than one's own, comes through experience, and through listening, which takes time. Asking a question can imply a demand to access knowledge that you may not be ready for, or lead to a person answering risking error by giving an incorrect/inadequate answer to another's question.

This process is understandable in light of the fact that traditional societies could not afford to have knowledge holders make errors - food could be missed when throwing a spear or lives lost when navigating to a new area. There is great shame attached to failures of knowledge application. Trust comes when these points are respected by researchers.

Protocols

There are existing protocols for research in Aboriginal knowledge (AIATSIS 2012), and the fair and equitable sharing of benefits arising from the utilization of genetic resources (Biological Protocol, 2016), These are especially relevant to knowledge sharing where the financial benefits of innovation are still unknown.

Before starting a research project with Aboriginal or Torres Strait Islander organisations, there are important issues to consider.. The process of creation of a product is as important as the final product (see Leigh et al, 2015). Research conducted at Wollongong University as part of an OLT grant developed and documented clear ideas about how to conceive of, and plan for, cross-cultural work with Aboriginal communities (Goldfinch et al. 2016)

The 5Rights© protocols include the need to find and develop contacts with the *Right People* in the community who can inform and champion the project without becoming overworked by these demands. These people must be from the *Right Place*, that is their country must include the place where the project is based, so that they have authority to speak about it. Then there is use of the *Right Language* to avoid offence and convey respect for the importance of oral history and the perspectives of the community. Then there is the *Right Time* as having a community understand the relative importance of new issues that arise take longer than planned, while other commitments can slow progress. Finally the *Right Way* involves incorporating these previous four ideas into a relevant, and appropriately scoped, project design and implementation plan.

To start this process we also need to prepare academics for teaching the new material in terms of the experiential, cognitive, affective and conative components of their attitudes to Indigenous knowledges and cultures (see Goldfinch et al 2017).

Findings for Future Work

We provide here examples of projects to engage with traditional technology and modern applications of traditional concepts. These projects have developed out of training engineers at university and in organisations.

Water engineering

The existing engineering artefacts around fish traps both on rivers (eg Budj Bim and Brewarrina) and on the ocean (eg Mystery Bay presented by Uncle Max Harrison, 2017) provide a physical experience of the vastness of the canals and rock constructions that were developed thousands of years ago in Australia. Information on these sites will be available on the Enduring Engineering mobile app with links to the community members who can speak on how the traps work. This process allows engineers and the general populace to understand how the structures functioned and link this with present engineering understanding of water and construction techniques. However there are many resources needed in the early research, rejuvenation and reconstruction phase of these sites. For these the local community should be included to ensure the knowledge is strengthened locally.

Construction

Sandon Point in the Illawarra region of NSW, is the site of an on-going protest against development on sacred land. The University of Wollongong ran a project with student engineers, who consulted with the community and developed designs for a number of relevant site needs including an artefact storage space that respected the people's request not to break the ground. The community is concerned about damage being done to the environment and the storage of artefacts that are being uncovered in the area.

The Illawarra Lands Council is now working with the University to consider designs for future development on the lands they own in the area. Engineers Without Borders is being approached to provide a resource to link these projects with students at University to ensure that the correct protocols are managed and that students are prepared for and supported during these projects.

Sustainability

Through the support of the Royal Society of the Arts (Australia and New Zealand) a workshop was held at Ausgrid with Benjamin Lange, an Aboriginal Engineer whose research into the acoustics of the didgeridoo has been used to expand knowledge of the vocal tract. The workshop explained the type of Aboriginal knowledge that existed before invasion and how this could be used by Ausgrid to deal with their community liaison issues in the present.

These talks are part of an ongoing series that the RSA A+NZ are running to raise community awareness of the engineering aspects and allow community knowledge holders to present to a wider audience. It is hoped that this support can be extended to a community run on-site exploration of a specific fish traps site, to both explore what might be found out about the site, and to develop repeatable processes for conducting future research projects.

IT development

At UTS software development workshop, students have been engaged in developing software for Aboriginal clients and for providing resources for students learning about Aboriginal Engineering. The apps are designed as a point of contact to link community experts with interested students or academics to share these projects through traditional forms of knowledge sharing. Tourists can also search for places to go for traditional knowledge. The development process has involved students in discussion with clients about the history of the knowledge, why the apps are now being developed, the market focus for such products and the social aspects relating to their use.

There are also various indigenous led IT projects such as the Indigital App which integrates digital technology and art by enabling users to scan an art work and link to videos etc. about the artist and the story of the art work allowing storytellers to reach a wider audience.

Conclusion

Indigenous and non-Indigenous engineering have many features in common, but until recently Indigenous knowledge about engineering has been ignored or denigrated. Developing ways to link awareness of similarities across engineering practices will provide practical and enjoyable experiences for students and educators, enabling them to expand their awareness of issues concerning sustainability, communication and cultural understanding in a diverse world.

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