Indigenous Engineering for an Enduring Culture

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Edited by
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Cover Artist

Cables-Technology and Engineering©Linda Payi Ford 2022. Payi is a Mak Mak Marranunggu woman. Payi Linda Ford's Country is Kurrindju southwest of Darwin on the Finniss and Reynold's Rivers, Northern Territory, in Australia. My painting title: "Cables -Technology and Engineering". The acrylic paint is on stretched canvas (A4) and this was done in April, 2022 during the Darwin's 'wet' season.

The significance of the painting

Payi has painted about 'Cables - technology and engineering' to depict the importance lines in the transfer of energy flows where each line has its own source of power. The power accumulates to enable the creation of programs to inform people. The lines of multiple blues, greens, grey and white acrylic paints are the spiritual synergies of her thoughts and knowledge used to conceptualise an abstractness likened to the cables, technology, and engineering of modernity. The relationality of wuda ngirrwat is cognisant with the conceptual abstract links to the expansion of new and innovative knowledge in a contemporary setting to mediate how to draw from an ancient way of knowing, being and doing from her ancient wisdom passed down through the Mak Mak Marranunggu and Marrithiyel generations about her wuda ngirrwats or water totems to even contemplate how this is connected with technology and engineering.

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FOREWORD

PROFESSOR REUBEN BOLT

DEPUTY VICE-CHANCELLOR FIRST NATIONS LEADERSHIP
CHARLES DARWIN UNIVERSITY

Indigenous Knowledge is an asset to the world and a gift to humanity. Developed from First Nations peoples' extended experience with the natural environment, it is vast, diverse, and complex, yet at the same time it is unique to place. With more than 500 distinct language groups in Australia at the time of first European invasion in the latter part of the 18th Century, each group thrived in their environment and developed a sophisticated and nuanced understanding of the world. The vast array of geological features and terrains across the Australian continent directly informed the substance of each Indigenous Knowledge System allowing for the establishment of an interconnected network of song lines and trade routes. This deep and complex system thus, contained a multitude of Indigenous Knowledge Systems each with their own unique creation stories, languages, logics, and morals.

Fast forward to 2022 and we see a very different culture in 'Place' due to the colonial expansion of Europe. The relatively short history of colonisation in Australia has had a detrimental impact on Indigenous Knowledge Systems. It is a history shaped by Western processes of dispossession, segregation, assimilation, and reconciliation which underpinned the interactions between First Nations peoples and the colonialists. As a result of this history, Indigenous Knowledge is positioned as *lesser than* Western Knowledge; it's an unequal relationship born out of a history of hegemony and negative treatment of First Nations peoples (by Australian governments and its citizens) resulting in the extreme marginalisation and disadvantage of First Nations communities. As a rejection of these processes First Nations peoples are resolute in their positioning to ensure they value and nurture the wisdoms contained within Indigenous Knowledge, so much so that Indigenous Knowledge has become a source of their pride, understanding and identity. This brings a dilemma

for Indigenous Knowledges – they are held in high esteem by First Nations peoples, but not as much so, from the perspective of Western science.

One way to address this dilemma is to bring broader awareness of the importance of Indigenous Knowledge, particularly in relation to world issues. This is critically important, because 'we' as a 'human race' are not doing so well in this current era of globalisation. At this point in time in the history of humanity, we have become much more efficient due to advancements in technology, medicine, trade, labour, and capital mobility which subsequently, has caused a human population explosion across the planet. Consequently, we are now faced with a myriad of problems and challenges: we continue to deplete the earth of its natural resources; we continue to uphold unsustainable practices; we continue to undervalue the importance of Indigenous Knowledges etc. And whilst globalisation is a 'global' issue, it often has local impact that is critically damaging, if not irreversible. Greenhouse gases and climate change, species extinction, the onset of deadly viruses, wars, increased frequency of natural disaster events etc. are all the result of human existence, particularly in relation to our recent past.

This is where this book is critical. It provides many examples of the role and importance of Indigenous Knowledges in the context of engineering practices in First Nations societies. Almost all chapters of this book have First Nations authors. The perspectives they bring to the process of researching what is known about their topics, is critical to the book's design. They draw from their disciplines of expertise, and at the same time, undertake the task of drawing on resources from the corpus, i.e., reviewing information captured in research reports, government documents, policy, journals etc. This, in and of itself, can be problematised given that the information 'about' First Nations peoples in Australia (particularly prior to the 1970s) was predominantly written by non-Indigenous peoples (Scholars, Academics, Journalists, Missionaries, Politicians, Historians, etc.). Informed by the sciences of those times, Australian First Nations peoples were positioned as primitive and unable to progress beyond 'savagery'. And whilst the authors do critique some of this content, they do not focus on it, nor privilege the problematic. There are also examples of resources derived from Indigenous Knowledges including personal experiences, familial relationships, community stories, dreaming stories etc. In this context, the reader is privileged to access such literature as the authors are required to undergo a process of *fancy epistemological footwork* when developing the content for their contributions. This is required because the logics and meanings within Indigenous Knowledges (which have specific theoretical

underpinnings) are not aligned with the theoretical underpinnings of the disciplines within Western Knowledge. Thus, concepts such as *'energies of Ancestral Beings'*, '*the land is a sacred entity',* and *'listening to the land'* remains mis-aligned to many of the disciplines in Western science, and indeed, to most Australians.

Finally, this collection of works draws from a range of disciplines including Anthropology, History, Cultural Studies, Architecture Design, Archaeology and Environment, to provide invaluable insights into the importance of Indigenous Knowledge and its contribution to the Engineering discipline. It is an example of *sharing* Indigenous Knowledge, which is critically important, because the act of sharing knowledge maintains it. And whilst there is a long way to go for Western Science to take Indigenous Knowledge seriously, this collection of works provides deep dive glimpses into how that can potentially materialise. This is where Indigenous Knowledge has an important role in ensuring we as a human race maintain and sustain the planet for the benefit of future generations. As indicated in the opening sentence to this preface, Indigenous Knowledge is an asset to the world and a gift to humanity.

Happy reading and enjoy.

PREFACE

INTRODUCING THE AUSTRALIAN COUNCIL OF ENGINEERING DEANS' POSITION STATEMENT ON *EMBEDDING ABORIGINAL AND TORRES STRAIT ISLANDER PERSPECTIVES INTO THE ENGINEERING CURRICULUM*

ELYSSEBETH LEIGH

Engineering, and engineering education, have experienced major shifts in perspective in Australia in the 21st Century. Position Statement #3 from the Australian Council of Engineering Deans draws on the outcomes of a project that prepared the way for a national approach to increasing Indigenous participation in engineering and holding true to the goal of employing a philosophy of two-way learning.

The position statement is available at
https://www.aced.edu.au/downloads/POSITION_STATEMENT_No_3_IndigenousPerspectives.pdf

and is in marked contrast to the approach of 'closing the gap' which implies a deficit model of Indigenous knowledge. The project team, led by Tom Goldfinch and including two editors of this book, concluded that

> Aboriginal people had been using highly developed, sustainability-based engineering principles and practices, honed over thousands of years of close relationship with the land and 'country' (pre-contact). In the centuries since that first contact (post contact) much knowledge about Indigenous engineering has been lost. (Leigh et al, 2014)

That project was intended to encourage greater Indigenous student participation in engineering. However, the process also focuses attention on the reality of Indigenous engineering as having its own long and

distinguished history, making the engineering discipline more relevant to our First Nations students.

A long journey lies ahead to recover, acknowledge and position Indigenous engineering knowledges[1] in their rightful place as foundational to an understanding of the country on which we live. This statement from the educational leaders of engineering education in Australia is an important indicator of a transition from little conception that Australia's indigenous nations employed engineering practices and principles, to a future time when their knowledge is embedded as a natural part of the knowledge required of all professional engineers.

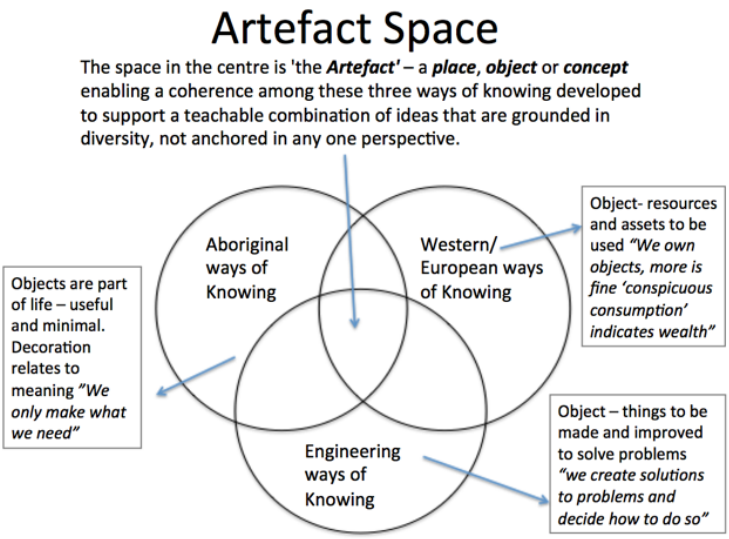

Fig P-1. Engineering Ways of Knowing related to two different cultures (reprinted with permission from Leigh et al., 2014)

To incorporate First Nations engineering principles and knowledges into standard classroom content and delivery across various engineering curricula requires a different way of thinking about ways of knowing as shown in Figure 1. These are called 'Western ways of knowing', 'Indigenous ways of knowing' and 'Engineering ways of knowing'.

[1] Indigenous researchers request the use of the plural form of knowledge to signify the diversity of knowledge systems that exist across Australia.

Of course, there are other sets of culturally based approaches to thinking about engineering. Appreciating that 'essentially all models are wrong, and some are useful' (Box and Draper, 1987) the model does provides a visual tool for considering how to expand engineering knowledge and principles and consider them in relation to both new and traditional ways. Presented this way the model highlights four aspects of concept:

- Engineers (Indigenous and western oriented) learn to deal with the world, and human problems, in a way that creates an Engineering way of knowing. Non-engineers who encounter engineering in action can testify to its difference from other disciplinary training.
- Western social constructs are built on a particular way of knowing that informs such diverse aspects as language formation, social relationships and connection to the physical world.
- Indigenous social constructs also build on particular ways of knowing, informing languages, relationships and connections to the physical world.
- All three embrace the abstract concept of 'the artefact' which is a way of representing whatever product or process is being considered.

Beginning with the *'artefact'* helps explain how different social constructs and engineering practices intersect. For example, the artefact of 'shelter' creates everything from tents and wurlies to palatial holiday homes, each manifestation dependent on user needs, priorities and expectations.

Given this it is possible to see how Engineering ways of knowing overlap with Western ways of knowing to create shared understanding about such artefacts as multi-storey buildings, highways, open cut mines and other technical processes etc. Conversely, Engineering ways of knowing intersect with Indigenous ways of knowing to create buildings, structures, transport routes which are only visible through knowledge of Country and processes of sustainable self-sufficiency.

Western ways of knowing and Indigenous ways of knowing share features relating to physical and spiritual worlds and use of language and social relationships (albeit with different outcomes).

Thus, the ACED Position Statement invites engineering educators to consider each of these different perspectives as they work across disciplinary and societal boundaries to create more aware engineers of the future.

With this support for integrating Indigenous knowledge into the curriculum, engineering educators have collaborated to plan ongoing integration throughout our students' study. The starting point is a whole syllabus approach, and the structure is based on the work of Nakata et al. (2012) and (2014) who propose a curriculum designed to assist students grow in awareness of the concerns of Aboriginal and Torres Strait Islander Peoples positioning them in a critical thinking framework to collaborate with First Nations at the cultural interface.

This structure is based around continuities in the curriculum and positions relationships between knowledge and people as critical in learning (Nakata et al, 2014) and was adapted to existing engineering curricula as in Table P-1.

This book contributes to this approach providing a resource for educators and students to engage with community stories and experiences in the engineering space.

Table P-1. Three approaches to knowledge integration (adapted with permission from Kutay & Leigh, 2020)

Awareness of History and traditional technology linked to the context of the specific subject		
Level 1	Level 2	Level 3
Acknowledgement of country and understanding of the significance to First Nations of the land area where a course or project is conducted (on or off campus). Share narratives from community on traditional technology eg Brewarrina fish traps.	Case study of community experience in technology eg papers on First Nations Knowledge repositories and the issues these raise over protocols of communication and knowledge sharing.	Designing a technology in class within the discipline of the subject/unit with community advice such as guest lecturers eg wearable technology, language translation, construction design, collaborative workflow support.

Design and development projects with community representatives to create Technology suitable for the culture and aspirations.		
Student led research into project of their choice with guidance from the lecturer as mentor to guide them to consider critical issues around culture and appropriate technology, rather than directing their study.	Designing an artefact with community consultations to develop an understanding of the complexity of co-design skills across cultures and understand the effect of history on available technology options.	Research Projects developed according to community design and guidelines carried out on location.
Adapting First Nations knowledge and processes to modern activities and designs.		
Workshops on processes and techniques for knowledge sharing relevant to a subject (eg Design thinking (see below), deep listening, yarning circle, teamwork around kinship, narrative learning techniques and sustainability, with video playlist (YouTube).	Scenarios or role plays on working with the community e.g. when a project digs up artefacts during construction. The preference here is to have a community member guest lecture to explain the context. Opportunity to put into practice the Aboriginal processes and techniques from level 1.	Use the Aboriginal processes and techniques from level 1 to collaborate with First Nations guest lecturer or community around an issue that is topical, ensuring there are plenty of resources for students to use.

For engineering students' 4th and final year or Honours in other technical courses, the component is a continuation of level 3 with a practical focus on a project whereby students can engage with community, an in-depth extension of the theory they have previously encountered.

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INTRODUCTION TO ENDURING ENGINEERING

CAT KUTAY, ELYSSEBETH LEIGH, JULIANA KAYA PRPIC AND LYNDON ORMOND-PARKER

Acknowledgement of Country

This work began in Sydney and on the NSW South Coast, so we start with an acknowledgement of the engineering skills and knowledge of the Dharug and the Dharawal, Cobrigal, Guringai and Gadigal people of the Sydney Cove (Waran). However, the story begins much, much earlier. Take, for example, Barangaroo, a member of the Cammeraygal clan and the wife of Bennelong who, in the late 18th century, was a master of traditional skills in fishing and the use of fire, using a clay base in her bark to maintain her fire as she fished around the harbour. The wasteful practices of the new arrivals, as recorded at the time, with their fishing nets and large catches, would no doubt have angered her.

This book shares Indigenous knowledges of the lands on which we live and work and explores some of the extensive array of engineering principles and practices that informed and sustained Indigenous Australian civilisations for millennia. The authors share examples of how this knowledge informs our teaching and engineering practice.

We have incorporated Indigenous Peoples' voice in this work in most chapters, out of respect for the knowledge holders, and to introduce readers to this mode of thinking, communicating and respecting others. This is an introduction to the unique technology of Indigenous communities in Australia who live on their own land perhaps around your workplace, your home, and where you holiday. And it acknowledges the pain of those who have had to leave their land and settle in another Country.

We aim to explain by examples how western engineering is based on one form of science, the science of materials and dynamics, while Indigenous science focuses on the whole system at all times. 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 nonlinear

equations than our present computer power could make any sense of. By breaking science down into component parts and trying to build them up again into the whole system, we lose sight of the system.

When confronted with a complex problem, engineers trained in western principles will approximate, reduce the variables and simplify the equations to extract the patterns and the main indicators, to ascertain how things generally interact in the system. Using this deconstruct/reconstruct approach such engineer principles ignore the holistic methods used by Indigenous teaching.

An Indigenous approach considers all stakeholders as active parts of the system thus incorporating sustainability from the beginning of any project and it looks to interweave all the factors contributing to a system. This approach enabled the First Nations cultures to survive in the harsh and variable conditions of Australia for thousands of years. We aim now to share some of the knowledge that has been ignored and can provide a new engineering approach that incorporated wellbeing and sustainable practice.

Engineering Concepts

Engineering is a problem-based practice-oriented discipline, whose practitioners are concerned with finding technical and economically effective solutions to concrete challenges. This book provides material for engineers to combine the practicalities and realities of good engineering practice with the present and future needs of holistic and sustainable societies which better manage the relationships among their social needs and the material means by which these can be met. It is intended as a resource for educators wanting to help engineering graduates:

> …. take responsibility for …. all interactions between the technical system and the context within which it functions. The latter includes understanding the requirements of clients, wide ranging stakeholders and of society as a whole. (Engineers Australia (EA), 2014)

which can only occur as the societies where engineers operate come to better understand the complexity of these interactions and require and support more socially aware modes of engineering.

In their report on Engineering Futures 2035 (Crosthwaite, 2021) the Australian Council of Engineering Deans noted that

> ….. future expected graduate outcomes will be delivered by programs that focus on practice, addressing real world complexity, and integrating the development of technical and generic competencies to provide authentic learning.

The Council is thus anticipating that engineers of the future will be held accountable for making judgments and solving problems using principles and practices that blend technology with broader social principles.

Learning to consider the existence and validity of different pathways to achieving desired goals can lead to a better understanding of how to incorporate sustainability principles into civil engineering projects. The following case study of contrasting ways of achieving a civil engineering goal provides a practical example of two very different ways of moving products across the Australian landscape. Consider the task of moving materials from a mine in Western Australian to users in Central Australia. The Indigenous engineering trading routes, developed thousands of years ago, used Songlines and petroglyph messages to map the route and guide those transporting the materials. There was very little impact on the landscape, but the route was clear to those how understood the signs. The other much more recent solution built both the Indian Pacific railroad and 2,500 miles of paved road. While the scope of each transport problem is undoubtedly different, the nature of the Indigenous engineering solution provides a clear insight into how those First Nations miners and carriers of goods survived and prospered in the same kinds of country in which the European explorers Burke and Wills died.

Histories of Engineering in Australia have, until recently, paid little attention to the engineering activities of Australia's first civilizations either before or after the arrival of European influences. Until Blainey's most recent volume Australian history (Blainey, 2015) history texts make no mention of engineering activities in the era prior to the arrival of European residents. The authors in this book provide numerous examples of what is now being done to identify and integrate the engineering skills and knowledge, philosophies, and values of the enduring First Nations, to create new and innovative approaches to engineering practices.

Background

Many current Australian government policies are based on a deficit view of First Nations society implicitly seeking to impose a range of 'mainstream' values and practices. While it is vital to address obvious gaps in the life

conditions of First Australians - including improvements in health, housing and education – doing so while ignoring the scientific, health and engineering knowledges of Australia's First Nations' cultures is increasing rather than closing the gap.

Reframing 'the gap' as a deficit of awareness about Indigenous knowledges highlights the need to engage with methods that empower full and equal participation, while avoiding assumptions of *deficiency* in the skills and knowledge of those on either side of the 'gap'. To succeed, such integrative methods must build on initiatives that engage all participants on equal terms.

An important outcome of revising perceptions of the gap is the revelation that it is not about a difference in capability, but rather that it is about a lack of knowledge of each by the other. Absence of awareness stems from failure to understand or appreciate the sophistication of another's beliefs and values as well as ignorance of the environmental sensitivity inherent in the other's practices, knowledges, and principles. For an understanding of the principles underlying Indigenous Australia's enduring civilizations see for example the work of Pascoe (2014) and Gammage, (2011).

The absence of First Nations students' engagement with conventional engineering practices has previously been highlighted by the Engineering Industry and University participation agendas (Behrendt et al, 2012; Billiton, 2012; Tinto, 2013). However, by 2021 the Universities Australia Indigenous Strategy First Annual Report (Jackson & Maddocks, 2021) showed some major advances both in engagement with First Nations knowledges and of First Nations students. It noted Australian Universities have travelled far in developing their strategy for First Nations engagement and highlighted the growth in Indigenous enrolments and graduations.

Increasing First Nations involvement in engineering, both as designers and consumers requires greater recognition of First Nations engineering knowledge. Increasing awareness of First Nations engineering principles and practices, as well as First Nations student retention in tertiary courses, involves engaging Indigenous community members as educators using appropriate teaching methods to convey the depth and validity of this ageless knowledge.

What is First Nations Engineering?

Engineering is a problem-based practice-oriented discipline, whose practitioners are concerned with finding technically and economically effective solutions to practical challenges.

Described this way the practice of engineering has been as integral to the survival of First Nations as for any other civilisation. The absence of conventional written records about the Australian landscape prior to European arrival and Australia's approach to history until recent times, raises the question of sources for evidence of First Nations Engineering. It is only very recently that we have begun to acknowledge the contribution of early European documentation of such evidence. As noted above authors like Bill Gammage (2011), Paul Memmott (2007) and Bruce Pascoe (2014) all draw in different ways on European records to support claims for sophisticated First Nations engineering practices. There are other equally compelling records on the landscape itself and in First Nations oral knowledges which are now being re-identified and recorded in book and digital form. Neille & Kelly (2021) Memmott & Page (2021) and Gammage & Pascoe (2021) are contributions to a series of books on First Nations knowledges incorporating this oral history.

Differences between First Nations and mainstream engineering indicate the ways in which philosophical and societal beliefs have influenced and shaped the achievements, technical skills and attributes of engineers within each community. Such differences are highlighted in an early definition of engineering from the Institute of Civil Engineers which, at the time of establishing their Institute (1812) identified *"…the profession of a civil engineer,* [as] *directing the great sources of power in Nature for the use and convenience of man."* (Jordan 2012)

In contrast with these ideas of control and power over nature a comparable definition of First Nations engineering practices based on current understanding of existing physical evidence indicates an approach that

> Works *with* Country to develop safe and healthy living for the group, in a manner that enacts a *custodial* role for humans of caring for Country and creating minimal impact on the environment as a self-sustaining system.

Of the many potential differences between these two characterizations of engineering, we are primarily concerned with the attitude to nature that each reveals. The Institute of Civil Engineers was explicit about Nature as existing for humanity's *use and convenience*. How their humanity then

responded to Nature is evident in the constructions that reshape and rework the landscape and its physicality, for human purposes. Land is there to be owned, worked and used as convenient. This sense of using Nature for human purposes is vastly different from First Nations concepts of relationship with an animate Nature, which reflect a set of expectations about humanity as being just one component in a complex systemic Nature.

Mary Graham's (2008) article on "Thoughts about the Philosophical Underpinnings of Indigenous Worldviews" highlights these contrasting perspectives -

> The land is a sacred entity, not property or real estate; it is the great mother of all humanity. The Dreaming is a combination of meaning (about life and all reality), and an action guide to living. The two most important kinds of relationship in life are, firstly, those between land and people and, secondly, those amongst people themselves, the second being always contingent upon the first.

First Nations engineers faced the same kinds of problems as all other engineers, in developing means to provide transport, housing, health and propagation and preparation of food. Their culture simply led them to choose quite different solutions. These very different solutions created misperceptions about both the quality of their work and the thinking that informs it, because the underlying philosophical stances do not separate humanity and country when framing problem-solving actions to deliver sustainable solutions. These different stances, explored by Sveiby and Skuthorpe (2006) using perspectives from the discipline of knowledge management, demonstrate that use of narrative was (and continues to be) a highly effective way to store and share cohesive knowledge.

This does not mean that First Nations did not construct, mine, harvest or otherwise disturb the course of Nature. In fact, it was quite the contrary. For example, First Nations engineers used stone to build extensive fish traps such as those seen at the extensive aquaculture site of Budj Bim (also known as Lake Condah) in the western region of Victoria, a place which was continuously occupied for thousands of years (Chapter 11). That community farmed eels, in a series of constructed dams and water channels, and smoked and traded their products over a wide region. Similarly, in Brewarrina (Chapter 23) in NSW fish were collected in stone pens in a lake on the river bend and used to feed large gatherings (McNiven & Bell 2010; Jordan, 2012; First Footprints, 2013).

First Nations also conducted extensive mining operations across Australia (DPI 2007), and Wilgie Mia, (Chapter 21) an extensive mining complex in the Weld Range of Western Australia, was in continuous use for over 8,000 years (WA) producing tons of high-quality ochre. Ochre from other reserves in Australia have been traded as far as present-day Queensland and The Nullarbor region in South Australia (AHD, n.d.).

While there is some current disagreement about the nature of how First Nations propagated and prepared foodstuffs (Gammage, 2011; Goonrey, 2012; Pascoe, B. 2018; Sutton, P., & Walshe, K. 2021) there is no doubt that each Nation undertook intensive and extensive agricultural activity suited to the conditions of their own Country. And this, of course, required application of knowledges that we would today identify as engineering. Similarly there is widely available evidence of an intimate understanding of the properties and behaviours of natural materials as shown in such items as intricately woven baskets, deadly accurate spears and boomerangs and highly crafted canoes (Sculthorpe, et al, 2015). The laws that were established, and strictly adhered to regarding managing such resources, drew on custodial principles and collaborative agreement on actions.

What happened to First Nations engineering knowledge?

There is no complete answer to this question, however history regularly records that when members of one culture witness the activities of another, observers routinely rely on their own culturally embedded norms and expectations to interpret the actors' culture and define the actions and technology of the other culture in terms of their own. Pascoe (2014) quotes from Kirby (1896) a European travelling around Victoria in 1894:

> 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.

Repetition of such reports (as found in many similar records from early European exploration) explain the lack of positive perspectives on, and respect for, First Nations engineering in Australian history. Since the introduction of European culture into Australia, First Nations skills and knowledges have been battered by perceptions of inferiority while simultaneously suffering cultural appropriation of practices perceived useful. However, a unique aspect of First Nations culture is the ability to adapt to new situations and understand and absorb new ways of perceiving and being. This ability may perhaps have been fortified by life in a country with a highly varied climate and fostered by strong oral traditions of knowledge sharing.

A few outstanding figures from early colonial history to modern engineering include Maria Lock, who as a young girl topped the school examinations in Sydney in 1819 (Parry, 2005) and the 20th century engineer David Unaipon (1872-1967). The latter became well known for his engineering designs including the one which adapted First Nations engineering knowledge, embedded in the design of the boomerang, to develop a propeller system for a pre-WWII conceptualisation of a helicopter. That this list is not more extensive is due to the scarcity of records rather than any absence of engagement or effort

More recently Eric Willmot worked as an engineer in the 1980's and 90's and developed a system for continuously variable-ratio transmission for use in gearing. His work in controllable variable-motion in mechanical engineering rigid body mechanisms was used in Australia's first hybrid car. He holds more than 90 international patents and has written several books including Pemulwuy, The Rainbow Warrior (Willmot, 1988).

Such successful adoption and enhancement of one society's technology by members of another society is uncommon and highlights the importance of engaging with First Nations knowledge traditions as a source of invention and inspiration in technology. In short much First Nations remains embedded in the artefacts created by the knowledge, while some has been lost because of their ephemeral nature. And some is being recovered as their values and validity is rediscovered and applied in ways described by these authors.

Representing Ways of Knowing

Bringing enduring First Nations knowledge to general consciousness and achieving its potential as equally valid as non-Indigenous engineering is clearly a complex process. We provide many examples of including this knowledge in Western curricula and projects where Western knowledge is shared with and altered by two-way learning with Aboriginal clients and students. What can be introduced in any context will depend on the knowledge of the Indigenous people involved, their expertise and interests. We cannot expert each person to know all aspects of technical knowledge.

However, while understanding that First Nations people are highly diverse in terms of history, culture and values, there are some aspects where most First Nations differ more from western approaches than from each other, and these aspects provide a way to view western practice through a new lens.

As an Aboriginal engineer, or as practitioners working with Aboriginal people on projects guided by the community, we consider the two-way learning approach can be a variation on the research methodology developed by Karen Martin and Booran Mirraboopa (2003). In two-way engineering we begin by **doing** the practice of engagement where knowledge systems are shared, then implement the technology into the community **being**. Only then it can become part of community **knowing** and linked back to the knowledge repository of the community, law and Country, the Dreaming stories.

In this way we provide an approach that can be verified and improved. We already have requests from communities that our engineers engage with community during their study, so that they understand how to handle artefacts exposed during excavations, etc, even before the inexcusable destruction of Juukan Gorge.

What we are aiming to teach our students new processes, protocols, and a greater understanding of new ways of knowing. We hope you will join us.

Doing First Nations Engineering

First Nations' perspectives on Engineering, includes understanding that relationship to Country is at the core of First Nations' values and knowledge, and that Country cannot be owned in the manner of western ownership. From this perspective, all life and all natural artefacts have equal

value and their place in the world is assured by relationships not hierarchies. Thinking is pluralistic not individualistic or dualist.

An ‘engineering perspective’ emerges in respect to considering engineers as primarily practical problem solvers. Solutions are valued for their simplicity of enactment, and thinking is focused on how to address problems rather than on considerations of the merits of acting or not acting.

An engineer excels at understanding the nature of gaps in service, performance, comfort, and access and aims to develop solutions to specific problems as they arise. Engineering education is, therefore, focused on understanding how things work in order to make them work better in some definable manner. From an engineering perspective, an artefact such as infrastructure development, shelter, community facilities, secure locations for storage etc. are framed as problems to be solved or designs to be optimised and the absorbing concern is what to do about it. From a Western worldview the absorbing concern is about how to engage with the opportunity it offers.

Our current understanding of a First Nations’ worldview indicates that the concern is for relationship with the artefact. The artefact is not separate or external to the thinker, it is part of them and must be managed, with that in mind at all times. Furthermore, relevant engineering knowledge and skills are perhaps shared more widely amongst the community, through stories and the involvement of the young in all processes. Mary Graham (2008) expresses this concept in this way:

> **The land is a sacred entity**
>
> not property or real estate . .. 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**
>
> Indigenous people have a kinship system which extends into land … One's first loyalty is to one's own clan group. … Every clan group has its own Dreaming or explanation of existence... a person finds their individuality within the group. To behave as if you are a discrete entity or a conscious isolate is to limit yourself to being an observer in an observed world.

Whereas western worldviews are based on centuries of science which have fostered the stance of an observer in an observed world. It is good to consider alternatives.

Being in the Engineering Space

Engineering education in Australia is gradually being redesigned to incorporate First Nations knowledges in our practice and engage First Nations students and communities in a way that benefits all people. The aim is to improve the development of technology appropriate for First Nations, to understand First Nations Engineering as a contribution to present engineering knowledge and to redesign engineering practices to include First Nations engineering perspectives at university and in society.

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