Engineering with Country

ENGINEERING WITH COUNTRY

First Nations Engineering in Practice

Cat Kutay; Timothy Boye; David Payne; Kate Harriden; Jayne Boase; Sai Rupa Devarapu; Peter McArdle; Susi Bertei; Curtis Roman; Tara Burton; and Elyssebeth Leigh

CHARLES DARWIN UNIVERSITY

DARWIN

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Contents

Acknowledgement of Country

We acknowledge this work comes from people working on many Countries around Australia. It is produced by First Nations people and others who have been given knowledge to share.

We acknowledge the Elders past and present in the lands where we live and work and thank them for the many thousands of years their people have cared for these lands. We acknowledge the land was never ceded and the task of Caring for Country continues to this day, despite impediments.

We hope this work will create a safer space for the First Nations into the future and encourage more First Nations to explore technology appropriate for their Country and people.

Acknowledgement

This book was produced with a grant from CAUL and supported by Charles Darwin University, Engineers without Borders Australia, the University of Technology Sydney, University of Adelaide, Monash University and Australian National University.

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The Blue spiral signifies the flows of Indigenous knowledges that come from lands and waterways. The Orange grid signifies colonial frameworks opening up to two-way learning and teaching through cultural arts and the scientific method. This initial icon was co-authored by Cat Kutay, Robyn Murphy and Lisa Roberts (2021-08-19).

Humans benefit from communities they interact with. Benefits for humans from human communities can be physical, emotional and financial. Humans also benefit from communities of other species from whom they get resources such as food, timber, fibre, medicines, and ecosystem services such as oxygen, water purification, waste dispersal and nutrient recycling.

Other organisms also benefit from communities they interact with, such as coral reefs, schools of fish, swarms of krill, pods of whales. Communities can be multi-species such as an ocean ecosystem or a rainforest with its myriad of interdependent organisms.

Introduction

Aboriginal and Torres Strait Islander people should be aware that the articles in this book (online) may contain images, voices and names of deceased persons

We all have stories of our engineering experiences whether as consumers or creators. These provide a reflection on our previous use or making of technology to consider how we can improve for the future. First Nations engineering is focused very much on process, not specific to any material, discipline or issue to solve. Hence we hope this collection will provide you all with ways of doing your engineering that respects the sustainable approach of our Aboriginal Australian ancestors.

This book contains case studies, scenarios and exercises that will immerse you in the culture and practice of our First Nations. We understand that these concepts can be quite a new approach, and we will provide as much as possible tools that help you engage and grow from these resources.

Material is being collected from engineering projects across the Pacific, Engineers Without Borders projects, projects by Māori Engineers, work with traditional builders of Vanuatu, both historical and present day. A major focus is on providing assessment of this material, which is for use

in Higher Education and Professional training. This book is being published in scheduled releases. Release dates of chapters will be listed in the versioning history page.

In providing these materials we include background resources on the culture and needs of Indigenous communities in Australia with more material on Māori communities in New Zealand to follow, as well as examples of traditional technology that can be adapted to today's communities. Similarly, students doing practical projects with First Nations communities or engineering graduates who are working with First Nations, in urban, rural or remote areas, will find this a useful resource during their professional development to consider the features that are significant in managing and designing projects that engage the knowledge of the local community.

We note here that the style of the chapters, and certainly the sections, are very different in their expression. They have different focus and intent. We should explain that with the different authors and their different expertise we did not want to impose any specific style. We hope you find this adds to the value of the book having the different approaches being in their original voice.

Parts

The first section is material from engineering that existed in Australia and Aotearoa prior to colonisation. This will be in the form of case studies and exercises for students to engage in the perspectives such as sustainability; flat governance; flexible, minimalist and holistic design; and learning as story-building, which are fundamental when understanding these technologies.

The second section relates Indigenous perspective to western engineering disciplines as short projects that may be introduced into the classroom or can be taken up as resources for project by a team within a discipline

In the third section the textbook provides case study stories from mainstream engineering projects viewed from an Indigenous perspective. This will allow students and those who are now professional engineers, to consider the approaches to sustainability, systems thinking, humanitarian engineering, etc that will enrich our engineering discipline and practice.

The fourth section covers common types of projects that are done with community, looking at community needs and practices that impact on engineering work in this area. While the individual projects we will provide can become dated, they are explained in terms that can generalise to other communities in terms of process as aspirations, rather than the details that will therefore be negotiated with individual communities in any future project.

Expanding on or re-interpreting old ways

When joining the two braids of Indigenous and Engineering knowledges we acknowledge the value of the first, more coherent and robust system developed over thousands of years. We acknowledge that Engineering is something more than what we teach and enact at present as academics and professional engineers, it is also the sculpting of the landscape and development of tools by First Nations in Australia and New Zealand.

By providing this work as an online book we can incorporate videos and other resources (with permission) that already exist on the web to ensure students can learn

through audio as well as written means from the one source. Where necessary we provide links to external resources. One such link is a playlist that has been set up for Indigenous Knowledge material. Furthermore, we will be able to add updates and remove outdated material at regular intervals, to ensure the students have resources that convey the most recent perspectives and depth of Indigenous knowledges. This will be provided by existing authors and others who wish to contribute.

In many of our universities, students work on a low-tech design solution to community problems, but also learn how to design a new technology. They learn how to research issues and potential solutions, develop a suitable solution which they must justify, and provide both a written and oral report on their work. They have available many references available on this generic area of learning, as well as library support sessions. However, it is hard for students to complete aspects of this work, such as justify their design, when they do not have material relating to the culture and practice of their clients. We want them to have access to the stories told by Indigenous people, based on actual projects, to enable them to engage with the complexity of this culture and the depth of knowledge of the people with whom they will be working or designing. Even when projects are not related to the communities included in this book, we hope you will consider how many of the concepts and experiences are universal within all nations of the world.

Also we acknowledge there are many more people doing this work than those who have contributed to this book, or have been contacted to contribute. *Hence we ask those reading*

this who have resources they want to share, to please contact Dr Cat Kutay at Charles Darwin University where this work is produced and consider sharing in future versions of this open text.

Respectful Language

Many documents on respectful language and behaviour have been writtten on how to work with culturally responsiveness. One aspect is how words are written and what words are used. For instance Elder, Country and Aboriginal are usually capitalised, but this can be checked with the local community, what forms of language they want used.

This guide can be useful, the a-z-of-first-nations-terms-student-guide

Accessibility Information

We believe that education must be available to everyone which means supporting the creation of free, open, and accessible educational resources. We are actively committed to increasing the accessibility and usability of the textbooks we produce.

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Accessibility features of the web version of this resource

The web version of this resource has been designed with accessibility in mind by incorporating the following features:

- It has been optimised for people who use screen-reader technology.
    - all content can be navigated using a keyboard

    - links, headings, and tables are formatted to work with screen readers
    - images have alt tags
- Information is not conveyed by colour alone.

Other file formats available

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Third-Party Content

In some cases, our open text includes third-party content. In these cases, it is often not possible to ensure accessibility of this content.

Accessibility Improvements

While we strive to ensure that this resource is as accessible and usable as possible, we might not always get it right. We are always looking for ways to make our resources more accessible and more useful. If you have problems accessing this resource, please contact Cat Kutay at Charles Darwin University to let us know so we can fix the issue.

About the Authors

The editing team is a group of Indigenous and non-Indigenous engineers and educators who are academics or practitioners. We all have worked together in various capacities or have common ambitions for educating all Australians in both the technology developed in this country and humanitarian approaches to future engineering.

Cat Kutay is an Yugambeh Senior Lecturer in IT at Charles Darwin University (CDU). She has been working in Indigenous Technology for over 34 years and teaching at university as casual then permanent for 17 years, and at TAFE for about 3 years before that. She published in Engineering Education, Artificial Intelligence and Gaming, Sustainability modelling, Ethics and Human Computer Interaction. In 2022 she published with Elyssebeth Leigh, Kaya Prpic and Lyndon Ormond-Parker and others the first academic book on Indigenous Engineering for an Enduring Culture. She has received Teaching citations and awards in 2019 and 2020 for introducing Indigenous knowledge into a Transdisciplinary course and Mathematics; and in 2022 received the VC's award for teaching. As an electrical and software engineer who has worked many years in remote communities in the NT and

NSW, she has broad expertise in engineering in this context, see https://researchers.cdu.edu.au/en/persons/cat-kutay

Jayne Boase is Ngarrindjeri and Bungandidj (Boandik) descent through her father and his mother. She works with Program Directors and Course Coordinators embedding Aboriginal content in undergraduate programs for Univeristy of South Australia STEM. Alongside of this and together with Professor Delene Weber, she developed and deliver the award winning Fire and Culture course.

From 2017 through to 2020 she worked for UniSA as a sessional academic providing lectures and tutorials across a range of subjects including Diversity, Women in the Workforce, and particularly Aboriginal Context, teaching into several STEM programs as well tutoring in Professional and Technical Communication with UniSA Creative. Throughout this time she also worked for COTA SA as Director of ZestFest delivering their annual festival for modern ageing.

David Payne is a Yuin gurandji and European/Australian man. He has worked with the Yuin community building bark east coast nawi, woy or bermagui/permagua tied-bark canoes for over a decade, developing a strong connection to elders and community in the process. He is also a self-taught yacht and vessel designer with over 100 designs in his portfolio, and has worked for professional naval architects including his well-known uncle Alan Payne. For over three decades he also worked for the Australian National Maritime Museum as a consultant and then as Curator of Historic Vessels until retiring in 2020.

Timothy Boye has been teaching at University of Technology Sydney for 4 years with a cohort of about 1000 students over the year doing the Engineers Without

Borders (EWB) Challenge based design projects. He has been a practicing software engineering for 4 years. He has published 15 papers on Equity and Inclusion, focusing on disability issues, and has an H index of 2. He co-authored a chapter in Indigenous Engineering for an Enduring Culture published last year, describing the EWB projects run at UTS and he received both in 2020 and 2021 a UTS Teaching and Learning Citation and Team Award. Timothy brings a software engineering and inclusivity perspective to the book, see https://profiles.uts.edu.au/Timothy.Boye.

kate harriden is a yinaa wirdyuri/wiradyuri women and currently Research Fellow in Indigenous water in the Monash Sustainable Development Institute at Monash University. Living up the wiradyuri as freshwater people moniker, she has been doing freshwater research for many years, including household water use, challenging the concept of storm water and examining stream functioning. kate has also been testing water quality in creeks on Ngunnawal country for more than 20 years, as a citizen scientist with waterwatch. During her PhD research, kate developed expertise in First Nations design, particularly water country design principles, and now presents lectures in this field to university students in undergraduate and postgraduate courses. In recent years kate has become increasingly involved in research about the impact of aqua nullius (the systemic disregard of First Nations water rights in the settler-state legal and water systems) on First Nations water rights and Indigenous sciences, as well as the customary water rights of First Nations women. kate is aware that expertise is not held solely by 'experts' and actively works to decolonise the academy, in part to give space for the expertise of First Nations people.

Sai Rupa Devarapu is an engineer and researcher who works with EWB to develop the Challenge there. She has been teaching for a year in engineering and 1 year in practice in the consulting industry and has also volunteered with overseas EWB organisations. At present the Challenge material that she supplies to universities are two projects, one based in an Aboriginal community and the other option overseas. She is passionate about the intersection of technology and social impact. She has an interest in socio-economic, political and philosophical events and explores the best way to integrate them towards creating a positive and lasting impact to underprivileged and underrepresented communities. Now based in Melbourne, Sai has a Bachelors degree in aerospace engineering and a Masters degree in Sustainable Manufacturing Engineering. Her Cross-cultural learning experience could potentially be of great value to this project which when combined with her Engineering qualifications of the team, could contribute to this ebook. https://ewb.org.au/team-showcase/sai-rupa-dev/

Peter McArdle brings 15 years' experience in international humanitarian action across the Middle East, Asia, and the Pacific to the role of Chief Engineer at EWB. With one foot in engineering and the other in social science, his work has included climate and environment policy, water and sanitation, public health, emergency operations, and the protection of infrastructure in armed conflict with the Red Cross/Red Crescent Movement, NGOs, and social enterprise. For his work preparing for and responding to global crises, Peter was Awarded the International Service Medal for 'exemplary service' by Australian Red Cross. Constantly curious, and intrigued by balancing diverse perspectives and knowledge, complexity,

and creative problem solving, Peter holds a Bachelor of Engineering (Civil), a Master of Peace and Conflict Studies, and a PhD in Sociology exploring the social impacts of community conflict and resilience in the face of water scarcity. Peter occasionally teaches environmental politics, peace and conflict studies, and humanitarian engineering at the University of Sydney, the University of Notre Dame, and the University of Technology Sydney.

Susi Bertei is an engineering lecturer at CDU who has been teaching the first-year Design and Communication unit for 10 years, focusing on the EWB Challenge as a vehicle for working on Indigenous projects, hence this eBook will be invaluable for her students. Importantly she has many international students in the course and if the projects that are supported move back overseas, she would like to keep the Indigenous content. Hence, she can advise on how to make the content relevant to this cohort even if they are not working with projects on the country of the material we provide. Her students have often received awards at EWB Challenge Showcases and her course is a core course for our technology students at CDU. She also brings her skill in engineering design and report editing that is a fundamental part of the courses in which this textbook will be embedded, see https://www.cdu.edu.au/staff/susi-bertei.

Elyssebeth Leigh co-edited in 2022 the book titled Indigenous Engineering for an Enduring Culture and has been a educator in contexts ranging from business and government entities to high school and tertiary settings. Her expertise as an educator and researcher draws on years of experience with learners who are encountering new and intricate contexts where understanding and appreciating their own expertise is an essential component of their

future success. She brings both a wealth of knowledge about adult and young adult learners as well as principles of good practice to ensure each individual has the best possible chance of achieving their goals. Dr Leigh has published in the areas of learning design, adult learning, simulations and games for learning and sharing of knowledge about Indigenous engineering. https://uts.academia.edu/ElyssebethLeigh

We also acknowledge **Tara Burton**, the Open Education Librarian at Charles Darwin University with expertise in open data and referencing who has provided consistent editing and licencing of the material included in this volume. We appreciate her tolerance of the chaos in producing this open text.

Focus of Book

This book was developed to provide authentic assessment for students learning First Nations knowledge and gaining cultural awareness around technology in Engineering and IT courses. To enable this we provide content and assessments that apply to many disciplines, extending into new ways of knowing, doing and being.

To provide authentic assessment of learning, we want students using their engineering skills to apply to new situations and demonstrate their cultural knowledge in action in their work. We want to emphasise that knowledge is from relationship with Country, not to be taken from Country, until an understanding of that local pattern is developed. Often the depth of this local knowledge is too much to transfer easily.

For instance, we can ask students to provide an oral narrative that ties their learning into a single story that they can develop over time or we can explain how they can reflect on their work by applying their engineering knowledge to and Indigenous community and consider the effect of this new context.

Example Questions

Questions may be:

- What workplace skills, knowledge and understanding are required by students? For instance how important do you think it is understanding Aboriginal links to Country in your professional work?
- How can we apply these elements to authentic, meaningful and engaging learning and assessment? For example how relevant do you think Aboriginal knowledge sharing methods is to your learning?
- What content needs adding to engage critical thinking and expose disciplinary assumptions and perspectives? Consider after running a simulation or role play asking what could you do better in this situation?

These approaches can help students expand their understanding at any level, but also they can help those not familiar with the technology to have an overview of their work, where they are heading. This can then help the technology make more sense. Similarly mathematical aspects can be estimated from this approach, to avoid getting lost in the detail, when this can be confusing.

Research

This eBook cannot cover everything that has happened and can happen in First Nations approaches to engineering. There are opportunities for lecturers to research local work that is already well advanced and applying some of these thought patterns discussed in these pages to a new domain.

Questions for Research

What happens when students who are used to a compartmentalised approach are given holistic problems?

How do they respond and what helps in the learning process? eg ask them **why** they asked any question they had.

Maybe it is not relevant to the problem but still helps in understanding the situation?

How do we learn about our cultural and physical environment?

PART I

Part A - Material related to Humanitarian Engineering Projects in community

This section is mainly focused on project categories used by Engineering Without Borders (EWB) in their work with First Nations in Australia. However this material has broader applicability to any design work in Humanitarian Engineering with First Nations communities around the world and provides background to assist students to take new perspectives on their work.

The material in this section is gathered from the web (with credit) or other material to provide these resources in one online location. They may be useful in projects that are not directly related to the topic, or through association they may provide useful ideas to students.

In particular we were inspired by the work by Campbell et al. (2020) which links significant new perspectives to different engineering topics. They encourage students at the end of their project to reflect on the impact of this First Nations' knowledge on their design and how much their

design is user-centred and fit for purpose. Also they ask students to consider how prepared they are to work with and respect First Nations in future projects.

We believe it is worth linking these to forms of assessment that may be appropriate where new ideas from old technology can tackle the problems of the future.

References

Campbell, J. L., Michael, R. N., & Crough, J. (2020). Embedding Indigenous perspectives in a first-year engineering design challenge course. In: 31st Annual Conference of the Australasian Association for Engineering Education (AAEE 2020): Disrupting Business as Usual in Engineering Education. Barton, ACT, Australia: Engineers Australia, 2020: 413-421. https://search.informit.org/doi/10.3316/informit.725847413523972

1

Simulation Resources

Cat Kutay and Elyssebeth Leigh

There are some concepts that are best learnt by doing, or in this case watching someone else working in that situation. We provide here some resources developed with Engineers Without Borders (EWB) to highlight the skills that are relevant in working with people of other cultures, with some specific factors relevant to First Nations in Australia.

These are immersive experiences, meant to emulate some aspects of real projects in community. These are publicly available and were developed with Sarah Herkess when she was working at EWB, Australia. All the production is by the author with help from a colleague at University of Technology Sydney.

Relationships

The first role play is about relationships. It is about how to develop these, or what happens where we assume they exist but they do not. When people from the mainstream Australian culture meet, they have common background with which to assume some relationship already. When

such people meet with First Nations, there is very little such background, and little existing relationship can be assumed, so we need to work on creating a relationship, from both sides. This segment also alludes to some of the warnings that we might get when we may be asking questions that will receive no answers.

Breakfast Roleplay

https://cdu.h5p.com/content/1291261059111299559

Sacred Sites

The idea of sacred sites and their significance to First Nations, are hard to explain to people who are not close to their Country and to its history. We are not talking about human constructed edifices, but locations that have been known to the people for thousands of years. These sites have supported people with food, water and shelter or could have been the source of illness. These are places that are significant in the survival of Country (eg tributaries to spread floods and prevent erosion), animals (eg important areas of food or places for breeding) and people (eg birthing sites).

There is also a history of appropriation of this knowledge, for sacred sites may be places of danger or high concentration of minerals (eg uranium). Hence mining companies have often benefited from locating these stories. For First Nations this has led to destruction of Country and spreading of harmful chemicals.

Nearing Sacred Sites

https://cdu.h5p.com/content/1291231716088725019

Whose Knowledge is it?

This simulation focuses on another aspect of knowledge sharing – who can share a story. A story may seem to be common knowledge when it is in fact the specific knowledge of one group (eg women) so you will get evasive answers from those not allowed to talk of such matters.

Fixing the water pump

https://cdu.h5p.com/content/1291254887767784219

Using Simulations in class

There are other exercises you can do in class that look at the broader context of engineering in the environment. These tasks can be created based on the environment around you, such as examples where the location impacted on a project.

You can set this exercise at different time periods: now, during early colonisation, pre-colonisation, etc.

It is wet season in the Northern Territory where you are travelling. You are stranded on the wrong side of Katherine River and its level is up and overflowing the bank but it is not flowing fast.

- What approach would you take to crossing this river from a Western Perspective: consider technology available, approach to the environmental situation, threats of the situation.
- How would an Indigenous Engineer approach this: consider technology that would be available and why, what is the

concern about the surrounding environment, what you would know about the threats.

Note the responses to this exercise will vary a lot due to different experiences in the class and have no wrong or right answer. They are designed to have people put themselves in the situation and think as others who have different values may think.

Also in current times there is a bridge over the river, and there are barges and houseboats that travel the rivers in the area. There are houses built close to the river, which overflows its banks often. There are crocodiles in the water and submerged logs. So you can change to a more recent context.

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Author: Cat Kutay and Sarah Herkess.

2

Engineering Projects Simulation

Timothy Boye

This simulation was developed for introducing first year engineers to the importance of concepts beyond the technical. It is run as an introduction to the Engineers Without Borders Challenge but can be adapted to many other situations.

In developing a simulation it is important to extract what are the learning objectives and remove the rest from the scenario. This scenario focuses on communication and respect for others' knowledge. This allows issues such as First Nations handling of knowledge sharing to be introduced as rules for the community and how they communicate, so that the students learn of some of these different aspects in a practical way.

The rules are simple but encapsulate aspects that create a lot of conflict and error in projects, such as community people not willing to share with those they do not know.

Materials Needed

- ½ a lego box per zone (1 box to share per 2 zones)
- 1 x Saibai Island Community Residents Packet
- 1 x TSIR Council Packet
- 1 x Big Ideas Engineering Consultancy Packet
- 1 x Additional Worksheets bundle

Required sheets are found here

Preamble

There is a lot more that goes into working as an engineer than students might think. Rarely do engineers have a single task to complete and often engineers may be working on multiple projects at different stages of completion at the same time. In addition, there are many pressures on all stakeholders including the engineers which can impact project decisions and outcomes, such as KPIs, other responsibilities, budgets, differing priorities etc.

This task aims to simulate this environment as best we can so students can reflect on these issues, ways to approach work, and how important it is to involve the community and stakeholders in engineering design.

In summary this task aims to:

- Assist students in meeting new people as an icebreaker
- Simulate realities of working in engineering
    - Rarely working on a single task/project

    - Projects are almost always in a complex environment where no one has all the answers
    - Ideals are tested through other pressures (KPIs, costs, etc)
- Provide an experience that leads to reflections regarding how human-centred engineering and the design process improve outcomes and are needed, and the differences between working for, with, and by.

Setup

Participants	This is a zone-based activity. Students will only interact within their zone and with their tutor.
Student Groups	Students in the zone are split into three groups: 1. Saibai community members, 2. Torres Strait Islands Regional Council administrators, and 3. Big Ideas Engineering Consultancy engineers.
Each Group Receives	Their packet which contains: – A brief for their group with the game rules and details – Several role cards which the group will assign – Reporting forms for reporting at the end of each week The Council and Engineers will also have in their packet: – Budget request forms for asking for more money – A budget tracking form for tracking expenditure – A map of the region for travel expense purposes The Engineers will also have access to: The box of lego to purchase prototyping materials
Background (Tutor version)	The residents of Saibai Island are fed up with poor services to the island and the council is struggling to meet the needs of the community alone. The council has hired the engineering consultancy firm to investigate the community issues and prototype solutions.

How the Simulation Works, In Summary

1. All teams will start work on their assigned tasks from their packet (role assignment and a worksheet).
2. Teams need to complete their tasks by their deadlines and within budget.
3. Teams need to report to you, at a minimum, at the end of each week
4. The engineers will lead the main project to investigate and improve services to Saibai Island and have until the end of "week 3" to do so.

Tutors have numerous avenues for adding or taking away pressure from each group, with the aim being to make it difficult to complete the simulation, without being too overbearing and causing everyone to fail at everything.

5. After the simulation, run a reflection in zones on how it went, what they can learn from the chaos (and hopefully some but not total failures) etc.
6. Get some students to share back some key reflections to the room.

Game Mechanics

	The tutors role is to monitor each group and provide additional pressure as needed to maintain the adrenaline and distraction from the main project, without going too overboard and making it obvious we want them to fail, at least in some ways.
Tutors Role	To allow the tutor to provide direction and pressure to each group as needed, the tutor plays three roles which all boil down to a high-ranking boss of each group *(Chief Engineering Officer, Council General Manager, or the community member's employer).*
Worksheets	The tutor will have several worksheets (such as crossword puzzles) they provide to groups at the beginning of each "Week" and as needed to ensure the groups are under pressure. These provide a simulation of competing priorities and distraction on other tasks.
Reports	Groups are provided several forms, these serve as real-world simulation (documentation etc), further distraction from the project, and a way to help the tutor keep track of groups.
Weeks	The simulation is over 3 weeks, each week is 10 minutes. At the end of each week the group will submit a report to the tutor. The tutor can provide performance concerns here if budgets are running high or tasks are not getting finished, as a way to make the boss role more real and provide more pressure.

	In order to keep the students on their toes, tutors may: – Assign additional worksheets e.g., "One of our other projects has made it to the next stage, your team need to complete this part to progress it further" – Shrink budgets e.g., "We've had a very bad quarter, and the company has to cut costs, I am afraid I need to pull 15% of your remaining budget" – Fire a team member (send them to another group as a new employee) e.g., "your work has not been meeting our expectations, I am afraid we're going to have to let you go, I hear the council is hiring" – Demand impromptu reports e.g., "Hey team, I'm getting a lot of questions from the board, can you give me an update on your progress?" – Experiment with your own ideas to simulate work.
Additional Tutor Abilities / Notes	Careful not to overdo it, there is a fine line between "under pressure and distraction", and "clearly we can't win this, why bother trying anymore". In order to take pressure off tutors could: – Suggest the engineers travel to speak with the council. – Suggest the council travel to speak to the community or engineers. – Suggest the engineers travel with the council to the community. – Etc. However, don't be afraid of having teams struggle, the goal is to get "half way there", not to succeed fully. We are modelling a bad project so we can reflect on better ways to do it.

Costs and Budgets	The engineering team and council have an assigned starting budget. – They must track their own expenditure and report it to you at a minimum in the weekly report. – They can submit a request for additional budget but you do not have to grant it or grant the full amount. Remember we want them to make mistakes and to be under pressure, but we still want them to be able to make some progress and stay engaged. Approve budgets where a team REALLY needs it, otherwise "sorry the company can't afford to spend any more on these projects at this time, you're going to have to cut costs" – There are only two expenses: o Travel costs (It costs money to fly to another team to speak with them) o Lego brick costs (materials for prototyping) – Both teams have the price for these expenses and their starting budget on their cards.
Incomplete Information	Each group has some important information to truly succeed at the project and they will need to ask the right questions of the other groups to learn it. In particular: – The community knows a lot about local materials, local conditions, etc – The council knows some materials are local and they can acquire them cheaper for the engineering team Some roles, such as the elders, know more than others in their group.
Travel, 'Interest', and culture limitations	– Teams can only interact if the initiating team pays to travel to the other team, so they need to make the most of trips or spend a lot of money – Teams spend money on accommodation while they are travelling per minute! This gives them a pressure to ask less questions and go home to encourage them to miss important things. – The islanders have seen many fly-in-fly-out teams come and go, and nothing has changed so are not as receptive to assist yet another team as you would assume. – Islanders are not going to interact much with someone they don't know so strangers need to be introduced formally, relatedly, they are not going to bother the elders until they know and trust someone new.

Reflection	After the activity reflect with your zone on what worked well, what didn't work well, was the project a success, do all groups agree, what might we do differently. Some additional suggestions are below: – You may wish to provide a summary of what you saw to the students to help with the reflection (eg, if you saw the engineers thought they'd solved the problem but saw the community were wondering what was happening). – Check in with some of the roles, do the team leads feel like they were listened to, do the senior staff feel like they were respected, etc, do all the roles/ students have the same perception of the team's success/failure?

Running the Game

This is a game where the effects of poor communication are felt quickly. The role cards all have different information so the teams need to communicate to find this out and to learn each other's knowledge. They are not told this at the start.

When running the game students will often become confused about what to do. As noted, we do not want them to withdraw from the exercise. Tutors can assist with ideas for what to do to avoid people feeling too confused. Alternatively tutors can intervene with extra tasks to increase the tension and reduce the group ability to focus on communication.

Reflection on Game

The students find that they have attempted to use their technical skills but what was needed was the extra skills like teamwork, communication, and respect. These are more important for the success of this project. Issues that arise include lack of communication within the teams and

between teams (representing the stakeholders). Rarely do the groups achieve much of their goals, so this raises good discussion about why they did not.

Also the rules for the community provide just a brief idea of the cultural conflict between the approach of a professional engineer and the community professionals or knowledge holders with whom they are working. This conflict again focuses on communication, as that is the key take away of this simulation.

One aspect that also is clear, the community can itself build the buildings and structures they need, however that requires a community team with a strong leader, who can grasp the situation, the needs, and the resources, and run with a solution within the team. Mostly teams are too confused by the new rules and the new situation to grasp this process.

This part of the exercise reflects what it is like for First Nations communities to be confronted with the changing government policy over the years: firstly mission policy; marginalisation and assimilation; then self-governance (with little funding); The Intervention; and so on. We can see the debilitating effect that lack of control over basic decisions has in the long term when we put teams into such new contexts with new rules they are not familiar with.

3

Scenario Teaching Through Vignettes

Jayne Boase

The Blue Wren vignettes are introduced to first year engineering students in the Sustainable Engineering Practice course at the University of South Australia (UniSA) to provide a way for engineers to understand the importance of working with Aboriginal organisations and communities in a way that is culturally sensitive, productive and technically sound.

Since 2017 the Blue Wren vignettes have been delivered by Aboriginal tutors to thousands of students across civil, mechanical, and electrical engineering programs at UniSA. This material was published in Deanne Hanchant-Nichols, Andrea Duff, Elizabeth Smith, Jayne Boase (2022) Blue Wrens Take Flight in Engineering Education.

Approach to learning

The Aboriginal Content in Undergraduate Program (ACUP) is scaffolded across the four years of the engineering degree.

The Blue Wren vignettes are included in first year through a facilitated discussion in a workshop delivered by an Aboriginal tutor. The discussions are supported by an online culture forum where students reflect on the ways in which engineers' work may intersect with Aboriginal peoples, and what culture means to the student (as the first step in developing their positionality). This learning then informs the design solution they develop later in the course for the Engineers Without Borders Challenge which is focused on a local or international Indigenous community.

The student's engagement in the forum together with an individual report, accounts for 25% of the total course grade. Project deliverables for the EWB Challenge project make up 50% and the remaining 25% is allocated for students reflecting upon their learning in this course.

In the vignettes, the fictional Blue Wren sporting association engages an engineer to run a project to update their sporting facilities. The engineer makes a series of mistakes as he engages with the association members, and through these mistakes, several important learnings are highlighted, such as the significance of collaboration and community voice, understanding Aboriginality, inclusivity in decision-making, learning about sites of cultural significance, reconciliation, what constitutes a 'Welcome to Country' and an 'Acknowledgement of Country,' and the avoidance of stereotyping. These themes are integrated into engineering considerations in the vignettes, including general aspects of collaboration and inclusion, site assessment, safety, the tendering process, conduct during meetings, and the importance of avoiding or clearly explaining jargon and technical terms.

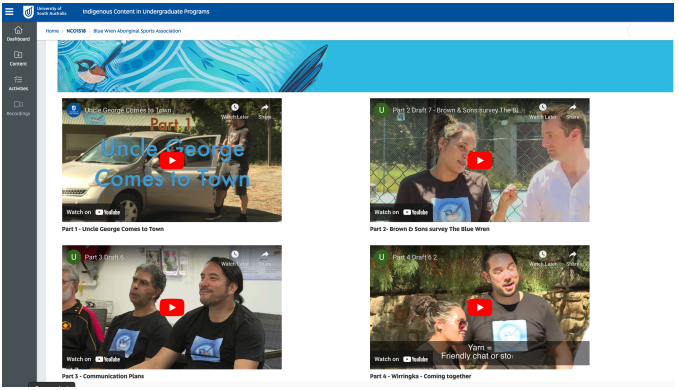

Figure 1. Interface to the Blue Wren Sports Project screenshot from https://lo.unisa.edu.au/mod/page/view.php?id=800420 (UniSA)

The structure of the learning and how the vignettes are included is shown by the content of the lessons being:

- Guided questions for students at start.
- Progression of the storyline with the actors on location.
- Piece to camera where Uncle George summarises key learnings
- Questions at end to help students reflect on their learnings and these can be discussed in class after each vignette has played.

As an example in Vignette 3, James is accompanied by his intern Paolo to a committee meeting to present to the members. Awkwardness becomes clumsiness as it becomes evident James does not know the difference between a Welcome to Country and an Acknowledgement of Country; he talks over committee members and uses alienating

technical jargon. These are all clear issues for students to see in action and realise the need to develop a different approach.

There is then a 'lesson' provided by Uncle George for James and the students. Finally, there is a set of reflective questions for the tutors and students to discuss.

Under Resources Page see:

 Blue Wren Aboriginal Sports Association Makeover

 What is Culture

 STEM, Culture and Aboriginal Communities – Aviation

 STEM, Culture and Aboriginal Communities – IT

 STEM, Culture and Aboriginal Communities – Engineering

 STEM, Culture and Aboriginal Communities – Science

 Stem, Culture and Aboriginal Communities – Maths

For more information contact Jayne Boase at UniSA

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Hanchant-Nichols, D., Duff, A., Smith, E., Boase, J.(2022) *Blue Wrens Take Flight in Engineering Education.* In Kutay, C., Leigh, E., Prpic, K., Ormond-Parker, L (Eds). Indigenous Engineering for an Enduring Culture. Cambridge Scholars Publishing https://www.cambridgescholars.com/product/978-1-5275-8759-5

4

Caring for Land Country

Cat Kutay

There are many aspects of Caring for Country that can be studied such as: construction for living on Country or Keeping Places for knowledge artefacts; governance and management of projects; communication and consultation strategies. This short case study presents an overview and examples of Firestick farming practices and the technologies that support this in Caring for Country.

The history of land care in Australia has been one of ignoring the knowledge of the First Nations, particularly around burning (SBS, 2021), to the peril of those now living near bushland, which is still adapted to regular cool fire burns. These are planned burnoffs during suitable weather and vegetaiton growth, which are low-heat and cause less damage and are done in a varied mosaic across country each year. This knowledge is starting to be respected by non-First Nations.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://oercollective.caul.edu.au/engineering-with-country/?p=80#oembed-1

From ABC News, 2020 . Licensed for adaption and re-use under (CC-BY) and used with the permission of the ABC.

Cool fires are fires that do not rage uncontrollably over the landscape, and which animals have a chance of fleeing. They can be deliberately lit at times when the ground, plant or air moisture is high to reduce the intensity of the fire and the burning is done in a regular rotation or mosaic pattern across the landscape. This reduces the build up of leaf litter and detritus in any area and ensures the area surrounding any new burn off will have reduced fuel load from burns in previous years. The resulting cool fire will generate less heat, spread less and have less impact on the environment. This practice was carried out across Australia by clans of Aboriginal people walking around Country carrying firesticks – lengths of wood that were alight or held embers, and could then be used to light grass or other growth.

The practice of fire stick burning is reducing carbon emissions from fire and is now supported by carbon credits. This is a process where other industries, government and organisations put their profits into a fund to pay communities who do this work of regular mosaic fire burning. The practice is seen by community as important

for maintaining their Country, and the credits tend to go towards other enterprises, allowing the community to choose what is funded.

However, there is more to fire management than just reducing the fire load. The actions of various animals reduce the fire risk. For instance, kangaroos and other animals that eat low hanging branches reduce the chance a grass fire will climb into the higher branches. Wombats and other animals that dig burrows bring moisture into the ground and reduce the risk of fire through the root system. It is a Whole of Country process to reduce fire and have sustainable land use.

The North Australian Indigenous Land and Sea Management Alliance (NAILSMA) is an organisation dedicated to creating partnerships with business and government to improve sustainability of land and sea management practices while creating jobs for local Indigenous people (https://nailsma.org.au/).

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Special Broadcasting Service (SBS). (2021). *Firestick farming: how traditional Indigenous burning protected the bush*. https://www.sbs.com.au/voices/article/firestick-farming-how-traditional-indigenous-burning-protected-the-bush/xc90vv8l7

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5

Caring for Water Country

Cat Kutay

This chapter is part of a developing project which will be updated over time. We are researching water rights, water usage and water needs in the Northern Territory where the State Government is investigating the resources required to support more industry. Water scarcity is a particular problem and there is further concern over the effect on our aquifers of the proposals by fracking industries. The aim of much previous research has been to maximise extraction without good understanding of the limits of the water system.

However the water usage by First Nations for cultural purposes is often not related to extraction or allocations but to ensuring that the resource and the area remain in its present state, that the environment and people are sustained.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://oercollective.caul.edu.au/engineering-with-country/?p=82#oembed-1

From Commonwealth Scientific and Industrial Research Organisation, 2013.© Copyright CSIRO Australia, used with the permission of the CSIRO Australia.

Work by First Nations water engineers is bringing back some of the First Nations knowledge, not to find the underground water, but as a way to understand its flow and its limitation. The work is described further in Moggride's (2020) Aboriginal People and Groundwater.

An interesting approach for students would be to juxtapose the work of engineering a large water system, such as supply for a city or suburb, with the approach of First Nations groups now working at state and national levels. More material is provided in Moggridge et al, 2019.

While this First Nations focus is usually local, with sufficient experience on Country many aspects of the water management and conservation process can be shared across language groups and waterscapes. There are always similar features in the stories of water management. For instance, the snake Baiame is known by many different names and moves across the landscape creating the rivers.

These stories contain indicators of local river health and aspects of the Country that need to be monitored, including the signs of imminent flood and developing drought. This reflects that water is a valuable resource and people have to prepare for these changes in Country.

This value of water is often not acknowledged in our present societies, as the presence of a piped supply is assumed. However in First Nations cultures water had a spiritual significance (Water Quality Australia, n.d.) due to its high importance for life. For instance as the value of fresh potable water was high, waterways were kept free of pollution, which now often occurs due to overloading the local environment, or mass extraction of material. This approach to caring for water arose from a very different perception of the place of water as part of the animate environment:

> Recognising and affirming that water has a right to be recognised as an ecological entity, a being and a spirit and must be treated accordingly. For the Indigenous Nations water is essential to creation and many of Dreaming and other ancestral beings are created by and dwell within water. Water is a living being and should be treated accordingly.
>
> From 2007 Echuca Declaration (as quoted in Murray Lower Darling Rivers Indigenous Nations, 2010),

The value of water to First Nations can be appreciated through the wealth of knowledge of the different types of groundwater and how it is used sparingly by communities. The knowledge of water management covered river water, ground water and care of sea country.

The right of access to and the care of water is a Human Right and part of the Native Title Report (AHRC, 2008). However the legal rights to access water for the care of

water are rare in the settler-state legal system (Taylor et al., 2022). Despite this lack of recognition of the need to manage water with a depth of understanding, gradually First Nations knowledge of water management is becoming more widely known and accepted which is changing the broader perception of water (Harriden et al., 2022) and how we manage or respect this resource (Australian Government, 2021).

Given this situation, there is much work to be done to change the legal and practical frameworks around water in Australia so as to match international law.

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6

Water Transport

David Payne

For First Nations in Australia, water was used for transport as a quick and convenient way to traverse various area of water and country up rivers, or cross to islands for their rich food supply, or just to go fishing. These watercraft were designed to suit the local resources and the challenges to water travel within their environment.

The existing distribution of watercraft around Australia is rich and extensive. In contemporary times the watercraft were gradually recorded in colonial journals and logs, then later in research papers. Throughout their existence, the craft have also been kept as knowledge by the communities building them, and many communities still hold that knowledge and can continue the practice. Despite the extensive distribution and examples of the ongoing tradition, today there are still many people who are unaware that any Indigenous watercraft even existed.

The map (figure 1) I have drawn records as best I can all those craft that existed at the time Europeans arrived, and almost all are still able to be made by their community.

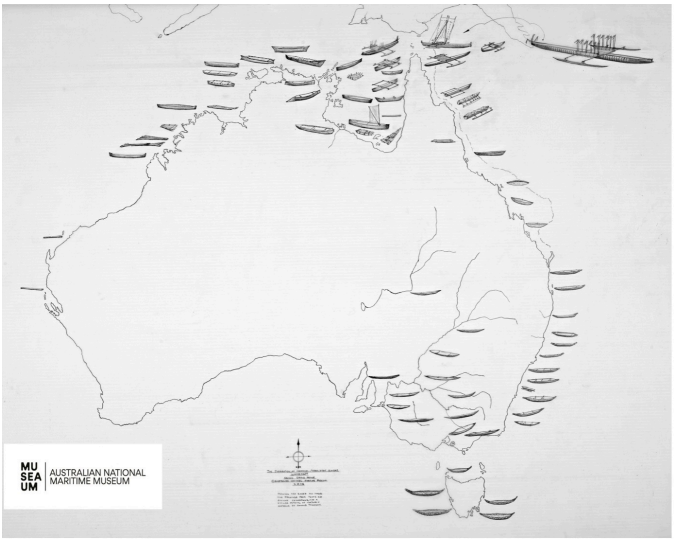

Figure 1. Provided by David Payne from his drawing Map of the distribution of Aboriginal and Torres Strait Islander watercraft in 2014, Reproduced courtesy Australian National Maritime Museum. Licensed for adaption and re-use under CC BY-NC 4.0.

The craft have been studied a number of times with basic maps that show some of the types and locations. Only one, by Rupert Gerritsen [1] was comprehensive, but he adopted symbols for each broad type. By drawing them individually, based on documented images and descriptions, it is possible to go deeper into these broad types and reveal the individual variation that exists, even within distinct types. Freshwater and Saltwater are a good division to start from.

Freshwater communities:

The freshwater, south east inland river system we know as the Murray Darling is the primary mainland freshwater region that supported communities with watercraft. Evidence from elders also connects similar craft to adjacent rivers flowing toward Lake Eyre in central Australia. This

extensive waterway system is home to a distinct type, a single sheet of smooth bark formed into an elegant boat shape. It goes by various names but is known as a *yuki* by the Ngarrindjeri people on the lower reaches. Whilst it is commonly known that the prolific river red gum was used for their construction, it is less well known that one or two other barks were also available and used.

Elsewhere, amongst the numerous inland freshwater rivers, lakes, swamps and billabongs that exist across the country, the ability to make a simple raft for temporary use was also practiced in a number of places. Sometimes these were made on a more or less regular basis, other times it may have been an almost spontaneous construction to suit the moment and perhaps only used once or twice.

Saltwater communities:

The great majority of watercraft belong to coastal and estuarine saltwater communities. As can be seen on the map, their distribution covers over 2/3rds of the coastline, and includes the lower tidal and brackish reaches of the many rivers that flow to the coast. Bark canoes are the most numerous types, along with dugouts, outrigger canoes and rafts. Dugouts were a greater commitment of resources and more designed for deep sea travel.

Tasmania is home to a very distinct type of bark canoe, the rolled bark canoes called *ningher*. Their relatively solid, three-part or multi-part configuration is quite different from other bark canoes on the mainland. Research is showing how different material choices, locations and uses gave subtle variation to the form within the overall concept of a bundles of buoyant material strapped together, then finished with a layer of stiffer bark.

On the mainland along the eastern coastline of NSW and Victoria the tied-bark canoes offer a good example of individual variation within a shared concept. They range from the Boonwurung and Kurnai communities in SE Victoria up along the coast as far as the Gubbi Gubbi community and the Fraser Island area in Queensland.

All these craft have the ends folded and tied together after the ends of the sheet have been thinned down, and the bark is heated by fire to help make it more supple. They are often both tied and fastened with a peg through the folds, and have minimal framing inside the hull. There are variations in the proportions, details of the ties and the method of framing. On parts of the NSW north coast the folds appear quite small and the bound ends are also turned upwards with a crease across the hull. From about Lake Macquarie south, the crease disappears and the folds become a bit wider. Ring frames with ties across the top pulling the frame and sides inwards appear in these craft, alongside the beam and tie system that is simpler to make. Gippsland craft show evidence of being quite long, and having their ends very tightly tied.

In most communities the bark sheet cut from the tree is then inverted to form the craft, and thus the smooth inside surface of the bark becomes the outside surface of the canoe. This also holds the resin rich, waterproof and strongest fibres, and as these are undisturbed by the thinning process, they maintain their integrity as a foundation for a strong canoe.

Along the north-eastern Coral Sea and Great Barrier Reef coast of Queensland the diversity of bark canoes begins with marked change from the tied bark canoes that have come up about as far as the Gubbi Gubbi community adjacent to Fraser Island. To the north including the area

around the Percy Islands, a more complex three panel, framed bark canoe occurs over a small section of the coast. This craft has flat panels made from the ironbark, and has the top edge (or gunwale) as well as the joint (or chine) at the bottom between the panels reinforced with a branch secured along its length .

Above this point on the coastline the beginnings of the sewn bark type appear. The principal element of these sewn craft is a neatly sewn join at the ends of the craft, bringing the sides together to form a rounded hull with a profiled bow and stern shape. Internal frames and longitudinal branches at the top edge help add support. The sewing is very precise and combined with a resin sealant provides a very watertight joint.

Torres Strait and nearby areas of Cape York's coastline are home to outrigger canoes. The Torres Strait examples are perhaps the most elaborate Indigenous watercraft, and their construction is closely related to the Indigenous communities in nearby Papua New Guinea. Traditionally the main hull was made by a Fly River delta PNG community in exchange for shell and other trade items from the Torres Strait islanders seeking the new canoe. The final arrangement of outriggers, platform and sails were completed by the Torres Strait Islanders. Ian McNiven has made an extensive study of these craft and their social story, showing that their trading reach extended well south [2] and possibly east as far as Hawaii [3].

Different types of outriggers that show an influence from the PNG canoes are built by Aboriginal communities along the Cape York coastline. These show as simpler forms of single and double outrigger canoes, using dugout logs

from the local region's trees. They share the waterways with the sewn bark type, providing a distinct comparison of materials and technology.

The top end of Australia, from Cape York and Torres Strait across as far as the Kimberley and Broome regions takes this comparison of different types sharing the coastline and waterways even further. Sewn bark canoes in a variety of distinct profiles and framing techniques exist from the Tiwi Islands in the west across to Cape York in the east, but all sharing a sewn method of joining the sides to form the two ends, and even joining panels of bark together to form a longer canoe shaped hull. The evidence currently points to them pre-dating the introduction of the Macassan style dugouts seen throughout this region.

The dugout canoes were introduced by the visiting Macassin traders, possibly as early as the 1500s. Initially they traded their lipa lipa craft, but eventually the skills and tools to make them were acquired as well. On the whole they appear quite similar in construction and shape, another point of comparison with the sewn bark ones and their variation in style. On the western side of Cape York, they have adapted dugout canoe hulls with the addition of simple outriggers to form a more stable vessel suitable for deep sea travel.

Added to all of this are the distinct raft types that would have co-existed in the same time frame as the many bark canoes. These are well known in the King Sound region of the Kimberley coast where *kalwa* or *galwa* double raft was used, with two fan shaped sections simply lapped together. Research is showing some variations of this type further to the west, including just single fan versions. Rafts are also represented by vee-shaped types, from the Mornington Island group in the lower Gulf of Carpentaria. the Kaiadilt

and Lardil communities' *walba* or *walpa.* Branches and trunks are bundled together and strongly tied to form a locked in rigid structure with sufficient buoyancy.

In addition to this, throughout Australia there seems to be consistent evidence of simple rafts and swimming logs being used in saltwater environments too. Sometimes they were made on a more or less regular basis, at other times it may have been an almost spontaneous construction to suit the moment and perhaps only used once or twice.

It seems that two thirds of the country have an array of specialised craft, but the south west quadrant remains empty of evidence. A lot of it is a rugged and dangerous coastline that would not be easy to use beyond the beaches, yet the existence of estuaries such as the Swan River where calm conditions prevail begs the question- were there craft that plied these waterways, but not recorded by early explorers? Community stories suggest that even in these estuarine areas there were no canoes as the water was shallow and everything that was needed could be sourced and managed in various ways without requiring a watercraft.

Overall, the map tells a story of the types, where they are related or where there are distinct changes, but in this form does not show how this might correlate to communities, and to the environment. It needs an overlay with both, to see how they could inform us further about the variations that exist. A study of stringybark for example shows it provides a good material over a range of similar trees from South Australia though to the top end, but how the pliability and other factors within the bark material compares to each other, and how this then relates to the eventual shapes and construction methods is worthy of further investigation.

This area is one where the results could help with a much bigger picture than shown on this map. If we compare the known evolution of the Australian environment since occupation with its current state, which has now existed in relative stability for about the last 7,000 years, then we may develop a new understanding of the possible chronology and age of these watercraft.

The construction of these water craft link to their diversity together, which we can highlight through a couple of craft.

The ningher rolled bark canoes (figure 2) from Tasmania seem to tell a story for floatation and stability, where the thin sheets of bark or strands of buoyant reed that are bundled together to form the craft, by bulking out the volume that gives the displacement needed to support its weight and anyone on board. The actual displacement volume is still porous and very dependent upon how tightly the reeds or bark is rolled together to minimise spaces that would fill with water as the craft entered the sea. Each craft would have varied, some better at floating than others, but their substantial size may be one element that reflects the difficulty in achieving volume.

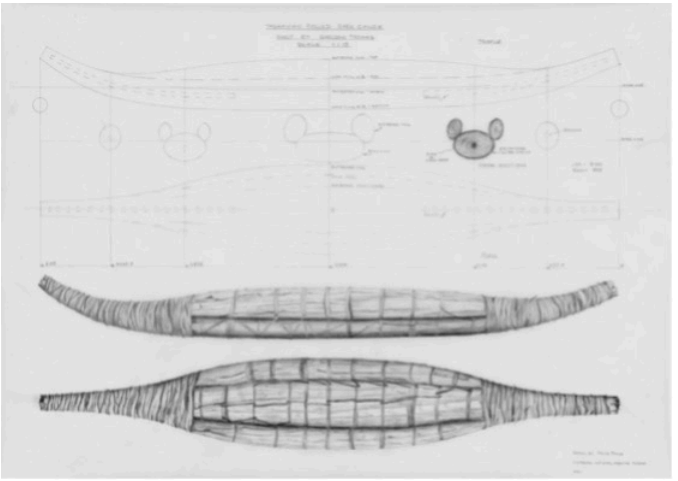

Figure 2. Rolled bark ningher built by Sheldon Thomas 2013 Tasmania, plan drawn by David Payne, Australian National Maritime Museum. Licensed for adaption and re-use under CC BY-NC 4.0.

A section through a rolled bark canoe shows the two outer hulls or sponsons around the main hull, creating on one hand a cockpit area protected from waves, but equally important, the volume out wide these hulls provide adds hugely to is stability. It is an idea seen again in a section through a modern polyethylene sit-on kayak where a lot of stability is provided by adding a section at water level on the outer side of the main hull, so that the craft are safe and usable by a wide range of people. At two ends of the time scale the same idea is being used.

However, an overall observation of the environment they are often used in and how well the shape is adapted to this is a consideration that I have made that deserves to be acknowledged. These craft when taken offshore of the coast are in a region where storms and strong winds can come up suddenly, and rough seas are very common. In these conditions an open canoe such as a tied bark canoe is

vulnerable to being swamped on many occasions. However, the relatively solid shape of these rolled bark canoes probably allowed waves to roll over them, and they remain buoyant after the wave has passed and the water trapped between the side sponsons has drained off through the gap between them and the main hull. In this manner they are the ideal solution.

The Kimberley coastline is home to the kalwa, galwa (figure 3) and kawlum (figure 4)- a two-part, fan shaped multiple log raft and presents a good opportunity to highlight some vessel design issues, in particular that key element; you have to have enough volume for the craft to float. It's easy enough to visualise a log floating roughly half in and half out of the water. The half that submerged is creating enough volume to support the weight of the log by itself, so the half that's left above the water is free to allow the log to support some more weight before it too is submerged. If you put enough logs together, you have enough volume in reserve to support a person, or even a couple of people as evidenced in images of these being used. The key is recognising how much volume is needed.

Contemporary designers can calculate this, as I have done on the drawings which show two craft. Both will support itself and at least one person with about at least 20% of their volume still above the water. The larger one has sufficient volume to take two people. However, an experienced builder, working with the knowledge handed onto him in a sequence going back countless generations, will know by observation of the length and size of the logs he has just how much it might be able to support.

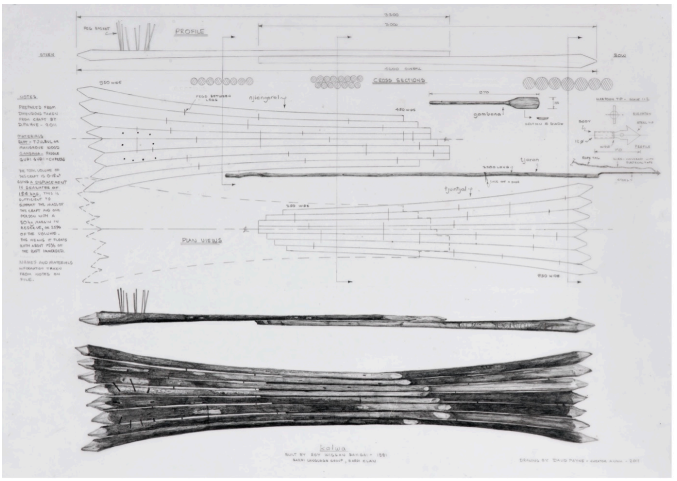

Figure 3. Galwa in Australian National Maritime Museum Collection, drawn by David Payne, Australian National Maritime Museum. Licensed for adaption and re-use under CC BY-NC 4.0.

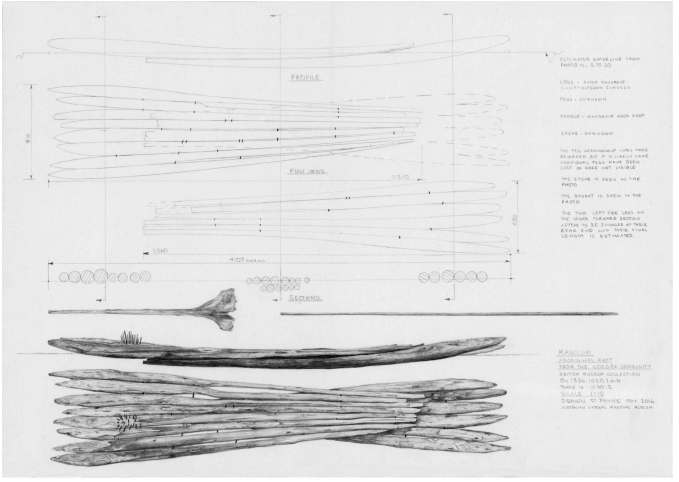

Figure 4. Kawlum in British Museum collection, drawn by David Payne, Australian National Maritime Museum. Licensed for adaption and re-use under CC BY-NC 4.0.

The construction is well thought out, with the shaped mangrove tree logs pegged together to create a rigid fan of logs in the same plane. Its use as a two-part craft for hunting dugong or turtle is a highlight. The line from the harpoon spear tip used to spear the animal is tied off to the forward part of the raft which is then separated from the aft part, with the animal secured to it and left to tire itself out before the raft section and animal are retrieved. This can be seen as a clever piece of lateral thinking.

There was also a single fan raft recorded, the brief sketch showing how it was made rigid with beams lashed across the ends.

What also needs to be highlighted is similar to the ningher. These rafts are quite open, the water can flow through and over them and they remain buoyant. This is a big advantage in this region of strong tides, whirlpools and rips. Over a month-long voyage in a sizable yacht, I have sailed through and experienced them myself and it is easy to recognise again how a conventional open canoe type would founder in these conditions whereas a raft passes through the waves unharmed.

The double outrigger craft from Torres Strait Islander communities are the biggest and most sophisticated watercraft, the longest were up to 21m overall (figure 5). The main hull is made in the Fly River region of Papua New Guinea by their community, and this and other features share a strong connection to New Guinea community watercraft. The construction begins with a hull that has similar features to that used in the dugout canoe construction. The canoe hull is made from solid tree trunk that's simply hollowed out, and has no frames. The hull has a strong base created by a heavy wall thickness on the bottom that compensates for the significant loss of

strength created by the cut-out along the top quarter of the cross-section's circumference. It also puts weight lower down as the sides have a significantly thinner wall thickness, helping lower the centre of gravity, very useful on this long and narrow rounded hull shape that offers little form stability derived from width, unlike the bark canoes.

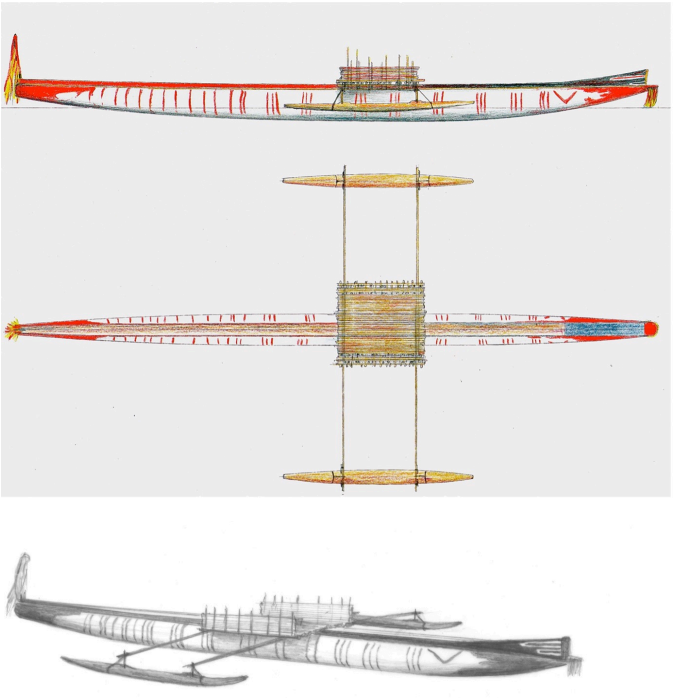

Figure 5. Kai Marri;na drawn by David Payne, Australian National Maritime Museum. Licensed for adaption and re-use under CC BY-NC 4.0.

Another feature not immediately obvious is that the craft is orientated to take advantage of the upwards taper in the trunk starting from its widest section at the base. Their custom is to always have the shape orientated so that the

bottom of the tree becomes the bow end, and then the shape gradually tapers aft to become thinner, perhaps not by much in some trees. The overall distribution of the volume then places more of it at the front, and one factor for this is it provides support where a hunter stands ready to harpoon quarry. In this case the forward concentration of the hull's volume distribution also requires the main structure across the hulls to be placed forward of the middle so that the hull will sit level in the water, and does not need an awkward distribution of the paddlers to compensate for the weight and bring it back to level trim. Outriggers such as *Kia Marrina* below show very elaborate construction and embellishment, and the width of the outriggers allows the floats to be smaller helping provide a balance between stability and manoeuvrability.

To finish its interesting to show how these watercraft craft have been developed to a high degree yet often appear quite simple, using the yuki (figure 6) from the Murray Darling River System. This shell-like craft can be classed in modern terms as a monocoque construction, whereby the panel is strong enough by itself to support the load with minimal or no support structure. The term comes from a combination of Greek and French, coined when the French created monocoque panels for aircraft in the early 1900s, and it was considered a very advanced method of building at the time. Essentially it is a shell or 'stressed skin' form of construction, where the shell supports the loads. Characteristically there are large panel areas spanning between the bare minimum of frames and longitudinal supports, perhaps none in some designs. Monocoque construction has had a resurgence of use with composite

fibre reinforcement panels, and in the maritime field it is now well known for its use on dinghies, yachts, powercraft and other vessels.

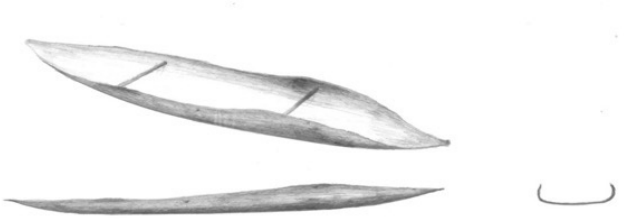

Figure 6. A typical yuki shape drawn by David Payne, Australian National Maritime Museum. Licensed for adaption and re-use under CC BY-NC 4.0.

Clearly the monocoque concept has always been well understood by Indigenous Australians. Bark is essentially a fibrous material. In some of the trees much of the fibre orientation runs parallel to the vertical trunk, ie: running up and down the tree or along the panel when it is cut. The interwoven nature gives a good cross connection, and often allows it to bend easily athwartships, while remaining stiffer and more rigid fore and aft. A yuki is generally made from red gum *Eucalyptus camaldulensis* and can be a shell that is 25mm thick. Their layers of fibres run more diagonally and interweave in different directions under each other forming a more homogonous panel that can be manipulated in both directions. The bend around the hull is easier than the bend fore and aft, but the ends can be moulded to rise up a little. The best yuki come from trees with a slight bend already in the trunk, along the length of the panel to be cut. Taking the bark from around this bend gives a nice curve fore and aft already built in that

can be accentuated more easily at the ends, with heat and pressure. Once completed the canoes often have just two beams holding the sides apart.

Some may look more elegant than others when placed side by side, but that's not the measure, the yardstick is how well each one relates to their circumstances- the environment they operate in and the materials it offers for community to work with.

Within individual types there is often subtle variation in the detail over the geographical range of the type. However, looking for a pattern of exchange and sharing of methods between the different types along the coastline doesn't seem to show any gradual change and evolution between type or community. In fact, there are some quite marked changes at times. While gradual change might seem an obvious avenue to explore, its actually the wrong pattern.

What is probably shared but evolves and changes to suit each community is the broad concept or pattern of making and using a watercraft, the one first outlined when we built the nawi. Is the vessel needed, what are the resources, there is proper ceremony or protocols to observe, a method to be practised each time, a way of looking after it for use. Overall it is a series of steps that delivers the required craft, steps that are repeated each time to maintain continuity, stability and sustainability.

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7

Songlines and Transport routes

Cat Kutay

The Songlines of Australia were ancient trade routes. These songs are easier to memorise than spoken stories and they tell of the path to take, the significant features and the water and food resources along that path. These cleared paths often provided the route taken by early horse drawn drays and so developed into the modern roads in Australia.

History

Research the main road routes in your cities, what older track they were built over, who used this route before? Consider how they avoided hills and wide waterways, what were the beginning and end points of the tracks?

The songlines are part of the traditional knowledge that is shared from childhood for those growing up on their country. The initial story is how to find your way on country, where the features are described as created by an ancient animal or human traversing the land. That animal will be an important food source in the area and knowledge of what it eats, where it rests, when it gives birth, and so on, is vital for survival on that Country. So these are the first things told to children in the Songlines.

This is explained more in the SONGLINES video which is available from National Film and Sound Archive (NFSA)

Australia

There were many such trade routes across Australia, all known in First Nations stories and linking people across the continent. However it is often not the people who travelled, but artifacts or resources, such as ochre from the mines at Thuwarri Thaa or Wilgie Mia; the Piturie or bush tobacco from Western Australia or the shells from the north. These were passed along the trade routes.

One or more interactive elements has been excluded from this version of the text. You can view them online here:
https://oercollective.caul.edu.au/engineering-with-country/?p=207#video-207-1

There were traders in Australia, those who specialised in transporting these goods for at least part of their journey. To help them do this journey they carried maps, on their woomera or shield or on message sticks. The criss-cross patterns on the wooden artefacts suggest the change in direction of the trade route to be taken. Cowan (1992) writes that:

> *Shield or sand drawings (also message sticks and clubs) formed a geographic map of regions from which trading parties or visitors could draw on knowledge when it came to travelling through unfamiliar territory.*

Knowledge of the stars was important for long land and sea voyages for First Nations as much as for European and Asian seafarers. For First Nations, the land, the sea and the sky are all part of Country and you cannot know one without the other.

Research

Research the different aspects that First Nations attribute to the stars. and what astrological knowledge is significant in the culture

One of the most famous songlines is the Seven Sisters Dreaming that crossed Australia from west to east and also had links through tracks off to other centres such as Hindmarsh Island. This is the same story as the Greek

Pleiades, the seven sisters running from Orion the hunter. This suggests that there was trade right around the globe long ago, guided by this bright star group as it traverses the globe.

Further material on trade routes is kept at Museums like Queensland Museum and the Australian Maritime Museum. First nations travel was by land and water, navigating by the stars and by oral memory.

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PART II

Part B - Discipline specific material

This section is a series of articles related to specific disciplines which have requested support in finding relevant material. We are interested in hearing of areas you want help in providing material for students, or ideas you have that can be shared with others.

The aim of these resources is to provide both assessment approaches and learning material that will enhance the understanding of First Nations approaches to knowledge gathering and knowledge sharing. While it is hard to slot First Nations knowledge into a discipline, we have found it informative to start a chapter on an area and follow the progress of the topic through many other disciplines, illustrating how knowledge is tied together across the areas.

When these are used in class, the assessments are designed to encourage students and practitioners to look beyond their discipline and the project boundaries to consider the impact on other areas. Also we expect that the reader will change not just their understanding, but their ways of thinking about engineering.

8

Cooling and Energy Saving

Cat Kutay

This case study presents an overview and examples of engineering of alternative food collection and storage solutions focusing on fish traps.

The Fish Traps on the outskirts of Brewarrina on the Bardon River are considered one of the oldest human made structures and the site is heritage listed (DCCEEW, 2021). They can be visited when in the region (Brewarrina Tourism, 2021). They show an ancient way of collecting and storing fish in the ponds, and they have been also linked to aquaculture in the area. The care of the fish population along the river was supported by regular knowledge sharing ceremonies in Brewarrina.

The Brewarrina Fish Traps are known as Baiame's Ngunnhu, as the creator spirit Baiame created these traps by throwing a net across the river and, with his two sons Booma-ooma-nowi and Ghinda-inda-mui, built the fish traps to this shape. They are a complex network of dry stone walls of river stones arranged in ponds that catch fish as

they travel upstream before breeding. Channels between the ponds allow some fish to continue up or down stream to avoid overfishing.

Ngunnhu Brewarrina Fish Traps

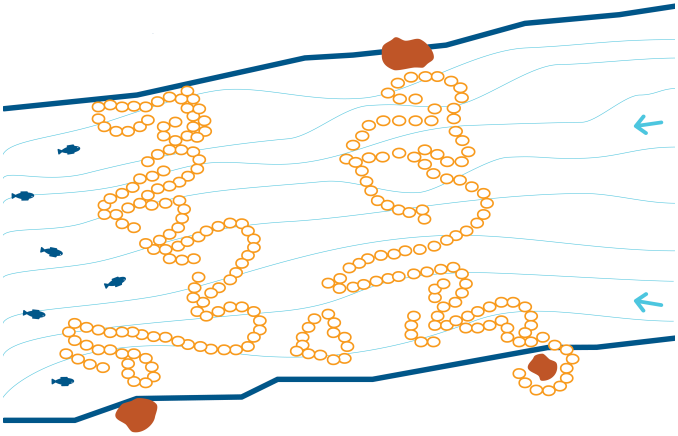

Figure 1. Image from The Guardian article by Monica Tan. Origin unknown

The fish traps reflect a simplicity of design, which was adaptable to the seasons and changing water levels. The traps higher up the banks were used in times of flood and the ones in the main river flow were used as the water dropped. The fish traps and the technology behind them show similarity to other natural approaches.

The stories of their creation, and the Aboriginal Law governing their use, are a significant spiritual, social and governance aspect of Aboriginal society, and important in the trade relations between Aboriginal groups from the entire region. The fish traps were an important site where food could be stored while people stayed to talk about land and water management and arranged marriages.

In the 1920s, non-Aboriginal people living in Brewarrina carted the stones away that had formed the fish traps and used them for foundations for buildings in the township. A weir was built across the river in the 1970s that again took stones from traps and also interupted the sediment flow and ecology in the river.

For instance the native fish could not move up the fishway built up the sides of the weir as it was constucted at an angle too steep for these fish to swim up. After more than 160 years of destruction of the traps and with loss of traditional management and maintenance due to people being forced into a mission and denied their traditional activities, there are still substantial elements of the fish traps in the river which the local Ngemba people continue to maintain along with the knowledge of their use and maintenance. The stories of the significance of the traps to people in the area are still told.

Below are old (pre 1970's) and a recent image of the traps.

Figure 2. From Powerhouse Museum, 1880-1923. Powerhouse Museum Collection. Gift of Australian Consolidated Press under the Taxation Incentives for the Arts Scheme, 1985. Licensed under CC BY-NC-ND 4.0

Figure 3. From Grahamec, 12 May 2014. Licensed for adaption and re-use under Creative Commons Attribution-Share Alike 3.0 Unported .

Sustainability

The traps are built as dry stone walls (ie no mortar) and can withstand high floods. A locking system made from the river stones fixes the base of the trap to the bed of the stream, while the keystone type structures provided more strength through the transversal forces of the heavy stones. They are designed with the small opening facing downstream.

As the fish swim upstream they enter the traps and are stopped at the top end. The trap can then be closed, or the fish can be caught by hand or spear and tossed into smaller ponds at the end of the trap for storage until needed. The traps are scattered across the river, not entirely blocking the passage of fish, but some in the centre flow for when levels are low, and some higher up the banks to work during floods.

Fish Traps around Australia

There are also many salt water traps along the sea coast. A survey of Queensland waterways in 2011 found 179 fishtraps and weirs. This research has been done to locate some of the traps in Queensland, the Gulf of Carpentaria and the

Torres Strait with the hope of preserving them (Rowland & Ulm, 2011). These were stone-walled and intertidal to control the coming and going of marine animals.

Figure 4. From S. Ulm (Australian Broadcasting Corporation), 2013. Licensed for adaption and re-use under CC BY-NC 4.0. Image used with permission of photographer.

The methods of construction, maintenance and use of the traps were shared with the community to ensure their ongoing use by people living in the region and sustainable use of resources. Some were made of rock, which had to be reset after high seas or river floods. Other were made of sticks and were set up when needed, and allowed to be re-incorporated or decompose into the surroundings when not needed, such as Figure 5 showing a wooden fish trap. The woven trap will be positioned in the gate when the tide turns and water begins to flow out, found at Bulgai Plains, between Liverpool River and Tomkinson River, Arnhem Land, NT, 1978.

igure 5. From Peter Cooke (Australian Institute of Aboriginal and Torres Strait Islander Studies [AIATSIS] Collection), 1978. Licensed for adaption and re-use under CC BY-NC 4.0.

Various other additions and adaptions have been seen at times, and the use of new technology and material that came with colonisation was adapted to reinforce the traps or made collection ponds out of rings of corrugated iron.

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9

History of Technology in Australia

Cat Kutay

To understand Aboriginal technology and the significance of some of the artifacts involves learning over time, just as this knowledge was shared over time with Aboriginal children as they grew up. It is a complex and holistic system of understanding and living in the country around us. Australia is slowly re-gaining a lot of the skills that we lost to all but a few, or skills that were diminished in value. Here are some selections from that history as found in the diaries which Bruce Pascoe read and then wrote about in Dark Emu (2014):

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://oercollective.caul.edu.au/engineering-with-country/?p=419#oembed-1

Figure 1. From B. Pascoe and TedxSydney, 25 July 2018. Licensed for adaption and re-use under (CC-BY) 4.0.

One quote from Pascoe's book is shared here as it relates to engineering practices prior to the invasion as seen by the new arrivals:

Embedded Knowledge

Later they witnessed the people fishing with canoes, lines and nets. The purpose of the weirs gradually became clear. They were made by damming the stream behind large earthen platforms in which channels were created in order to direct fish as required. On one particular day Kirby noticed a man by one of these weirs. He wrote that:

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 around the peg. (pp. 6-7)

How did Kirby interpret this activity? After describing the operation in such detail and appearing to approve of its efficiency, he wrote, "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."

Such quotes are found in diaries kept by the early colonisers of the country and are quite open about the attitude towards the people who had owned and cared for this country for millenia. Based on the quote above do this exercise to reflect on what this story means in terms of the history of engineering in this country.

Knowledge is embedded in the artefact

James Kirby was a marine, who had limited knowledge of general engineering and design. He could not assess from his experience the sophistication of this technology. Use your engineering knowledge to analyse and describe the fisherman's practice and what engineering knowledge is embedded in his design

There are many other technologies that are now being appreciated by non-First Nations. These include systems which were probably the first constructions by humans, such as the Brewarrina fish traps, and Budj Bim eel traps. These constructions involved large collaborative efforts that were managed within the tight system of relationships and responsibilities of Aboriginal culture.

Books such as the work by Page and Memmott (2021) provide case studies of Aboriginal design used in practice both before invasion and since then, incorporating new technologies. The adaption of place-based understanding in design has impacted improvements in adaption to country and local resources. Respect for the sophisticated minimalist and flexible designs of many Aboriginal artefacts such as the woomera and boomerang can inspire new approaches to modern technology. For exampe, while the woomera is a spear thrower which provides four times the kinetic energy of an arrow launched from a compound bow (SMH, 2004), it was also used as a water carrier and surface on which to draw maps of routes (see Trading Routes). The understanding of local material can provide for new manufacturing, such as the use of spinifex fibre in building (Guo et al., 2024) and in nanotechnology (Saltmere et al., 2022).

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10

Aeronautics

Cat Kutay

The ability of science to understand and manipulate the world is exemplified in our engineering. All civilisations have developed technology to suit the world they live in and to assist them to live a life they value. The technology that First Nations Australians developed not only had their own features unique to the culture, they also embraced principles that were valued by western cultures, such as aerodynamics and flight.

David Unaipon has been recognised on Australia's $50 note since 1995. He lodged 19 provisional patents during his life which he could not afford to fully patent, including shearing blades that converted a curved motion into the straight line movement which is the basis of modern mechanical shears. He wrote prolifically, and conceptualised the helicopter two decades before it became a reality. Three elements were regularly referred to in the press during his life: his sheep shearing innovations, his basic design for a helicopter based on the motion of the

boomerang, and his interest in the then entirely theoretical field of laser light. In a 1914 account Unaipon gave to the Daily Herald he suggests:

> "An aeroplane can be manufactured that will rise straight into the air from the ground by application of the boomerang principle. The boomerang is shaped to rise in the air according to the velocity with which it is propelled, and so can an aeroplane" (Unaipon, Daily Herald 1914).

A functioning helicopter did not appear until 1936, however the concept produced by Unaipon has been shown to work by students' projects at various institutions including Deakin University. The boomerang is an aerofoil design which provides the lift to enable it to fly long distances. By pairing two boomerangs and combining with motorised energy to rotate the blades, Unaipon provided the basic design of the rotor now used in helicopters.

The principle of aerofoils is important for lift in large aircraft and can provide direct lift when rotated rapidly in a circle. For more analysis of the flight path of a returning boomerang see this paper by Nicholas Landell-Mills (2019) on How boomerangs fly according to Newtonian mechanics.

On the boomerang, the aerofoil design is created by the carver who whittles the wood into the uneven profile that creates the pressure difference around the blade. The amount to remove from the faces and the amount to bend

the blades come from good judgement of how to affect the flight. The carver is a person skilled in the design and balance of a boomerang, however nowadays they are often carved by programs from plywood or moulded in plastic.

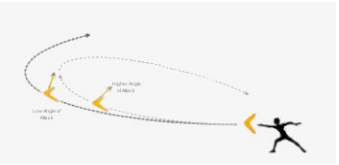


Figure 1 Flight Path Depends on Angle of Attack provided by author

The second aspect of the flight is the curvature of the path, which is created by the gyroscopic procession. The uneven lift between the two arms of the blade tries to tip the boomerang over, but just like leaning a moving bike over makes it turn in an arc. When the boomerang spins the tipping force between the blades is at an angle to its flight plane. This curves the boomerang's flight.

The angle of attack on a boomerang is the angle between the incoming airflow and the plane surface of the boomerang. The angle of attack affects the boomerang's lift and stability. It also affects the angle of curvature of the flight path. The greater the angle of attack will:

- Increases lift
- Reduces spin rate
- Creates a lower, circular flight path
- Makes the boomerang more stable in the wind

It is not possible to study the boomerang in flight without understanding the aspects of the design that are balanced to achieve its manufacture. So students need to find

suitable wood, carve the shape, adjust the curve and fly this versatile and portable technology, which is alo used for digging and rhythm sticks.

Shaping a boomerang

Manufacturing a boomerang requires selecting the wood you will use, with the correct angle of the wooden arms, or bending this wood through soaking in water and using steam. Then there is the angle of the arms above or below the horizontal or dihedral. Bending the arms will affect the manner in which it hovers, the distance it will travel and the path of your boomerang. See some comments on the link here.

Boomerangs are built to return, when used to frighten animals into a net or trap, or as non-returning, when designed to strike an animal hard. These have different designs to suit their function, where non-returning boomerangs are longer, straighter and heavier. The curvature of the return depends on the angle of attack and the curve of the boomerang including the warping or sanding of the opposing arms of the boomerang to make dihedral lift.

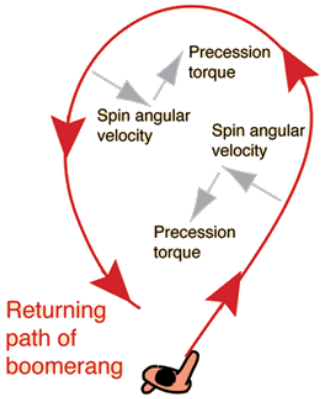
For the Aboriginal people making these aerofoils, the knowledge of how to adjust the size, horizontal shape (such as the slope of the front of the arms) and curve of the arms to suit their own throwing style and needs was **embedded knowledge** that would be shared with young learners in practical settings.

Exercises

Invite a local person with throwing skills to your class. This can be spear or boomerang.

- What material is used to make the artefact?
- What techniques do you need to design that artefact?
- What techniques do you need to throw the artefact?
- How can you change your throw or the artefact to make it easier to throw, or the throw range greater?

Throwing your boomerang



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The path of a returning boomerang is created by a number of forces. This is an example of gyroscopic processsion. When thrown, the boomerang receives angular velocity at right angles to its path (spin angular velocity). The cross section of the boomerang is an aerofoil which reduces air presure on the top side when moving to give it lift. These forces combine to create a torque (precession torque). The angle between these forces can vary (see diagram above). This is perpendicular to the spin velocity and will be clockwise or counterclockwise depending on the throw. This gives the circular path.

There are many ways to share skills and enable people to learn your skills, or for you to set up training for yourself that you need in your career. You can consider what ways you learn, what is best for you to remember and understand a lesson.

Then consider how this varies with the different topics you learn. What modes of learning you use and how this depends on the content or skill you are learning.

Exercises

Consider what ways you have been taught skills such as these, what was the context given and how were they repeated to help you remember:

- A mathematical concept
- A physics equation
- A sports skill
- How to do landcare or other environmental knowledge

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11

Materials and Construction

David Payne

Introduction

The Aboriginal people with their culture and community have been in Australia 'for ever'. Contemporary western science and archaeology tell us people crossed over to Sahul (a paleocontinent that included Australia and Meganesia by watercraft, somewhere between 45,000 to 60,000 years ago (Wikipedia, n.d.).

Creation stories refer to the spiritual origins of Aboriginal people on this country, with no measurable time span as to when that was, and these stories are still true today. The spirit of that creation remains in the land around us.

Watercraft feature in Dreamtime stories and watercraft exist today, therefore they have been part of the countless generations that have existed before the present. This legacy leads us to the understanding that in some form or other, these watercraft have also been here 'for ever'.

What they look like now may or may not be what they looked like then, and this should not matter in the bigger picture. Speculating what they once were and then how

the first craft might compare to the contemporary craft can easily head off on a subjective path of discussion and theory. What is important is the process that delivers these watercraft, and there is reason to accept that this process has, in concept, been developed and remained consistent for much of, and perhaps almost all of this 'for ever' timespan.

The example I will employ later in the chapter outlines a process that is used for one watercraft that is very familiar to me, the nawi tied bark canoe. I build them and pass on the instruction as my responsibility within my Yuin community circle. The process is a cycle that is repeated every time one is made, with a combination of spiritual or deep knowledge and practical aspects ensuring continuity in the community and sustainability within the environment. It also happens to be a good design.

This process is about taking only what is needed and doing ceremony for respect to elders, to mother earth, asking the trees for their permission, to settle ourselves, then for healing afterwards. Each time we move on to another place out of respect for the resources, to not take too much from one place.

There is cooperation with each other as the nawi is formed, respect for what the material can do and cannot do, then there is care when it is in use to maintain the craft for a length of time before it is returned to mother earth. It is not there to be used for just a few times, or for one season or cycle. In current marketing terms, this is not a single use, throw away item.

BUILDING CANOES

Vessel design as a profession is now taught as a branch of engineering called naval architecture but there are many who say it is an art as well, particularly with yacht design. Art has that intangible feel to it.

Form can follow on from function, but this often lacks a sympathetic, aesthetic style. We as people also see something within shapes that stirs our emotions in relation to beauty or elegance, and that also defines the chosen form. It can become a guide for judging if your object is going to work as intended. With boats, the flowing lines and form that are generated in the structure can be that guide, when they are looking right, they are in sympathy with the action and flow of the water and waves which it must move through.

Design by accident is often an accident waiting to happen. So, it might help to begin with an outline of what are the practical needs to be considered to make a floating craft, what requirements there are within the engineering or physics that must be observed to avoid accidents.

Vessels are a significant structure and like any structure they need to respect essential engineering practicalities to hold together. In addition, there are specific vessel design factors in relation to their volume and shape that will ensure they float and make progress on the water with the load they are expected to carry. Formal education now gives these factors names and methods of calculation, but there is much that can be observed from nature that would help make the process just as reasoned. Trial and error can help you arrive at a working solution, but clarity within this observation will reduce the errors considerably.

A boat is a complex item, but five things as broad concepts seem to stand out.

It has to be shaped to have:

- Enough volume to support the weight of the vessel and its load
- Enough freeboard in reserve to allow for waves, pitching and rolling.
- Enough stability so it does not capsize easily
- A shape to go through waves and water easily without excessive drag
- A shape that is controllable and can be propelled in any direction as desired.

Then there is construction, and the shape has to be built strong enough to:

- float in the water and support those in it
- accommodate changes in loading over the hull due to wave motions and being propelled
- be handled out of the water and stored on shore

If there is one thing that stands out as a priority it is this- there has to be enough volume to support the weight of the craft and what it will carry, with a reserve capacity. The remainder is fine tuning the shape of that volume and the hull overall to work better, and having it strong enough for its task and environment.

Instead of talking about weight, modern vessel designers talk about displacement, meaning how much water is displaced or pushed aside when a vessel floats. Think of it as the hole or shape created in the water by the floating

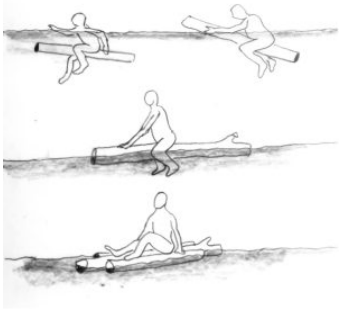
object. If it were a ball, it could be a half sphere. With a boat, the displacement shape is the submerged part of the boat below the waterline. That volume is the first part of an important consideration, and when weighed that volume of water pushed aside or displaced will be equal to the weight of the object that created the hole- that is the basis of the Archimedes principle.

Therefore, a canoe or raft has to have enough volume to support its own weight and the added weight of the people and whatever else it carries. It then requires a margin, in the form of additional volume and depth to the hull, obtained by adding height to its sides above its waterline called freeboard, to stop waves coming in and allow for rocking from side to side. To restate things, this additional material becomes a margin of safety providing additional volume in reserve.

And the bottom line here? This can be observed by seeing something floating, adding a weight to it and seeing how much lower it floats in the water, and deducing what the limits are before it submerges, or alternately what extra is needed to allow for more weight. You learn to see and feel the size of the hole in the water you need to fill and then deduce the volume needed for your canoe. You know how big to make it.

A swimming log will serve to illustrate this. If the log is too small it will all be submerged and not provide any assistance to the swimmer. But if it is big enough some part will remain clear of the water and the swimmer will also be partly supported out of the water. If you keep looking you will eventually find a log you can sit on with just your legs in the water. Then put the three of them together and you have a basic watercraft with volume and stability.

From *swimming log to raft.* D. Payne, Australian National Maritime Museum.



From swimming log to raft. From David Payne (Australian National Maritime Museum). Licensed for adaption and re-use under CC BY-NC 4.0.

All the Aboriginal watercraft in Australia recognise the many requirements beyond just the volume; they have the necessary engineering and hydrodynamics for their purpose within them, and it seems most likely this was all determined through observation and gradual improvement. It wasn't a matter of discovering engineering as a principle of design then building a craft, the craft that were best and hence their design was repeated, were those that observed the necessary practical requirements to build a well-engineered watercraft, otherwise it would not work in the first place.

The plan

The plan and the information for building were not drawn or written down. The process from the natural material to the finished watercraft was handed down by the older people to the younger people. Initially it was observed, and you probably just grew up with it from the day you were first placed in a canoe and developed a feel for their motion in the water.

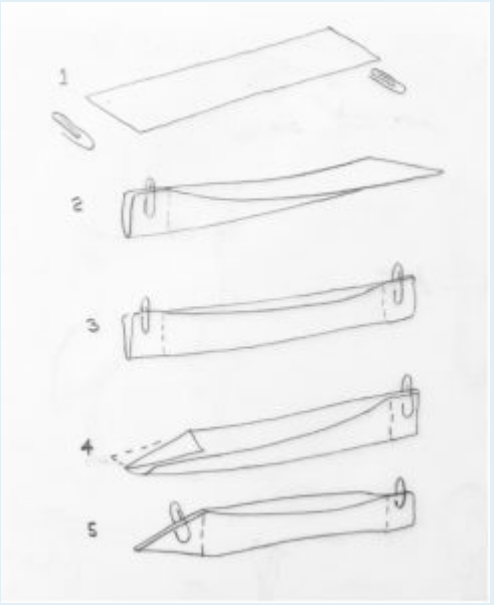
When the time came to participate it was spoken about, described, modelled or demonstrated, then finally acquired through repeated participation in the building process until this plan, including the things that could go wrong, had been absorbed. The plan was kept as knowledge within each community, and it was shared and passed on, ensuring continuity and community cohesion.

The craft kept to a 'plan' to recreate the canoe each time, it was a process that was practised and renewed through the continued seasonal construction of the craft. Generally speaking, there was apparently no desire to change or improve this model a community had arrived at, it fitted the equilibrium of living with the environment. Within the various communities it seems that maintaining a stable and sustainable culture was a much stronger practise than one seeking continued technological improvement.

However, the design changes depending on where and when you build the canoe (see Chapter 12), the environment supplies the resources and the challenges of water travel that determine the construction.

Exercises

For now we can do a paper exercise that demonstrates some basic aspects of simplicity in this process very quickly.



- Take a sheet of paper, cut so its length is at least four times its width. Note how it bends easily in either direction.
- Bring one set of corners on a short side together and secure with a paper clip, then do the same with the other. Now the shape holds itself up.
- Take off the paperclip from one end, fold the corners inwards, then fold it up again and secure with the paper clip.
- You now have a pointy end.

You have also just made a Yolgnu *nardan* or *derrka* canoe shape, the type seen in the movie *Ten Canoes*.

Drawing by D Payne

We have demonstrated some key points to take in.

- We've taken an available resource and not processed the material
- In simple steps we have shaped it
- We were letting it form in a way the material is happy to move
- We have an elegant and usable object

Think what it would mean if all engineering could be this simple and effective?

Building a canoe

Why are we building a canoe, or building yet another canoe? Why are we doing this today? This should be a question to ask before you start using resources.

The purpose of a canoe or other form of watercraft is to harness the waterways for transport. It enables easier movement within or between communities, improving communication, supporting social activities, along with fishing and food gathering. We can walk on the land, but the canoe becomes an object to take advantage of the water that is already there, and often provides or more direct link on the journey being undertaken.

With that reason we will create a nawi tied bark canoe from the eastern coastline. I have been building tied bark nawi canoes for over 12 years with the Yuin community. Within this a special relationship has been made my mentors, Saltwater elders Uncle Dean Kelly (Yuin) and Uncle John Kelly (Dunghatti). For all of us, it has been a period of relearning the past practices. Because the detail

comes when you are there, being an active participant in the story, I can share only a broad description. This follows the teaching methods of my elders, mentors and community,

When I began my journey over a decade ago it was with a model, then a 3 m long canoe full of leaks. It was just about the building back then; I didn't realise many aspects which I have since learnt. The actual building of the canoe from the sheet of bark is just the middle stage in a passage that begins with sourcing the material and progresses through the construction to the eventual use, but they are all stages with an impact on the design and engineering, as well as a strong cultural or spiritual relationship. So, its not just a practical exercise of construction, it's a wide-ranging process where each step is an important connection.

There is also another aspect not immediately obvious. Building nawi became an opportunity to bring people together for many other much more things. The men make much more than just the canoes. They make friendships, listen to the elders and teachers, and understand and practise the key behaviours of patience, observation, responsibility and respect. They talk, yarning openly about personal issues. As both uncles said to me recently in the wake of personal tragedy 'This will be healing for you, brother'. It has helped me through a difficult period, and it's brought a lot more to others inside our group. So, the building process has other qualities as well.

The tree we use is the stringybark, so having brought our group together, we begin with the tree.

From Smoking the tree before taking the bark Yula Punaal [Drawing], 2018, From David Payne (Australian National Maritime Museum), 2018. Licensed for adaption and re-use under CC BY-NC 4.0.

We ask permission from the tree to take the bark. By this I mean we observe what the tree is telling us. Is it saying to us it is the right tree, the right size, are we in the right place, is it accessible for us to secure the bark, is this the right season, and taking it here will not deplete a resource dramatically. Respect starts here. Before we start, we let the ancestors know we are there and acknowledge the tree's gift, and do this with a smoking ceremony. Then when we have taken the bark, we do another smoking ceremony to close off and offer healing to the tree.

With the sheet of bark secured we can now build a *nawi.* Here is the story of the *nawi.*

Grey, red, yellow.

Fire, forming, finishing.

These are the individual chapters in the story I tell for building a nawi. It is a story that has grown gradually until I have been happy with how it flows.

First, the colours – *grey, red, yellow.*-you often see them at sunrise. They are also the layers of bark we work though. The grey outside layer is taken off to reveal a stronger red bark. This red layer is trimmed down until the body of the nawi can be formed, then at the ends the red bark is

removed to reveal the yellow layers, which have the strongest fibres. They are the inside face next to the hardwood trunk of the living tree, whose outer rings carry a flow upwards from the roots to the branches and leaves. But these yellow layers are also very much alive – they take the downward flow back to the base of the tree They are adding to the spirit and life that are always in the nawi, and this comes from Mother Earth and Grandfather Sun. At the ends, this yellow layer is thinned down further.

Fire is a tool to respect, and a friend to work with; use it to heat these thinner ends to help soften them further. Forming the nawi, you take the sheet off the fire, bring up the sides to make a body, and then fold the softened ends to create a raised bow and stern. Finishing requires you to peg and bind the folded ends, then hold the sides apart with branches that push out against the cross-ties that pull in.

Now it's done. We have shared the knowledge and our nawi is complete. It's hard, physical work. Our hands are dirty, but we have a feeling of great satisfaction. For everyone, the process of working the bark into a nawi has taken patience, observation and respect for the material, along with personal responsibility and respect for others to work as a team. The finished nawi has its own individual look, but in concept it is the same as all those that have come before it – a mark of respect for the elders and their knowledge which has been passed on, observed and now preserved in another generation.

Before we go further, how does this connect with those points made earlier about what a vessel needs to float? Our period of building these craft has shown us how to arrive at the answers by observation. However, we did start with a basic guide, as some of the early colonial reports describe basic elements of the process and even some basic

dimensions. However, in the end we have had to relearn almost all of it, and arrive at our own conclusions about process, dimensions and scantlings, whilst delivering a craft that looks identical with the depictions of early artists.

The first three key points of volume, freeboard and stability came quickly, by building the canoes and observing them in the water noting just what they could support, and how they felt to paddle. We soon knew how wide and long a craft needed to be for one or for two people. Inverting the bark to give a smooth outer surface gave us a lower drag and retained strength, and the longer the craft the easier it was to paddle at a reasonable speed. Some of the craft came out quite flat at the ends, this taught us the need to have them fold so that the bow and stern rise up so it can go over waves. With these features in hand, we were meeting the last two objectives. Overall, we had a shape that satisfied what those engineers, the naval architects, call the hydrodynamic requirements – the how and why of a vessel's ability to float and move in a usable manner.

Strength requirements also came for building many craft and learning from each one. We learnt how far to go with thinning down the layers simply by going too far in the early days. We learnt what proportions were best, and what thicknesses were best. There is a lot of feel in this, feeling the bark to see how pliable it is as it is being worked on, and understanding what feels right came with practise. With experience we found we had craft that were strong enough to support the load it carried in static and dynamic situations, and we learnt how to handle them out of the water so they were not damaged.

Then the last phase, the use, is something we are now learning more about. Many of the craft we built went on display, and in that controlled environment they held their

shape as a result. Some deteriorated, but we didn't really ask why, often putting it down to poor support. Others took to the water, sometimes for just one event, but a few did multiple events before being retired. They all leaked, and some had significant cracks sealed up as best possible, but they still had a very limited watertight margin for the time they could be used on the water before being sponged dry.

We began to solve these leaks by sourcing our bark in the right season so it was quite moist and came off the tree easily without developing cracks. However, even then if there was a delay in forming a nawi from the recently cut sheet it would dry out gradually and develop some cracks, so we still had faults to deal with. We experimented and learnt more about traditional resins that would help seal the remaining leaks, working principally with different combinations of grass tree resin, the red eucalyptus gum that seeps often prolifically from angophoras and iron barks, ochre, black wattle resin and water. Clay and paperbark were part of the mix too. And once again, collecting these had to be done with respect to culture and community, and always only taking what was needed at the time.

Something else is just becoming apparent as we build bigger and better *nawi* without any cracks in the bark to begin with. It is about learning how to maintain them for use on the water. The observations and actions we need to take are still being learnt, but it may come down to something simple as an answer, don't let them dry out completely.

Reflection

Let's go back to our paper model. How nice it would be if all engineering could be as simple and as sympathetic to the environment. There was a time and place when it was, and through tens of thousands of years of history that place is still here, and we are in it now.

What have we learnt overall? It is a practical and spiritual process; the latter keeps the former in balance. It is a journey that is an example where the actual building, the practical engineering part is significantly influenced by much earlier actions that should be observed, and they help ensure it's a process that works in sympathy with the environment and the material rather than coercing both into unnatural behaviours.

Contemporary practice follows an industrial and commercial process that by and large supports the individuals taking part with everyone focused on their own part of building the object, while manipulating the materials along the way. Instead, we have walked through a cultural act that has brought community together to do more than build an artefact, and created this in sympathy with the environment. It is an example of where Indigenous engineering and construction satisfies needs, whereas modern engineering seems to becoming more about satisfying wants or luxuries, things that go beyond

the basic need. And like Country, the canoe has combined not just the tangible but also the intangible elements throughout, they cannot be separated.

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Dreamtime stories of watercraft include:

- Canoe in Orion -Yolgnu**;**
- Illawara and 5 Islands -Yuin;
- Three Brothers – Bundjalung;
- Ngurunderi dreamtime canoe– Ngarrindjeri

12

Materials and Strength

Cat Kutay

One of the most diversified aspects of First Nations engineering in Australia is the making of rope, twine, thread and fibre from many materials. All these manufactured items have cultural significance, because of their origin or the use they are put to.

When people cut their hair with flint or quartz knives it is kept and reused by rolling into yarn on the thigh and stored on a hand spindle. This is then used for making rope objects such as the head ring for balancing a coolamon, headbands, waist bands for ceremonies, and rope for carrying small game.

Skins are prepared as clothing, as cloaks or skirts, then woven plant fibres or hair belts are used to tie coverings for the groin such as skirts for women and wraps for men.

Bark fibre is used to make dilly bags in the south of Austrlai. In the centre spiniex may be mixed with hair to make a stronger fibre. In the north pandanas leaves are often used for weaving, stripping down the leaves to the right size for knotting.

Twine is also made to tie axe heads to the handle, spear heads to the shaft, etc. These are often strenghened with resin such as from spinifex (Memmot & Page, 2022).

Weaving

When a yarn or fibre is prepared it is then dyed for weaving. Dyes are made from ochre and other minerals, leaves, flowers, sap, roots and some insects. The community knowledge of how to prepare dyes and yarns is passed down through the generations as part of the community instructions.

The process of weaving is also taught by women, instructing how to ensure the weave is tight, such as for dilly bags, or holes the right size to allow water through in fish traps. Stronger rope is create for nets for kangaroo and emu by twisting two strings together into one for tougher yarn, using a reversed twist to create a strong even product.

Figure 1: Makers unrecorded. Three woven bags, Moreton Bay region c.1910. UQ Anthropology Museum Collection.Licensed for adaption and re-use under CC BY-NC 4.0.

Knotting

Various knots are using in weaving and for tying parts of a tool together. The patterns made in weaving are highly symbolic as they are designed for different strengths and uses. The patterns that are created often represent the animals the nets or bags are for catching, or the totem of the maker. The loops and cross hatches created are highly artistic and symmetric.

Weaving and knotting are skills being regained and shared often in workshops. First Nations are proud of the wide array of atefacts made by our people and we want to share these skills. Ask around local organisations and you will find a weaver who can instruct your class.

The styles of weaving and yarn making are varied across the country, so we leave it to your local community to instruct on what is done using your local resources. The way a weave is started, left or right handed, the colours and fibre used, all vary.

Yarning

Yarning is a particular method of knowledge sharing, often with rules about how you relate to others in the circle. For instance people take turns, you listen well to others and you should not respond to what others say, but add to it.

This process is often accompanied by weaving. The process of weaving creates a product that records aspects of the conversation, either because the conversation is focused on the gathering of the material, or the history of that pattern, or the conversation itself, its tensions and hightlights, gets woven into the artefact (Bell, 2014).

Exercises

When you are invited into a session for weaving or yarn making, consider these:

- What is the material you use in your weaving? How strong are they when gathered? Where do you gather them, or where were they obtained by someone else? What time of the year do you collect them?
- What patterns do you create from the colours and the type of weave?
- How strong is the weave. All weaves and yarns are made to withstand some tensions. What tensions is your artefacct made for?
- How is that strength created? By the original fibre? By how it is prepared? Or by the weaving or yarn making?
- What did you talk about while you wove?

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13

Navigation

Cat Kutay

While there is no written evidence of extensive navigation across the ocean by First Nations from Australia, this was a common skill in the region. It is assumed that First Nations in Australia adapted the technology of the Macassan traders as well as already having the seafaring knowledge to travel across the open ocean since they were assumed to arrive in Australia by sea (Briggs, 2023).

The use of dugouts with outriggers would have enabled open ocean travel as far as South America (Gray, 2015) when First Nations' navigation skills were sufficient to traverse the open ocean. The knowledge of ths astronomy was vast (Johnson, 2014) and the skill of open sea navigation was documented well by Lewis (1972):

> Since the place where the sun rises or sets varies even on the equator by 47^{O}, it follows that some fixed points of references are necessary on which to orientate the seasonally changing poitions of the sun's rise and set. This is most conveniently provided by the stars (Lewis, 1972, p.79)

This navigation process was summarised in Briggs (2023) as:

> The night sky was used as a calendar and a series of interconnected maps. These maps were used extensivly to predict all sorts of things in hunting and gathering, such as seasons, weather conditions and resource management (Briggs, 2023, p.73)
>
> ...the most acurate direction-indicators are stars that sit low in the sky, having just risen or being just about to set. These are called horizon or guiding stars. This process can be summarised as 'steering towards the setting points of stars, by maintaining an angle to the sun, swells, and wind and occasionally judging latitude by the unaided eye when a particular star was passing directly overhead' (Johnson, 2014). The procedure was to know which 'star rises or set in the direction of the island you wish to visit' and to follow it.(Briggs, 2023, p69).

However the process requires a broad knowldge of the sky as all stars:

> rise in slightly different places and follow different trajectories, so that some stars stay in the sky longer than others....This means that a navigator can only use a rising star for a certain period of time. When this star goes too high in the night sky or veers too far in one direction, the the navigator used the next start that rises on the horizon' (Briggs, 2023, p.70)

Aboriginal Australians possessed the necessary astronomical knowldge required for sea travel common amongst Pacific Islanders:

> The Aboriginal Australians could also give, with a fair degree of accuracy, the time of the heliacal rising of any star. They clearly knew the stars rose in the east and moved across the sky to the west as does the sun, They also knew of the more gradual annual shift of the star groups, and based complex seasonal and ritual calendars on the locations of particular stars at dawn or dusk (Johnson, 2014, p.82)

Importantly this knowledge was retained through songlines of the land and sea which are 'mirrored by sky Songlines, allowing people to travel vast distances and highlighting the deep connection they have to earth and sea' (Carstens, 2016, p.35). But also the ability to travel between islands was dependent on the prevaling winds and swells. 'Wind and swells are connected and apparently ocean swells are consistent and predictable across the Pacific in the trade wind seasons' (Briggs, 2023, p.67).

Also the ability to find the next landfall was important, even if the direction of the island was known and '...other things that navigators used to identify where land was [included] cloud formations over islands and the reflections from lagoons of atolls. Birds in the sky were another sign of land nearby' (Briggs, 2023, p.67)

Briggs (2023) also notes that the sun or moon and stars were generally visible to seafarers, as cloud cover at night rarely lasted more than three days and clouds disperse at night. Also cloudy wether is seasonal and predictable, along

with the winds. 'The winds across Oceanis allowed people to sail in most directions at some time during the year with the wind behind them' (Briggs, 2023, p.68)

This was important as the outriggers could not tack close to the wind, although the Pacific Islanders adapted the Macassan design to sail closer to the wind (Briggs, 2023). The hull was designed as a deep-V and often a long steering oar was used which reduced the sideways push of the wind ((Briggs, 2023). Also double outriggers up to 450 feet long were used to allow the carriage of more crew and products for supplies during travel and trading.

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14

Indigenous design: Water Country

Kate Harriden

This chapter introduces Indigenous design principles in the context of water and highlights their theoretical and practical applications. I write this chapter as yinaa wiradyuri/wiradyuri woman, water woman and engineering sceptic. This chapter includes some activities to encourage you to engage with these ideas beyond this book. An exercise to develop student's sense of country and Indigenous design principles is also included.

All design systems operate with an associated scientific system. The scientific system you are familiar with came with the colonisers and is referred to as settler-state science in this chapter. Human centred, this science tends to be exploitative and extractive, and marked by its reliance on western engineering and its use to change waterscapes (harriden, 2023). Settler-state science results in a transactional understanding of scientific priorities, practices and outputs. This brief characterisation of settler-science informs its relationship to water, with water regarded as transactional; a commodity to be used for

human purposes and profit. By contrast, Indigenous sciences are country-centred, relational and adaptive (harriden, 2023), requiring the human be but one of many entities considered when practicing science and crafting designs. The relationality in Indigenous sciences strongly contributes to water being seen as having life and rivers regarded as kin which is the basic premise of this chapter.

Indigenous design principles stand independent of settler-state principles and are best used as such, rather than attempt shoehorning them into settler-state design frameworks and paradigms. The principles presented in this chapter are high level and do not represent the specific design principles or knowledge of any particular Aboriginal or Torres Strait Islander group. Indigenous design principles exemplify how all aspects of country are considered simultaneously, thus reflecting country's indivisibility and the relational interconnectedness of Indigenous sciences with other types of knowledge.

Country

Country is an actor in Indigenous design, hence when using Indigenous design practice you are working with country. The importance of country cannot be overstated. Thus, it is necessary that when designing a technology or process that students have some understanding of country, its complexity and enduring significance to Indigenous peoples. Designing is working with country, including the materials used and the sites where they are accessed, the physical sites where designs are located or used, and sites where the manufacturing and construction occurs.

Country continues to guide Indigenous people practices and daily activities. Rather than empty rhetoric, the phrase 'caring for country' is a guiding ethos for Indigenous lives. County is more than soil, water, plants and animals; more than 'the environment'. Certainly, these are part of country, but so too are the stars, sky, moon and sun, earth, wind, air, mountains and ancestors, songlines, dreaming, humans and language. How these, and other, entities relate to each other within in specific place/space *is* country. Importantly, country is indivisible (Marshall, 2017). This means no one entity can be considered in isolation or attributed more importance than another. That is, the web of relationships between all aspects of country is the primary focus of research and design.

As well as indivisible, country is unique. No one country is the same as another, be it the waterscapes, landscapes, skyscapes or the animals and plants. Thus, there is an element of bounded territorially to the web of relationships forming country. Certainly, the ancestors, dreaming and songlines of each Indigenous Nation differs. These differences contribute to an imperative of country centred design – to design with country.

Activity 1 Introduce yourself to water country

Spend some time every day for at least a week consciously, deliberately walking around a body of a water near you. If you can walk to this body of water, do so in a conscious and deliberate manner. Some tips:

- Go at different times;
- walk in different directions;
- look up as well as around; and
- be quiet.

Walking consciously and deliberately will help you start seeing some of the web of relationships that create country, including some of your relationships in that web. As you begin building your relationship with this body of water, you may find yourself greeting it upon arrival (country loves hearing our languages, so if you speak an Indigenous language, use it).

Indigenous design principles

When working with country and its people, the appropriate protocol is to work with the specific design principles and practices of that country and people. Thus, while the broad high-level principles presented here are good for country and inform all Indigenous design practices, the appropriateness of a specific design will vary from country to country. Recognizing that country is indivisible, the water examples in this chapter are designed to support your recognition of Indigenous design principles as applied around waterscapes, rather than suggest they only be used for waterscape design requirements.

Country centred

Being country centred reflects the indivisibility of country, with all decisions, including design, putting country first. No one aspect of country, whether water, an eastern water dragon or soil, is regarded as more important than another, or managed separately. The consequences to country, as a complete unit, are considered and weighted appropriately in decision making and action taking. One aspect of country can not be 'sacrificed' for another.

Most design projects crafted in the settler-state framework do not centre country. Indeed, they are often crafted in the face of country's complexity, focusing on one aspect of country. Consider the following example. Figure 1 shows a reach along Yarralumla Creek on Ngunnawal country in Canberra before a government initiated 'stream rehabilitation' project. This site is downstream of the storm water system to which the stream has been converted.

Figure 1 Heavily vegetated bank and shallow pool of water

Figure 1 shows a heavily vegetated bank and shallow pool of water, indicating this reach to be less heavily modified than upstream. Hidden by the vegetation at the top left of the image is a natural riffle located immediately downstream of where the stream has a second (terminal) channel. Also unseen is the large raft of eastern water dragons flourishing in this section of the stream and the diversity of macroinvertebrates in the water plants. Despite this complexity and generally low levels of turbidity, the stream rehabilitation project was designed to manage solely turbidity (ACT Government, n.d.). This project specifically and consciously divided country.

Figure 2 shows the same reach upon completion of the so-called stream rehabilitation project. By focussing only on reducing turbidity, it was considered appropriate to widen, straighten the channel and construct three large artificial riffles in the channel. This was clearly a human-centred design. Consequences included the extinction of

the local water dragon population, the removal of banks and their associated vegetation. Outcomes such as these are not possible when centring country.

Figure 2 after rehabilitation project. by K. Harriden, 30 December 2018. Used with permission of the photographer

Designing with country places the emphasis on using extant features in country to achieve design outcomes, rather than removing country to achieve design outcomes. Designing with country includes using on-country features to layout camps, for example trees as camp windbreaks or tended and mended as shade or water trees (Page & Memmott, 2021). The use of lava flow formations for fish and eel traps at sites such as Budj Bim is another example of designing with country.

Settler-state approaches to design sometimes feel like 'design despite country'. Stormwater systems are an example of this approach. Despite country providing floodplains and a range of physical processes to

accommodate high flow events, some humans have felt it appropriate to modify streams to support the rapid removal of the increased runoff created from a particular form of urban development. Contemporary urban water practitioners are gradually coming to understand that the design values and practices reflected in storm water system design are damaging urban waterscapes and leading to increased flooding.

Everything is animate

Indigenous ways of being and valuing, including those of science and design, regard all entities in the web of relationships forming country as animate. This need to be remembered and respected. Songlines, art and dance tell of times when mountains, trees or birds, for example, manifest in human form. Their animacy remains constant across the physical forms taken whether human or a more-than-human entity of country. As will be outlined in the water specific design principles section, creeks, streams and rivers are animate and the water within them is regarded as having life.

The animacy recognized in non-human entities is an expression of the relationality that imbues Indigenous ways of being and valuing. Relationality is a central tenet of Indigenous worldviews, referring to the connection between all entities and reflecting the web of relationships that forms country. Relationality exists between ideas and entities, meaning that not only do Indigenous people see the world in terms of relationships but also "feel the world as kin" (Tynan, 2021:4). The belief that every thing is alive

and related strengthens the country-centred imperative, fundamentally altering what can be regarded as legitimate design choices and processes.

Functional sophistication

A hallmark of Indigenous design is that an artefact may seem simple in both design and material, but is extraordinarily effective. For example, Page and Memmott (2022) highlight the woomera as an example of functional sophistication, as it can be used for hunting and carrying food gathered while hunting. The boomerang is a better-known example of the functional sophistication of Indigenous design.

The leaky weirs designed in my research were to modify baseflow in open storm water channels. The weirs were simply lengths of untreated pine cut to a template roughly reflecting stream bed shape and attached with coach bolts in the expansion joints. Yet the changes in channel reach conditions, in terms of biodiversity and a range of physical and chemical processes for example, were significant. Figure 3 shows the channel flow before the leaky weirs are install; Figure 4 is after weir installation.

Figure 3 Channel flow before the leaky weirs are install

Immediately obvious from these images is the impact on flow morphology, as the flow slows and widens to pass around the weir. While hard to observe in Figure 4, this simple intervention traps sediment, which influences bed morphology and the retention of organic matter (Fig 5), allowing insects to thrive to the point that a mother duck brought ducklings upstream to forage in the resultant islands and accumulated sediment.

Figure 4 and 5. From Post-Weir Installation [Photograph], K. Harriden, n.d. Used with permission of the photographer.

Embedded storytelling

Figure 6. From Drone.jpg by D. Indigai [Photograph], 2024. Used with permission of Dera Indigai.

In addition to functional sophistication, Indigenous design often embeds a narrative in artefacts. A contemporary example of this aspect of Indigenous design is found in the Gagudju Crocodile Hotel in Kakadu (Figure 6). The crocodile is an important totem animal of the local traditional custodians, the Gaagudju people. With every aspect of the building reflecting the crocodile, include carparks shaped and located to look like crocodile eggs from the air, only the most insular visitor does not immediately understand the significance of this animal to the Gaagudju people.

Embedding narratives in design allow Indigenous peoples to demonstrate their knowledge, connection to country and history. More than including Indigenous art or motifs, Indigenous narratives or story telling in design influences the function and feel of a place/space. Embedded narratives also demonstrate the dynamic and continuing culture of Indigenous peoples beyond design.

Small scale, local materials and adaptive design

Indigenous design prefers small scale design, be it stream interventions or toolmaking, reflecting the design requirement to centre country and fulfil relational obligations.

The use of local materials supports small scale design. Fibres are widely used, being possibly the most common material globally (Page & Memmott, 2021). Not every place has an abundance of fibre. In places with an absence of grass fibres the locally abundant material, including rocks and tree fibres, are necessarily the preferred material. The reliance on local material encourages small scale design through the volume of material available at a place. That

is, small scale artefacts require less material, reducing what is taken from country. If accessing materials from other places is not an option, or only small volumes of coveted materials can come from other places, small scale design is a practical way to ensure effective use of limited materials. There does appear a link between the size of an artefact and its capacity to be adapted, with larger artefacts, think bridges, dams or storm water systems for example, being less amenable to accommodating adaptive design features.

Adaptive design reflects the need for trial and error to achieve appropriate and effective artefacts. More than ensuring high performance of an artefact, the capacity to adapt designs is critical to the long-term survival of any community given the imperative to respond to changes in environmental conditions and knowledge systems. The waterwheel, for example, continues to be used in some Indigenous communities across southeast Asia, despite engineering alternatives such as pumps, for their capacity to continuously supply water without any fuel source. As people became more experienced with waterwheels they identified that sealing the wheel allowed more water to be moved. More robust materials have also been used to enhance the design function of the waterwheel. Consequently, the adaptive design capacity in these communities has seen the waterwheel remain entrenched in many waterscapes, despite the engineering solutions now available.

Small scale design based on local materials supports the adaptive reuse of both materials and artefacts. Large structures are not as readily convertible as small structures as their individual components can be too large or weighty to manipulate and manoeuvre, and these components may not be able to be put to another use as readily as smaller

components. Page & Memmott (2021) provide evidence of structures that could be expanded or contracted in response to seasonal and other needs. That is, adaptive reuse is a design principle embedded in Indigenous practices, in contrast to its very recent inclusion in settler-state design principles.

Activity 2 Identifying non-Indigenous design on water country

As you walk water country, how may features in and around the waterscape that do not reflect Indigenous design principles can you identify?

For example, does the waterscape appear to have been modified with only human wants and needs in mind? Do the design features in water country have a sole purpose? Is the scale appropriate and material local? Can you see the story of water country?

Indigenous design principles – water specific

This section introduces Indigenous design principles with specific relevance for water country. These principles compliment those just discussed and do not detract from the recognition of country as indivisible. While the following design principles are specifically about water, they build on and work within those presented in the previous section.

Water and streams are of such significance they require a specific design focus. For example, Gammage refers to templates, defined as "plant communities deliberately

associated, distributed, sometimes linked to natural features, and maintained for decades or centuries to prepare country for day-to-day working" (2011:xix). Water, particularly in creeks, could be used as a template "anchor" (Gammage, 2011:222), to extend water's availability across time and a range of environmental conditions. Templates are not about dividing country but supporting country's indivisibility. As such, templates represent designing with country.

Rivers as kin

Relationality is the basis of recognising rivers as kin. Every entity enmeshed in the web of relationships forming individual countries is sentient. Many entities are integral members in human kinship systems. Totemic relationships are an example of Indigenous kinship systems. Rivers and water are entities widely regarded as kin. Wiradyuri people in southeast Australia describe themselves as fresh water people; the people of three rivers. One of these rivers is marrambidya (currently called the Murrumbidgee River). The wiradyuri translation of marrambidya is big/good friend.

The Tlingit people in North America consciously cultivate a "powerful intimate and spiritual relationship" (Hayman, James, Wedge & Katzeek, 2017:222) with many more-than-human beings. Those who cultivate such a relationship with water learn deeply about it, and appreciating water as an individual. They also hold the obligation to identify and articulate things that may damge the relationship. The different ways of understanding water and rivers offered in these examples transforms the nature of design questions asked and solutions proposed.

If you have cultivated, and are obliged to maintain, a deep relationship with water or see the river as your good friend, you simply cannot treat water or streams as sites for human-centred manipulation and extraction.

Don't build on floodplains

First Nations people have been telling settler communities since their arrival to respect rivers by not building on their floodplains. While this principle may seem self-evident, if only to access the fertile farming soil of floodplains, it is about respect. Respect for the rivers, streams and creeks to express their sentience. This principle acknowledges the animacy of country, and that rivers and streams, as kin and country, have the right to flood and not be controlled.

Nothing attached permanently to stream bed or banks

This principle supports the prohibition on building on floodplains. Prohibition of permanent design artefacts on beds or banks ensure the range of biological, chemical and physical processes in play in water country are not affected by human-centric design. For example, channel bank storage, an important process occurring in channel banks ameliorating in-channel event flow, has a critical role moving water between ground and surface sites and performs water treatment functions. Channel bank storage processes are extinguished when urban streams are converted to storm water channels with impervious armouring such as concrete. Importantly, leaving channel beds and banks free of permanent design features allows the stream to express the flow regime and course of its choice.

Pre-1788, there would have been many water interventions designs. For example, Gammage refers to a "duck under" (2011:26) which, from assembling logs and sheets of bark, was one of the designs allowing water to be temporarily (re)directed. In the 21st century, new designs using Indigenous science and design principles are required to manage the impact of setter-state science and design on waterways. My research incorporated installing artificial channel bank storage sites (Figure 7) in a creek converted to a storm water channel, to replace the event flow storage role of this process.

Figure 7. From Artificial Channel Bank Storage Site, Yarralumla Creek [Photograph], K. Harriden, n.d. Used with permission of the photographer.

Don't permanently change flow patterns or stream course

To permanently change stream course or flow patterns is regarded as disrespectful to water's rights as a sentient entity. Temporary modifications are acceptable, particularly when they extend water availability to food and drinking water sites such as wetlands.

Permanent changes to stream course generate unintended consequences affecting the web of relationships that is country. Water remembers the path, and will try to follow it. The consequences can range from: the catastrophic failure of meters of stream banks and bed armouring of materials considered permanent, such as concrete or rocks being ripped up during a large event flow; to the trickle of subsurface flow through concrete armouring into channel flow (Figure 8).

Figure 8. From Subsurface water flowing through concrete into Yarralumla Creek [Photograph], K. Harriden, n.d. Used with permission of the photographer.

Indigenous water country design principles are a stark contrast to those of settler-state design. Each set of design principles reflects how water and rivers are understood in the respective design framework. Vastly different waterscape outcomes are the consequence of these difference. For example, dams, channel diversion, storm water systems and other water management features of the settler-state design framework, including pumps and pipes built into stream banks and beds are problematic in terms of Indigenous design. Even when settler-state water designs seek to mimic nature, such as renaturalizing or daylighting streams, these projects are expensive and highly engineered, with the stream given a course to

follow. Settler-state design principles do not regard streams as independent, kin related entities able to set and follow their own course.

This short section indicates how deeply waterscapes are influenced by design principles. The principles inherent in settler-state design tend to support highly controlled waterscapes reflecting human needs. By contrast, Indigenous design principles aspire to design for country, where human needs are not the highest priorities, water is regarded as alive and rivers as kin.

Activity 3 Identifying Indigenous design on water country

As you walk water country, how many features in and around the waterscape reflecting Indigenous design principles can you identify?

In this case you are looking for designs that includes features such as having more than one purpose, use local materials and built at a scale that is reasonable and relevant. What water country designs can you identify that treat streams/rivers as kin?

Summary

The beliefs and values represented in the Indigenous water design principles are an extension of the general principles outlined early in the chapter, including centring country and relationality. Engaging with Indigenous design

principles generates design problems and artefacts fundamentally different to those of settler-state design. These differences are the physical output of the fundamental philosophical difference between a transactional and relational understanding of the world. Using Indigenous principles supports crafting designs and artefacts that centre country and allow streams to run free. Thus, the decision a designer makes about which principles to use matters.

Doing the three activities provided in this chapter will guide designers in critically applying design philosophies and practices in their work. Completing the following exercise is an opportunity to deepen and extend designers understandings of both Indigenous and settler-state design principles, and how each influences the waterscape. A short reference list is provided to support independent research.

Final exercise

This exercise could be used as an assessment piece, or a way to bring together the three exercises in this chapter.

Reflecting on the different design approaches identified in the water country you walked in the previous activities, select an existing water storage system and assess it against the design principles presented in this chapter. What are some benefits of each design approach? What are some of the limits or problems associated with each design approach.

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15

Humanitarian engineering skills: A perspective from Engineers Without Borders, Australia

Sai Rupa Devarapu

Working for a fairer and more equitable future in the face of social inequality and environmental degradation remains the greatest challenge for engineers of our era. Humanitarian engineering, at its core, is both an approach and a discipline that seeks to strengthen engineering principles to address global challenges and improve the well-being of the planet and its people. Humanitarian engineering, as practised and advocated for by organisations like Engineers Without Borders (EWB) Australia, aims to address the closely interwoven social and technical challenges faced by communities worldwide, including First Nations.

EWB takes a community-centred approach to engineering practice to bridge First Nations-identified gaps in access to health, wellbeing and opportunity. Since

2009, EWB has worked with Aboriginal and Torres Strait Islander communities in Queensland, the Northern Territory, South Australia and Western Australia on a range of community-identified projects.

We believe this provides an opportunity for engineers to also work with a highly skilled low-tech society that places sustainability at the heart of its engineering. If you consider what engineering would be like if it was developed from a foundation of sustainability, it would inevitably resemble the engineering of the First Nations, hence this is an excellent learning space. Moreover, the work is productive as the designs we develop with community often go on to be used by the group they were designed with.

However, that work requires various skills that are not taught in technical units. This chapter outlines 10 essential skills for effective humanitarian engineering practice, both in the context of Engineering on Country, and more broadly:

1. Work alongside communities to understand the context
2. Engage in collaborative and empowering partnerships
3. Value and integrate multiple knowledges and ways of thinking
4. Mind your language
5. Focus on strength-based resilience and problem solving
6. Leave no one left behind
7. Promote cultural safety

8. Lean on multi-disciplinary approaches
9. Rethink project management to enable relationships
10. Integrate environmental protection, climate action, and engineering

Work alongside communities to understand the context

EWB recognises and acknowledges Aboriginal and Torres Strait Islander People as the first engineers and scientists of this nation, caring for Country sustainably for as much as 65,000 years. As such, Engineering on Country (EoC) is not about imposition of Western ideas; it is about walking alongside and supporting Aboriginal and Torres Strait Islander People to pursue their aspirations to live and thrive on Country, facilitated by equitable access to appropriate engineering, technology and infrastructure.

When working with Indigenous communities, humanitarian engineers must continually seek to understand and appreciate the historical, cultural, social, and environmental contexts in which these communities exist. Such understanding helps to establish respectful relationships and ensure that engineering interventions are appropriate and sustainable. At the heart of this approach is trust – an expansive, multi-disciplinary and multi-faceted term, with most definitions involving a combination of relationships, expectations, and the behaviours linked to those expectations (Notter, 1995, p. 4). As Feltman (2011, p. 7) writes, trust often involves 'choosing to risk making something you value, vulnerable to another person's actions.' As such, working alongside communities

comes with great responsibility to listen to, seek to understand, and centre their values before imposing our own values.

Exercises

What local community groups are in your area? Does anyone at your university or employer have any links with a group, through friendship, a previous project, anything. What are their needs and what could you do to assist in supporting that developing, either technology, labour, or just support.

- What group can you contact?
- What skills do you have to offer them?
- Keep your project within your skills and ability to complete the design and implement in community.

Engage in collaborative and empowering partnerships

Engineers Without Borders Australia recognises the importance of working with First Nations communities in a collaborative and empowering way. Through the EoC program, EWB aims to support communities in identifying and addressing their engineering requirements.

Engaging in collaborative partnerships with real involvement of all parties is a fundamental principle of humanitarian engineering in general and is amplified when working with First Nations communities. Engineering programs that centre the interests of

community members in decision-making processes through involving members throughout the process can create greater agency and empowerment, active participation in the engineering projects, and foster self-determination with First Nations supported by technology.

This approach recognises that First Nations are the experts on their own needs and aspirations. By valuing and incorporating traditional knowledge, engineers can design and implement engineering solutions that are not only technically sound but also culturally appropriate sustainable and valued by community.

Cultural context reflection

Choose a current (or recent) project or course where you have had some engagement. Re-read the project/course materials and build a list of items that you can see were ignored or avoided because of specific pre-set requirements.

Now applying this EWB approach to thinking, what might you do now or in the future in regard to such items?

Value and integrate multiple knowledges and ways of thinking

As engineers, we are typically taught to focus on numbers and figures – the language of litres, kilonewtons and torque is our comfort zone. Rarely are we called on to think and engage far beyond what can be observed and measured. Yet

the ability to integrate social with technological thinking is among the most important keys to unlocking humanitarian engineering. It does require multiple different understandings of knowledge, and the ability to hold them all as valid and valuable at the same time.

The typical engineering approach represents 'positivist' thinking. Positivist thinking is one epistemological approach, but there are other ways of understanding the world and developing knowledge that can impact engineering decision making. Beyond yield strength or balancing forces, humanitarian engineering incorporates considerations like perspective, values, and justice – considerations that have a massive impact on how we live and work but are not readily measured (McArdle, 2022). Rather, humanitarian engineering requires what we call constructivist thinking, which still draws on those observable, measurable aspects of the world around us, but at the same time acknowledges that the different ways in which people interpret and make sense of that world also matter. It is important to keep this duality of observation and perspective in mind because it is not just theory, it has practical implications for how we work as engineers. Forrest and Cicek (2021, p.2) put it this way:

> The approach to problem solving in engineering courses focuses on repetition of mathematical problems. These problems are distinct in their subject matter and their requisite mathematical formulae, but are all generally approached the same way. Problem solving is treated as a fairly simple algorithm to navigate calculations, often under stable conditions. Such an approach neglects the fact that an engineer should engage with other perspectives to

> understand a problem fully. Multi-perspective thinking, which is the recognition that various perspectives exist with respect to an event, idea, or problem, can influence an individual's problem solving (Wang et al., 2006). … In an analysis of creative problem solving strategies, perspective taking, or considering more deeply the needs of another person (generally a stakeholder), was found to be strongly associated with developing a diverse array of creative solutions, which is an outcome more likely to produce useful solutions (Rubenstein et al., 2019).

In no small part, integrating knowledges and ways of thinking is difficult because it means admitting that we may not have the right answer; that our solutions to problems may be inadequate; or that we may not always have all the data we want and thus find the problem hard to understand. These acknowledgements are uncomfortable, and it can be tempting for engineers to seek comfort in the certainty of numbers and parameters. But that discomfort comes from the power and privilege embedded in the 'normal' ways of doing engineering, whereas humanitarian engineering is about breaking down those norms to reveal and address social inequity. For instance the positioning of First Nations communities as rightsholders rather than stakeholders helps change consultations and collaborations.

Key Takeaways

We are seeking new ways from old ways as we are in crisis. We have been supporting an approach to our earth that is not sustainable and does not even respect that resources are limited.

- What are Australia's most evident resources
- How can we maximise their usefulness and minimize waste within a circular economy

If we want to practice humanitarian engineering in substance, not just in rhetoric, we need to put energy into aligning our values with our practice, and not turning a blind eye to social inequity that engineering can bring about. As Brown (2018, p. 184) puts it, 'Daring leaders who live into their values are never silent about hard things'. Humanitarian engineering facilitates more effective and successful engineering projects because it demonstrates respect for differences in cultures and ways of working.

Importantly, incorporating First Nations knowledges into engineering practice is not only about the 'what', but also the 'how' (Yunkaporta, 2019). Too often, mainstream science risks viewing such knowledges as simplistic, when if anything it can be the other way around. The complexity and nuance of Indigenous systems thinking can be difficult for Western science to comprehend within its existing paradigm.

It is for these reasons that Engineering on Country emphasises valuing and incorporating First Nations knowledges as a critical aspect of working with these communities. By recognising the wisdom and expertise that Indigenous communities have fostered across many millennia, engineers can gain a deeper understanding of

the intricacies and complexity of systems and environments. This knowledge can profoundly inform the design and implementation of engineering solutions, ensuring that they are contextually appropriate, sustainable, and community-driven. By engaging with Indigenous community members in ways that break down the unhelpful power structures of who is the 'knowledge-holder' and who is the 'listener', to instead emphasise both-way knowledge sharing, an Engineering on Country approach can avoid imposing solutions on communities.

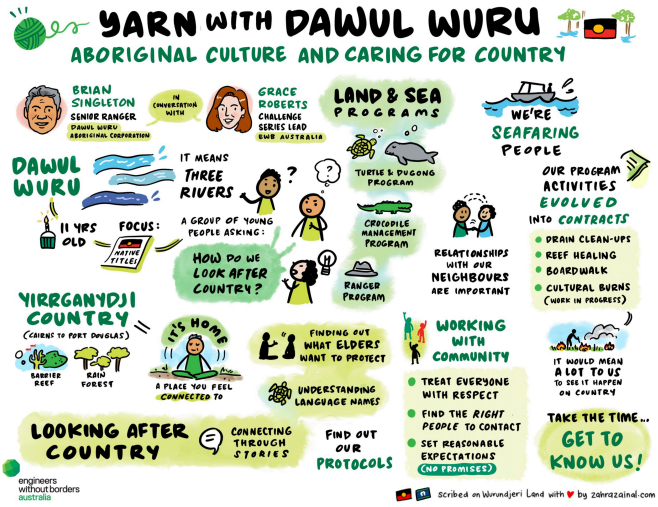

Figure 1: From *Graphic representation of Yarn with Dawul Wuru Aboriginal Corporation* [Illustration], by Engineers without Borders Australia, 2022. Licensed for adaption and re-use under CC BY-NC 4.0.

Figure 1. From Engineers without Borders, 2022 . Licensed for adaption and re-use under (CC.

Key Takeaways

Listening is hard especially when people speak a different first language. Cultural assumptions are a barrier to seeing other ways of doing and being.

- When listening to others try not to assume anything not said or ask when there is a chance to.
- When joining the conversation, you are confirming what you understand about what was told to you, it is a way of others see what you know from their contribution.
- Both-way learning is where you listen, wait, then explain what that means to you, so both can understand the others perspective and values. Both ways need explaining and both ways have equal value.

Mind your language

The language we use is central to how engineers learn from and share knowledge. For that reason, paying attention to the language we use is an essential skill for humanitarian engineers.

In his book 'Sand Talk', Tyson Yunkaporta (2019, p. 21) highlights the trouble of discussing problems in English.

> *English inevitably places settler worldviews at the centre of every concept, obscuring true understanding. For example, explaining Aboriginal notions of time is an exercise in futility as you can only describe it as 'non-*

> *linear' in English, which immediately slams a big line right across your synapses. You don't register the 'non'—only the 'linear': that is the way you process that word, the shape it takes in your mind. Worst of all, it's only describing the concept by saying what it is not, rather than what it is. We don't have a word for non-linear in our languages because nobody would consider travelling, thinking or talking in a straight line in the first place. The winding path is just how a path is, and therefore it needs no name.*

At the very least, this calls for engineers to emphasise what we call reflexivity, the intentional consideration of specific ways in which our engineering work is influenced by our own histories, familiarities, world views, and perspectives (Yardley, 2015).

Reflection:

Next time you're in a project management class or meeting, pay attention to the language being used. Think closely about where certain terms might have come from, and if that could have any subtle implications. For instance, when going to the 'kick-off' meeting, you could reflect on who would have traditionally participated in a 'kick-off'. Or, in the projects 'control phase', does 'controlling' allow for both-way knowledge sharing and partnerships, listening, and adaptation? (Atkinson et al., 2021; Dix & Visser, 2022; Gollan & Stacey, 2021).

Focus on strength-based resilience and problem

solving

The concept of resilience is a common term in engineering practice, and while there are many definitions, it is often used to describe the ability of a system to absorb, cope with, and/or recover from adversity. That's fine if you're strength-testing reinforced concrete so that your building design can withstand an earthquake. But we can go deeper, *why* do we want the building to stay up?

The answer is because we want people to be able to use the building safely even during the earthquake. People are the reason we talk about resilience.

Yet, if we talk about resilience as coping, we suggest that people are passive or helpless. But people and communities are not helpless – they have strengths, preferences, and agency which must be considered in humanitarian engineering. Taking this a step further, even adaptation – a term we often hear in relation to a changing climate – can be problematic. When talking about resilience, we need to be mindful of who is responsible for shouldering the burden. If we suggest that the person or community facing adversity is responsible for adapting to it, we deflect scrutiny from our own thinking, designs, and behaviour which might in fact be contributing the problem (Chandler & Reid, 2016; McArdle, 2022).

But it doesn't have to be this way. Eleanor Ostrom, a trailblazing environmental scientist who won the Nobel Prize for Economic Sciences in 2009, summed it up well. Instead of focusing on the helplessness of a situation, she instead chose to focus on people's strengths and aspirations for change. In her words: 'I would rather address the question of how to enhance the capabilities

of those involved to change the constraining rules of the game to lead to outcomes other than remorseless tragedies' (Ostrom, 1990, p. 7).

Examples

There are many examples of the way that over catering to the negative aspects of projects we can ignore the value that community can bring.

- What skills/training is there in the community already which can contribute to the project or design of the project
- What new knowledge is being provided on the ground to the technology you are working with, are these examples of local technology or a new use of western technology that can inspire change

Enhancing capabilities is a very different way of thinking about engineering than, say, fixing a problem. This mindset is not solely focused on a recipient community benefitting from outside assistance, but refers to all those people taking part in a system and, crucially, redistributes the burden of responsibility for resilience onto the broader society. This leads us to a crucial point, resilience is, by its nature, social. An inherent element of community resilience is the way in which they are supported by their community. The ways in which people are supported by infrastructure, services and systems that they use every day are crucial in our resilience to adversity. The more

accessible and appropriate our engineering designs and the more inclusive and just our work, the more resilient the people and communities who use them will be.

Leave no one left behind

All engineers have a responsibility to consider the impact of our work on the communities that use them, or in some cases, don't or *can't* use them. This is why humanitarian engineering talks about 'leaving no one behind'.

To leave no one behind is language that comes from the Sustainable Development Goals (SDGs). It focuses our attention on the fact that not all people have equitable access to goods, services, and infrastructure, and 'calls for all stakeholders to intensify their efforts to narrow existing gaps' (Bennett, 2020, p. 9). It's also the reason that EWB says its purpose is for 'Harnessing the potential of engineering to create an equitable reality for the planet and its people' (Engineers Without Borders Australia, 2020).

When it comes to engineering, equity goes hand in hand with principles of fairness, and participation, and justice (Sultana, 2018). Like resilience, these principles are heavily dependent on relationships, and are contextual rather than universal (Boelens, 2015; Roth et al., 2014)

What this means for the engineering profession is that the people who use and access the infrastructure and services we design are not only interested in the material aspects of buildings and roads, but also share in the fairness of our work (Lauderdale, 1998, p. 9). Often, engineering work is about deliverables – constructing that bridge; or reaching that efficiency target. But fairness is

not the sort of concepts we're taught in most engineering degrees, and isn't often talked about in project management meetings.

Key Takeaways

What has to change in our approach to our designs

- Who should contribute to designing?
- Who can be employed on the development?
- Who should be engaged in the implementation?

Sometimes, leaving no-one behind is not efficient. Sometimes it's arduous, or expensive. It's rarely financially economical to make sure people living far from the city have equitable access to the facilities enjoyed by people in large urban centres. Sometimes listening to the concerns of all water users along a shared river basin is time-intensive, and frequently uncomfortable. It can take active engagement to look for social inequity. It often takes significant funding to engage with issues of injustice. It is essential that humanitarian engineers build our skills in areas that will help us to engage positively with these issues

Promote cultural safety

Engineering on Country acknowledges the notion that 'cultural safety is a pre-condition for First Nations of Australia to access, be involved in and thrive within workplaces and services' including the contexts of engineering project work (Gollan & Stacey, 2021).

Developed by Māori nurse Irihapeti Ramsden (2002) in Aotearoa/New Zealand, the concept of cultural safety has been adapted for First Nations Australia contexts and communities (CATSINaM, 2017; Gollan & Stacey, 2018, 2021; Lowitja Institute, 2018). As Gollan and Stacey (2021) articulate, 'A culturally safe environment is created in policy development, evaluation, research and service design and delivery when the circumstances are in place' (S. Gollan & K. Stacey, 2021)

As with the EoC approach to community resilience discussed above, it is important to remember that the responsibility for cultural safety is heavily rooted in genuine, balanced, both-way relationships. Accordingly, non-First Nations engineers 'have a high level of responsibility as well as significant capacity to create culturally safe environments' (Gollan & Stacey, 2021, p. 5).

Extending on this, cultural safety situates humanitarian engineering skills as an ongoing process, rather than an endpoint or definitive output. Where skills in this area are sometimes referred to as cultural competency, humanitarian engineers should approach safe engagement with First Nations communities as dynamic and will, after long preparation, be informed by communities themselves. This not only leads to more effective and sustainable

solutions but also fosters trust, collaboration, and empowerment as central to humanitarian engineering work.

Exercises

Consider a large-scale engineering project in, or affecting your community

1. Examine the ethical considerations embedded within Western engineering practices such as risk assessment, cost-benefit analysis, and legal compliance.
2. Discuss how Western engineering often priorities individual rights, property ownership and liability avoidance
3. Compare this with Indigenous ethical frameworks, which may prioritize collective well-being intergenerational equity and connection to the land.
4. Reflect on the ethical dilemmas that arise when Western and Indigenous perspectives intersect in engineering projects

With cultural competency training, engineers will engage in meaningful and ongoing dialogue with community members, elders, and local histories. It is important to seek opportunities to learn about Indigenous tradition and values and strive to build relationships based on mutual respect and trust. Integrating Indigenous studies and

perspectives into the engineering curriculum is crucial for fostering cultural competence and understanding; and these competencies are essential to effective engineering practice.

In the engineering industry, we rightly talk a lot about workplace health and safety. But how often do we think about culture in that context? Safety is physical and cultural. Take water, for example: the way in which water is managed is not only about drinking and cooking – water is also about health and wellbeing. This can be seen in the barriers to teaching on Nari Nari Country when water is scarce:

> *The knowledge transfer from the elders to the younger generation can't happen because they [the community] can't go back to those sites on the river where there were waterholes and there were stories attached to that. No one wants to go and see a waterhole and talk about a story when there's no water (Woods in McArdle 2022, p.169).*

Health and wellbeing considerations are thus paramount in humanitarian engineering projects and are as pertinent as ever when working with Indigenous communities. Engineers must prioritise the safety of community members by conducting thorough risk assessments, implementing appropriate safety measures, and addressing potential health hazards. These must extend beyond physiological hazards, where health and safety analysis incorporates and respects Indigenous practices and beliefs.

Lean on multi-disciplinary approaches

One of the key distinguishing characteristics of humanitarian engineering is its multi- or even trans-disciplinary nature. Undoubtedly incorporating the fundamental physical sciences, life sciences, and mathematics expected of the engineering profession, humanitarian engineering expands our understanding of problem solving into fields such as social sciences, public health, psychology, education, political science and peace and conflict studies, among others.

Approaching engineering beyond its familiar technical efficacy opens space for us to also consider the interconnectedness of social, cultural, and environmental dimensions of the challenges faced. Collaboration is a cornerstone of humanitarian engineering, necessitating the ability to work with diverse groups inclusive of non-engineering experts, community members, individuals of various genders, and those from different cultures and identity groups. The effectiveness of humanitarian endeavours relies deeply on interpersonal relationship to collaboratively address complex issues of social justice embedded in technology, infrastructure, products and systems.

Learning Objectives

What are the enduring aspects of First Nations knolwedge and science, that provide similarity across many countries and Nations. These are key to any real collaboration on projects and any integration of sustainable thinking

- Respect and Reciprocity
- Flexibility and minimalisation
- Local based solutions based on deep knowledge of local systems
- Holistic knowledge collection through stories

What else?

Rethink project management to enable relationships

Project management skills are also crucial in humanitarian engineering projects. Engineers must be able to effectively plan, organise, and coordinate projects while considering the specific needs and priorities of the community.

This includes engaging in meaningful consultation and collaboration with Indigenous community members throughout all stages of the project, from initial planning to implementation and evaluation. By incorporating community members as active partners, engineers can ensure that the project is culturally appropriate, respectful, and aligned with the goals and values of the community. Additionally, engineers need to consider the historical and ongoing impacts of colonisation on Indigenous communities. This awareness can help in mitigating

potential power imbalances and promoting equitable partnerships, allowing for more effective project management and sustainable outcomes.

Integrate environmental protection, climate action, and engineering

Humanitarian engineers must always prioritise environmental and social considerations in their projects. Or even better, recognise the mutual complementarity of each component, whereby environmental protection, climate action, and humanitarian engineering each supports the success of the others. Similarly, neglecting one component undermines the others, which emphasises the need to integrate approaches to each.

Recognising the benefit in breaking down silos can open space for more systemic and holistic responses to addressing community needs and aspirations. For example, integrating climate action and environmental protection into engineering thinking and practice, rather than a more siloed approach of triple bottom line can not only improve community outcomes, but in the process also reduce duplication and optimise use of limited resources. 'The degree of integration will vary based on the needs and priorities of each [region or community]' but simply prioritising integration will open space for mutually beneficial outcomes (Pacific Community [SPC] et al., 2016, p. 7)

Different actors in the humanitarian engineering space will be at different stages of their journey. Just as different organisations have different roles and resources, an empathetic approach that meets people and organisations where they are on their path can foster inclusivity in

moving the engineering sector forward. An inclusive engineering sector that advocates for greater listening, learning and knowledge sharing is encouraged to bring about positive change.

Exercises

What would change in your latest project if you integrated more envirnonment and climate considerations:

- What materials would you use?
- How big would your project be, can you separate it into parts?
- Who would you engage on the project?
- How would you implement the project?
- How would you convince other engineers to implement your approach?

Note: Country, capitalised, is described by AIATSIS as 'the term often used by Aboriginal peoples to describe the lands, waterways and seas to which they are connected. The term contains complex ideas about law, place, custom, language, spiritual belief, cultural practice, material sustenance, family and identity' (AIATSIS (2024) *What is Country?*)

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PART III

Part C - Professional Skills

This section is material related to Professional Development for Engineers with case studies of how to relate First Nations approaches as new perspective on engineering design.

When we are practising in our areas of expertise, we are often starting fresh in the field. It helps to read of others' experiences and consider what we can take from that, so we do not go in without some process to handle the project.

So too we can take much learning from the experience and processes of the last 60-100,000 years in Australia. We are finding that the new knowledges and new approaches are not always successful or sustainable. We hope these case studies will encourage a new way of looking at our work.

16

Sustainability and Systems Engineering

Cat Kutay

Sustainable practice by First Nations in Australia are often viewed through a lens of providing low tech systems. This assumes a certain approach to how to make improvements in our present engineering development projects.

People often do not see bark canoes made from bark harvested from living trees or cycad nuts soaked for hours to remove poison are inspirations in an age of air conditioned dwellings (mobile and fixed) and homes controlled by interlinked devices on voice command.

However it is the process of design and knowledge sharing of the technology that makes First Nations technology sustainable, not just the materials used. It is these processes that Aboriginal people wish to share before our earth is totally destroyed.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://oercollective.caul.edu.au/engineering-with-country/?p=145#oembed-1

From *Walking on Country with Spirits – Wagul Wagul. From A. Ramos Castillo and United Nations University, 2009. Licensed for adaption and re-use under CC BY-NC-SA) 3.0 Unported License.*

When we tell you our Dreaming Stories we invite you into our culture and values. We provide you the framework of our Country, how to navigate it, what you can eat (such as our totems) and how to survive. We also tell you our values and how to negotiate our social systems. All these are combined in one story that grows with you as you learn more about the aspect of Country that relates to where you want to build, or engineer and what that will impact.

First we will look at some key aspects of First Nations knowledge processes that may apply in the area you are working:

Oral Knowledge

1. Knowledge is shared by referring to the dreamtime stories that children grow up with.

2. These stories increase in depth and link to other sub-stories about more deep knowledge.

3. To hear these stories, a person talks to the different holders of each different component.

4. When people tell their part of the story, there will often be other people there to confirm or correct them.

5. New elements to the story are created as times change, climate changes, and people experience new things, but only those with authority over the story can tell new parts, and they will again check this with others before they do.

6. When telling a story, the person with authority over the story is always acknowledged, as Europeans do in peer reviews.

Knowledge is located

1. Stories are usually told on Country as the Country will remind the storyteller of key features to cover, such as the animals and plants in that area and the seasons.

2. The stories are about how the animals and plants live together in that Country, how the rocks were formed, where the water is, and so on.

3. While many people have died these stories come back as our people settle back on our Country, they say the story remains in the Country, and by developing a relationship with Country you find the stories again.

Systems approach

1. Instead of breaking knowledge down into parts, the knowledge is presented as a whole story.

2. The listener will not understand all the parts at once, but over time, the depth and interconnectedness will be learnt.

3. Learning is both conceptual through the stories, and practical through the hunting and gathering along the storylines which link the places that are important in the life of that Country, the animals and plants.

Listening and learning

To understand your environment, the animals, plants and landscape, you need a holistic approach to the system. You will learn about Country while at all times understanding how the features interconnect, interact and adapt to changes. For Aboriginal people, all the land, plants and animals have spirits, they are living beings. Only what is created by humans is not animate.

Then you need a method that helps you to remember and share this oral knowledge. A way that people can recall the history of the place and share patterns that re-occur over time, in the weather and in the inter-relation of the local features. This is done through storytelling.

There are different ways that cultures create knowledge and share our understanding. If you come into a community, you need to understand and engage in that system of knowledge management and listen to the stories. For Aboriginal people 'gut feelings' are often as important as visual observation, for these come from long experience. However no one individual will create knowledge, the stories need to be reinforced by others who have a role in the development of that knowledge.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://oercollective.caul.edu.au/engineering-with-country/?p=145#oembed-2

From *UTS Kangaroo Story – Tacit Knowledge Sharing. From C. Kutay and University Technology Sydney, 2017. LLicensed for adaption and re-use under CC BY-NC 4.0.. Used with permission of authors.*

If you want to understand the situation in the community, you too will need to hear different viewpoints, and understand how these all form part of the community reality.

Then if you are planning change, a new design, you will need to introduce that slowly. When discussing a project it takes a long time for a group of people to reach agreement, so it is important that the community is allowed time to do this, rather than enforcing a design or solution that is not suitable to some. The idea of "settlement politics" has grown from the understanding that people can come to the same conclusion or settlement from very different standpoints. We just need time to reach that agreement.

So when people come to community and propose a project, you may hear a respected person stand up and praise the project. Then another speaker may get up and say "I agree" but then continue to propose an entirely different approach. If the project group only stays for a few speeches, they will miss what is the real solution or collaboration. It takes time to reach a real settlement.

Design

Consider how you would design a sustainable house on an area of country, somewhere to live comfortably with minimal damage to the country.

What are the aspects of your process that will ensure the final house is as sustainable as possible.

Describe this in a short narrative, as a presentation of your project, without slides except where you need images to explain what you are doing.

Systems Thinking

Modelling systems is an important part of project design and planning. Two different approaches to system modelling are a western and First Nations approach. The western approach uses an interdisciplinary approach integrating aspect of different field of engineering and engineering management and focuses on how to design, integrate, and manage complex systems over their life cycles. That is, the approach looks at the components that are well modelled and attempts to reconstruct the whole from these parts.

The First Nations approach to systems engineering avoids breaking a system into components by retaining the whole picture of the physical environment, as well as its value, in the engineering mind. The Dreaming stories are

a way to remember all the components of this model. Imagery and symbols can be used to present these components and their inter-relation. A narrator may break the story into sections such as locations in time or place, but that part of the story will be a coherent or complete representation of that aspect.

Note

Sustainability was and is fundamental to the way of life of First Nations. When people have a chance to live on the country which they know, and have some control over its well-being, we will work sustainably.

To understand some aspects of Aboriginal society now, such as the reliance on motorcars and the littering of the community surrounds, we need to understand the culture and history we are working within. This is expanded in the chapter on Narratives

17

Process to Develop Your Project-based Unit

Curtis Roman

How to develop and manage a project with an Indigenous community

Community Engagement:

- Establish relationships with community leaders and members. Seek permission and involve them in the decision-making process.
- Commit to co-design at all stages of a project – consultation, development and implementation with community. Not just 'listen to their needs, aspirations, and concerns' but actively engage them in activities, bringing lived experience into the design process.

Cultural Sensitivity:

Engage in co-design to ensure

- cultural values and practices of the community

informs all aspects of the project. This includes integrating traditional land use, sacred sites, and cultural protocols from initial planning stage into operating systems.

- that the project aligns with and respects cultural heritage because the lived experience and voices of Indigenous elders and cultural advisors are integrated from the design stage onwards.

Identify Community Needs:

- Design any project with the community to identify their economic and social needs. This could involve conducting co-design workshops, surveys, or other forms of consultation.
- Tailor the project to address specific challenges and aspirations identified by the community.

Skill Development and Employment:

- Design training programs with community input that build local capacity and skills. This could include technical skills related to manufacturing as well as other business and management skills.
- Prioritise local employment opportunities to enhance economic self-sufficiency within the community.

Sustainable Practices:

- Incorporate environmentally sustainable practices in the manufacturing process, co-designed with community input, to minimise the project's impact on the local ecosystem.

- Consider renewable energy sources, waste reduction strategies, and environmentally friendly technologies.

Local Resource Utilisation:

- Explore opportunities to utilise local resources in the manufacturing process with community. This can include traditional materials or resources that are abundant in the region.
- Foster partnerships with local suppliers to support the broader community economy.

Ownership and Governance:

- Co-explore models of community ownership and governance for the project. This could involve establishing a community-owned enterprise or partnership with existing businesses.
- Ensure that decision-making structures include representation from the community at the heart of any project.

Long-Term Viability:

- Co-plan for the long-term sustainability of the project. This may involve developing a business plan that outlines ongoing operations, maintenance, and expansion strategies and includes communities at all stages of the design, plan, build and manage cycle.
- Seek opportunities for diversification to mitigate economic risks.

Cultural Preservation Initiatives:

- Co-design with community to integrate cultural preservation initiatives within the project. This could include supporting cultural events, language revitalisation programs, or other community-led efforts.

Continuous two-way Communication:

- Maintain open and transparent communication between community and the project management team throughout the project's conception, development and implementation.
- Be adaptable and responsive to feedback, lead every development with a co-design mindset, adjusting the project as needed based on community input.

Ongoing Management of the project

The success of the project: measured both in economic terms and also in the positive impact on the community's cultural identity and overall well-being.

- Revisit, reassess the impact of the project – and the project's economic and cultural wellbeing
- Continuous two-way respectful communication
- Adjust to meet all economic and cultural wellbeing needs viable, as required
- Ensure the project is built on and continues to remain aligned with the community's vision and values.

How can engineering improve the lives of people living in remote communities today?

Key approach to any project: build strong relationships with community members and **embed their knowledge and aspirations** into engineering solutions are crucial for long-term success.

Water and Sanitation:

- Implement sustainable water supply and sanitation systems. This involves co-designing with community input and installing reliable water sources, wastewater treatment facilities, and promoting water conservation practices.

Renewable Energy Solutions:

- Integrate renewable energy solutions to provide reliable and sustainable power sources. Co-design solutions with community input to explore the options of solar, wind, or hybrid energy systems, reducing dependence on traditional energy sources and improving energy access.

Infrastructure Development:

- Engage in a 360 degree co-design and development of essential infrastructure, such as roads, bridges, and community buildings to include professional and lived experience of living in each remote community. Well-designed infrastructure with community input enhances connectivity and accessibility to services.

Telecommunications:

- Improve telecommunications infrastructure to enhance connectivity in remote areas. This includes expanding mobile networks, internet access, and communication technologies to overcome isolation and support economic activities.

Housing Solutions:

- Develop innovative and culturally sensitive housing solutions. Consider climate-appropriate designs, sustainable construction materials, and community involvement in housing projects.

Healthcare Facilities:

- Co-design and improve healthcare facilities with community input to meet the unique needs of remote communities. This includes telehealth solutions, medical infrastructure, and technologies that address health disparities.

Education Infrastructure:

- Enhance educational infrastructure by co-designing with community input, the schools that accommodate the needs of remote communities. Incorporate technology for distance learning and consider community input in educational facility planning.

Agricultural and Food Security:

- Support sustainable agriculture and food security initiatives. Co-design engineering solutions with community input for efficient irrigation systems,

community gardens, and food storage facilities to address challenges related to remoteness and climate.

Emergency Response Systems:

- Co-design with community input engineering solutions for effective emergency response systems. This includes early warning systems, evacuation plans, and resilient infrastructure to mitigate the impact of natural disasters.

Cultural Preservation:

- Collaborate with communities to re/discover, identify and embed traditional knowledge and cultural values into engineering projects. Respectful engagement ensures that engineering solutions align with and preserve the cultural identity of Indigenous communities.

Job Training and Employment Opportunities:

- Introduce engineering projects that provide job training and employment opportunities for community members. Engaging community members throughout the design, plan, build and manage stages of a project will build local skill development and lead to economic empowerment.

Technology for Education and Skill Development:

- Integrate technology for education and skill development programs in consultation with communities. This could involve providing access to online courses, vocational training, and mentorship

programs to empower community members with valuable skills.

Community-Driven Development:

- Adopt a community-driven development approach, where engineering projects are initiated and led by the communities themselves. This ensures that solutions are tailored to the specific needs and aspirations of each community.

Environmental Conservation:

- Implement engineering solutions that promote environmental conservation. This includes waste management systems, conservation of natural resources, and sustainable land-use practices.

Collaboration and Capacity Building:

- Foster collaboration between engineers, community leaders, and residents. Empower communities by building their capacity to understand, manage, and maintain engineering projects in the long term.

Example Area — Water in remote communities — what are the issues — how can they be improved?

Collaboration with Indigenous Knowledge is key: Incorporate First Nations knowledge and practices related to water management at every step of the design, plan, build, manage water projects.

Accessing Clean Water:

- Challenges in accessing a reliable and clean water

supply due to the scarcity of water sources or inadequate infrastructure. Develop ways to sustainably transport and distribute clean water.

Water Quality:

- Exploring filtration solutions to filer out contaminants, such as bacteria, parasites, or high mineral content.

Sanitation Infrastructure:

- Explore opportunities to develop innovative wastewater / sewage disposal systems and treatment facilities to protect against environmental contamination and health hazards.

Climate-Related:

- Researching traditional methods which communities have used for millennia to manage the Top End's seasonal rainfall pattern may offer innovative NT solutions. Focus on both daily life of the community and agricultural activities.

Infrastructure for Rainwater Harvesting:

- Co-research traditional ways of rainwater harvesting, which may provide a more sustainable infrastructure for more effective collection and storage of rainwater.

To address these water issues, engineers can contribute engage with First Nations perspectives in several ways:

Water Infrastructure Development:

- Co-design and co-research traditional methods of capturing and managing water supplies as **identified and developed with community input**. Implement any innovations to source more reliable water infrastructure: wells, boreholes, and pipelines

Water Treatment Solutions:

- Design with community re. traditional /place-based environmental solutions to water purification, with a focus on designing NT-specific water treatment technologies for NT context

Sanitation Infrastructure Improvement:

- Design with community to develop and / or upgrade sanitation infrastructure, including any community-led insights into better wastewater treatment and sewage systems to mitigate environmental pollution and improve community health.

Community Education Programs:

- Co-design educational programs to raise awareness and empower communities about water conservation, hygiene practices, and the importance of maintaining water quality using community input – engaging in language, traditional designs and images, as culturally appropriate for each community.

Rainwater Harvesting Systems:

- Co-design community-led research and install rainwater harvesting systems, including storage

tanks and distribution systems, to capture and utilize rainfall during wet seasons. This can serve as a supplementary water source.

Climate-Resilient Water Solutions:

- Design with communities to engineer innovative solutions that consider the NT's climate challenges – resilient water infrastructure capable of withstanding drought conditions and seasonal dry.

Community Engagement and Participation:

- Involve the community in all co-planning, co-design and co-decision-making processes. Engage with community leaders and residents in every community to understand their community, environment and place-based unique needs and preferences regarding water infrastructure and management.

Capacity Building:

- Build local capacity by engaging community in the design, plan and delivery of any project. Training community members in water infrastructure maintenance and management. Ensures the sustainability of any water project in the long term.

Technological Innovation:

- Further co-explore innovative technologies within each community and Country, assessing the viability of solar-powered water purification systems or mobile water treatment units, to provide flexible and

sustainable solutions for remote communities.

18

Governance in projects

Cat Kutay

One of the significant factors to emerge from the consultations in Austrlia over improving land management, has been the greater understanding of consultation techniques. Our Knowledge, Our Way in Caring for Country provides a resource for ongoing projects with community:

One or more interactive elements has been excluded from this version of the text. You can view them online here:
https://oercollective.caul.edu.au/engineering-with-country/?p=156#oembed-1

Available from https://www.csiro.au/ourknowledgeourway. Licenced under CC BY-NC-ND 4.0

To run First Nations projects with community, we need to work with the existing organisations and the local people of the area where we work. In terms of engagement with community there are two important groups:

1. Local Aboriginal Lands Council

There is funding for Aboriginal people to support their communities through the *Aboriginal Land Rights Act 1983*. This is distributed through the about 120 Local Aboriginal Lands Councils (LALCs). These are elected representatives for Aboriginal people in their region.

These Councils manage the finances to support all Aboriginal people in their area, not just those who are traditionally from that area. The services they manage include housing, legal affairs, employment, training and property acquisition and management.

2. Reconciliation Australia

Reconciliation Australia was established in 2001 and is the lead body for reconciliation in the nation. They are an independent not-for-profit organisation that promotes and facilitates reconciliation by building relationships, respect and trust between the wider Australian community and Aboriginal and Torres Strait Islander peoples

There are many local Reconciliation groups that provide links between the Aboriginal and non-Aboriginal communities. They are also a good point of contact with community people.

History of Governance

Aboriginal people lived in Australia for over 80,000 years, During this time they established genomicaly distinct groups of people around different landscapes of Australia. The paper by the Aboriginal geneticist Ray Tobler

"Aboriginal mitogenomes reveal 50,000 years of regionalism in Australia" published in Nature wrote about how his team worked with hair samples collected around Australia in the 1900's. The samples included data on where they were collected from. This provide the resources to verify the genetic make up of people of different areas before major colonisation of much of Australia.
This work showed that Aboriginal people lived in specific regions of Australia for 45-50,000 years. No mass invasions, forced migrations or land disputes.

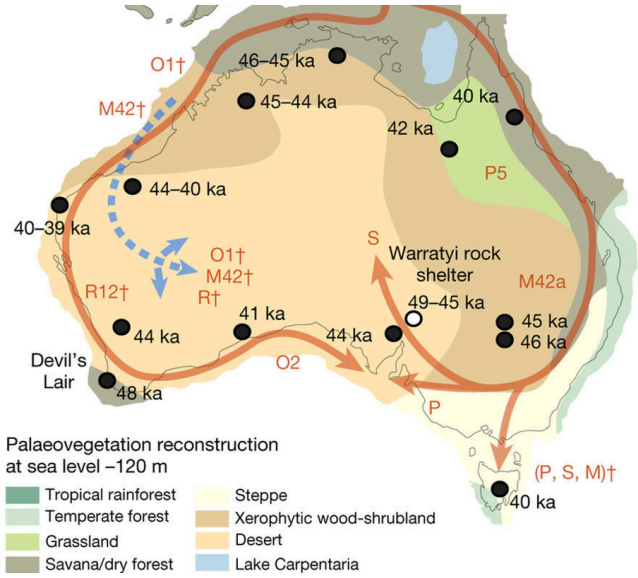

Figure 1. With Permission from Tobler et al (2017). Aboriginal mitogenomes reveal 50,000 years of regionalism in Australia. Licensed for adaption and re-use under CC BY-NC 4.0.

Bruce Pascoe in his book Dark Emu describes the governance that enabled this settled life style, and work by the philosopher Helen Verran (2008, 2022) also discusses this. Aboriginal people developed a complex governance

system that ensured that people came together regularly to share stories, marry out of family and heal social wounds. This system was run by a group of elders, each with different expertise and all working for consensus, which is not an easy process. The system was a form of flat management that allows hierarchy, but within each level, people have more control of their life.

Governance styles

If the Voice were to be set up in Australia, it would be the first government funded participatory democracy organisation in Australia. The Voice was designed with layers of representation from local, to regional to national, where any national representative also attends, report to, and listens to, their regional and local groups.

Aboriginal culture has always been participatory. The elders that meet to organise the corroborees are a group of people with vastly different expertise (totems) who decide on a common path forward in caring for country, that enabled all animals, birds, plants and resources to flourish in balance.

In European society the notion that those affected by legislation should be involved in the drawing up of that legislation has been slow to grow. As a result we see repeated policies and platforms overturned as unworkable and not good for most. In software development the grown of participatory research arose from the realisation that the software being developed by those who know the technology did not suit those who merely used it. Hence more had to be done to engage the users, right from the initial design.

This approach is being taken up in architecture, and the growth of tools for online sharing of designs and gathering and analysing feedback are flourishing. We need to manage users expectations, not by negating them, but showing users what is possible or not, and working to find compromises where necessary.

In our projects, Participatory Action Research (PAR) is part of any development with First Nations communities, as the source of issues and the possible solutions will only be known to community members, not to those with different priorities, values and experiences. In the recent COVID crisis, First Nations people were forcibly moved from urban areas back to their communities, to 'protect them'. Due to distrust of government, the communities were ready to get up and all move to urban areas, they understood from this forced move that living in communities must be harmful. By elders and leaders demanding to be informed, the health message started to be delivered to community leaders, not just the health clinic workers, and the community started taking control of the messaging. As a result, very few First Nations people in the NT died from COVID.

First Nations are more familiar with working in this way and will always guide projects to consider this process as important. Similarly other groups are realising it is import to consider the great human and physical environment.

Learning Focus

There are various case studies in software that illustrate the failure of developments without client involvements and the history of Participatory Design (PD) in Human Computer Interaction. Students can run a design project

using PAR or PD so they become used to the steps involved, and reflect on the changes to their design that result from this work

We try and invite members of the client community in to assess such projects done **for** a community, so that students start to realise that design **with** community is different. This has an advantage as only one session will be required for the students to get feedback on their presentations. In designing with First Nations communities, the situation is so different to what students tend to assume, this point is brought home easily.

Assessment

This understanding of group governance and consultation with community can be assessed as part of the rubric of a student's design report, or as a reflection after meeting with community. Again this reflection can be part of the report, in what did we change from the community meeting.

References

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19

Narrative Knowledge

Cat Kutay

This is an exercise in sustainable and holistic knowledge creation and sharing. It's about students making their own learning journey with a focus on the whole picture.

We start with looking at how Aboriginal narratives or Dreaming stories develop as the child grows:

- At first they explain natural features and animal behaviours

This helps the child find their way back home. The simple Dreaming stories that are shared with those outside the culture are for those who are not aware yet of our knowledge system, who are like children. So we help people enter our social knowledge system with the most basic aspect, of knowing Country.

- Relationship between people in the community – eg kinship

Next our stories assist people to work together and understand our complex relationships that tie us together and ensure we work for each other, with responsibility to each other and the community.

- Relationships between community and environment – eg moiety

As people become adults in our culture they need to work with community and the whole environment in a sustainable way. So the stories expand to explain how all the components relate and the indicators at each significant part of Country show how well the Country is.

- Spiritual understanding of complex patterns in the environment – knowledge that is too complex or intuitive to express

It is only when people become expert in knowledge that they are able to understand the deepest knowledge of Country intuitively, using long experience to manage complex situations. This knowledge is shared in the sacred stories.

Audio narrative exercise

Provide an audio reflection (recorded)

- What is your country you are most affiliated to – area of land. This is "your Country"
- What is a food item there you know about – this is "your

totem"

- What can you tell about that food, how to increase it, where to get it, how to prepare it
- Tell a story to teach others about living on your Country

Use this information to develop your narrative about learning:

- What can you share about your story of learning, living on the Country within your University/TAFE/ College/School?

Now start the story with a moral approach:

- What are your values? Introduce your story with these

What you have now is the start of your learning in this domain, in the area of learning.
How can you make this narrative a common story for students in your unit, such as a story about sustainability. The following example is a short story about working in a team, using the Lyre bird as a team member who facilitates but maybe tries to please too much, the Wedgetail Eagle is is able to abstract from the various views the team provided, and the Common Myna is the individualist.

Example story on Teamwork

The animals gathered around the local spring to admire the reflection of the sky and trees. The birds flew down to admire their own reflection, and the trees quietly dropped their leaves to disturb these images as they were tired of the noise.

When the Lyrebird enters the circle beside the spring the other animals are confused, they understand a little of what he was talking about: respect, space, others, but together the words do not make sense. They struggle to engage with the story.

It was a soaring Wedgetail Eagle who described the unified scene she saw that inspired the gathering to consider how to see themselves as a group, as having some ideas in common, while some are different, but the process of change can be planned with all them in mind.

It was only the Common Myna who could not accept this collaboration and made it difficult for them to assign tasks to each clan, as the Myna did not think the process should be divided up that way.

It was the Lyrebird that suggested that while they would do separate tasks, they needed to understand each others' contribution to the process to maintain their cohesion. The Myna could accept this approach.

Narrative Indicators

As students continue through their studies, provide material to develop the story. To develop these stories, teachers can deconstruct the narrative for deeper learning

at each significant indicator in the story. Those with more experience and knowledge in each aspect can provide a narrative on what they know.

The students can fit this into the larger narrative if each new story is linked back to a point in the large narrative. This may be a location in the story, or a deeper explanation of what a character in the story did at some point.

Building Narrative

The students will construct their own version of the narrative around their discipline and projects. They will start to incorporate the significant features of their learning into their own story that they can tell, which is about what they know and have verified with other experts around them.

If the students work as a community this will be based on the one story, which will have extra material each student can share, as an expression of their expertise. It will be a story that repects all students' experiences but provides a common thread on how to navigate learning, how to deal with the important aspects, and how to gain a deep knowledge of learning.

Example of narrative

An example story is one told of the Ngunnhu – the fish traps at Brewarrina – created by Baiame, the serpent spirit who created the rivers.

Note: We warn that the speaker in this video has passed away.

https://youtube.com/
watch?v=7uYKg1M6PRk%3Fsi%3D_GSAFpuchS_BGd_y

Recorded by the Department of Climate Change, Energy, the Environment and Water. Licensed for adaption and re-use under CC BY-NC 4.0.

This video records a story told to children, but there are clear points in the story where more detail could be added as the children grow. A description of the countryside created by Biaime provides a way for children to find their way home. The way the traps form a net is described as a way to perceive the layout of the traps; the black fish that Biaime hunted may refer to fish that lay their eggs in the bank and were collected by Aboriginal people and distributed to other areas of the river; the ceremony when the dust is kicked up into a high cloud links to the techniques of cloud seeding used now.

References

Sveiby, K-E. & Skuthorpe, T. (2006). Treading Lightly. Allen and Unwin.

PART IV

Part D - Examples of engineering projects

We are sharing here some projects that are ongoing and which students or professionals may work with. Please share your projects with us to be included. While most will be located in a place, they will provide ideas of what people are doing already.

Sometimes process or technology can be generalised from individual communities to something that can be done in a different area. The important thing to note in doing this, is how the project developed in its initial location: the process; stakeholders aspirations; restrictions; and so on, that led to that project. Then when applying the ideas to a different community you will need to re-assess these in the light of the new context.

We can only learn some ideas from these projects, not the solution.

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Participatory Action Research and Co-Development

Cat Kutay

We aim to improve our engineering practice by localising project to the needs of the community from design stage, to engaging community in their enactment. When designing and implementing projects, what are the sort of communication issues might you experience and how can you prepare for them? More importantly how can you learn from your mistakes, reflect and improve?

When you travel to another community, to another culture, you will find you cannot explain matters as clearly as you would like, nor can you hear clearly. Most importantly, this will affect how you think and your ability to solve technical problems in a complex environment. Be careful not to blame others for your confusion in the new environment.

A non-First Nations person explained once that after many years, their understanding was finally changed by consultations. They had been hired to review the situation

in the town camps of Kempsey years ago. They said they had worked a long time in Aboriginal Affairs and had previously found the community people very frustrating, as they could not make a clear decision and the outcomes of any consultation did not get implemented within the community, it must come from outside. Until, when on this Kempsey project, they sat and talked to the community and could then clearly see the reason behind each decision and outcome.

Reflection

Why was this not easy to understand before people sat and listened?

Was the lack of clarity only from the community? Aboriginal communities regularly raise the following experiences:

- Lack of clarity among government agencies about roles and responsibilities in the partnership arrangements and failure to follow agreed processes;
- Lack of clarity and transparency about government processes for the Indigenous community.

Both of these issues caused confusion and frustration within the community trying to enact programs put on them.

Issues that Arise

Some specific aspects of cultural difference are common across projects and these give rise to issues that need to be considered to improve our consultation processes.

Authority

Often governments have little relationship to a specific community and work through individual champions, who they set up as leaders or managers. Setting up authority for individuals or family over a whole group creates issues over avoidance. Some people cannot attend an office run by people who are in-laws they must avoid, or if a centre is run by one family with whom they do not get on. People from different areas and historical experiences of colonisation may not wish to engage with each other. It's like Parramatta Road in Sydney – it divides the Italian and Greek communities.

This comes from the history of putting many people into the one 'hub' or camp without considering if they have much in common. People from different language, cultures and with knowledge of different landforms and ways of living are forced to work together. Maybe one group are the traditional owners or custodians, so others are usurpers to them.

Those originally from the area will have the stories, the others will feel cut out or assume there are no stories to know. That is how the First Nations women who were responsible for Hindmarsh Island had their case for preservation of this site opposed in court, many local First Nations women did not have the stories and denied they existed.

Communication

Merely doing all communication in English, which is second, third or fifth language to many Aboriginal people, can be an issue. There are ways we express ideas in English that do not match any way of thinking in First Nations languages. Using Plain English is often a way to help community understand, so the engineer needs to know how to talk this language.

For instance if an engineer or IT consultant visiting the community says: 'If I come out Monday I will drive you to town' and they do not come back Monday, they are seen as dishonest. There are consequences of mis-communication.

This example is a way of speaking that is too vague to translate into Aboriginal languages, where often honesty is paramount. To understand someone speaking English, any listener who is from another culture needs the concepts in their own language or their own experience to translate to. Even if the listener now think in English, if they were not brought up to think this way they may not be famiiar with, as in this case, the use of the conditional 'if' to describe future possible plans.

Relationship

With a strong kinship system, constantly reinforced when people meet together (a common question is who is your mother?) we find Aboriginal people tend to know each other and where everyone fits in. Or if not they find out. This means people from outside the community do not fit into the community network.

While people are friendly and welcoming to outsiders, it is hard for community to relate in a 'normal way' to those who come in. The presence of someone outside the relationship network is quite stressful for people used to negotiating with people as a relationship in a community, not as individuals.

Consider when introducing Aboriginal people to each other through a project, they usually know each other already, holding a lot of unspoken history that you will not know. There are the frictions, the hidden knowledge, the rules that describe what they can and cannot share with you or each other.

Shared knowledge

First Nations may deny knowledge of something if it is not their role to know or tell this. So it will seem that the community all have different experiences of events and of the local structure and organisation in the community. A typical example is when engineering consultants work with schools. The non-Indigenous project officer may introduce the consultant to the non-Indigenous teacher. The community may introduce them to the Aboriginal "teacher's aide". Both see a different person as the real teacher for the community.

Humour

The lack of humour in non-Aboriginal society causes much confusion and angst. Aboriginal people will engage in humour whenever possible, because to laugh in the face of hardship is good for well-being. For example in the Western Desert a special name Jukari is used for a dead

person to avoid their real name and not raise their memory for a year or two. Hence for a time in Punmu, a homeland community in the Western Desert, the word for Keith, or even Key as it sounds close to Keith, was Jukari. The word for Allen was also Jukari.

So as engineers working there we were told 'pass me the allen key' was 'pass me the Jukari Jukari'. We suspected community people were taking the mickey out of us! But that did not stop us following these protocols.

Appropriate Technology

The approach to technology is very different for community. Having the latest gadget is no use if it cannot be maintained. Learning to set up an expensive system for one person is not as motivating as setting up something the whole community will use, or learning how to maintain a simple technology that can be shared. Low technology solutions are what is needed in humanitarian work.

People will often make do, and by-pass new resources and technology if they do not like the culture that is assumed in that technology. They will not want to adapt their life to accommodate something that is against their cultural values. So we design with culture in mind. This allows us to design for the "whole picture".

Scenario

We provide here a small scenario as an example of a process for community projects. Achieving participation in a technical project is often idealistic due to the amount of preparation work needed to bring community up to speed

on the technology. However it is important that in each project we at least bring people on part of the journey that interests them, to enable longer term engagement.

Context

A team of engineers is tasked with designing a water management system for a remote Indigenous community located in a coastal region. The community has expressed concerns about water scarcity during the dry season and pollution of their water sources.

Western Perspective

One sub-team begins by conducting a thorough hydrological analysis of the area, collecting quantitative data on rainfall patterns, water usage rates, and pollutant concentrations.

They proposed a centralised water treatment plant and distribution network, emphasising technological solutions like desalination and chemical filtration to address water quality issues. The team focuses on optimising efficiency and minimising costs to ensure the project's financial viability.

Community engagement is limited to informational sessions where experts present their findings and proposed solutions to community leaders.

First Nations Perspective

The other sub-team organises discussions and workshops to talk to the community about seasonal water cycles, sacred water sources and traditional methods of

conservation passed down through generations. The engineering team listens respectfully, recognising the importance of integrating Indigenous perspectives into their design process.

Instead of imposing centralised infrastructure, they explore decentralised solutions that align with the values of self-sufficiency and environmental stewardship. This includes rainwater harvesting systems, community-led watershed protection initiatives and culturally appropriate education programs on water conservation.

The team collaborates closely with community members, fostering trust and mutual respect throughout the project.

Reflection

Through this example we see the contrast between Western and First Nations perspectives on water management.

While western engineering tends to prioritise technical expertise and standardised solutions, Indigenous approaches emphasise community engagement, holistic understandings of the environment, and respect for traditional knowledge.

By integrating these perspectives, engineers can develop more sustainable and culturally appropriate solutions that benefit both people and the planet.

Which team do you think produces a solution that is used by teh community and lasts for some time.

Card Game

We provide an example of an exercise to encourage people to see that there is more to an exercise than the imediate task, to look beyond that. This is also a good exercise to consider team communication.

It is a simple card game that highlights communication gaps and mis-understandings. It also helps students to learn about how groups work when they have a task where information is in segments and there are no clear links among all the pieces.

Described below.

This is a simple card game that highlights communication gaps and mis-understandings. it also helps students to learn about how groups work when they have a task where information is in segments and there are no clearly links among all the pieces.

Audience

Anyone wanting to learn about how to work effectively in a team of any kind

Materials

Sets of cards – 1 set for each group of 4 players. The following information is printed on separate cards

For 4 people

A + B = 15

B x C = 84

C = 12

D = C – A + B

C=12 B=7 A=8 D=11

The answer – which is not revealed until the game is finished – is 11

Introduction to group behaviour and to problem solving.

- The basic assumption in this game is that humans are decision-makers, who explore ways in which decisions may be effectively linked to other decision-makers.
- It is really helpful to have an observer watching each group of 4 so that an objective description of their actions can be shared with everyone.
- Discussion begins once all groups have declared a value for D.

Duration

Some teams may only take two or three minutes however some may take longer. So have a plan for how and when you will end the action and begin the discussion. With preliminary briefing and subsequent discussion, at least one hour is necessary.

Rules

- The written formula on the card must be kept face down.
- They must play by writing messages to each other,

there is no talking.

- Play proceeds by written communication amongst the group and stops when the value of D is discovered (even if the answer is not correct) *or the time limit is reached*

Setting the scene

- A group of four people sit around a table.
- Each player has a card on which is written part of a formula as in the list above. It must be kept face down.
- The teams are told their task is to '*find the value of D*'
- They can work in any way they want as long as follow rules.
- Each player has 4 or more small pieces of paper on which to write messages to pass to others, and a pen or pencil. If more paper is needed the managers will need to have more paper ready to distribute.

Observer points

- Time taken
- Data collected (i.e. what information does each player possess at end of game?)
- Note any individual frustrations
- Pattern of interactions
- Primary focus of attention of group/individuals

- What is the value of D?
- Who agrees? Disagrees?
- What strategy was adopted by each group?
- Who devised the strategy?
- Did it change during the action?

For instance consider if a team member shared their original information directly with the whole team, or just one other? Did others follow suit? What did they think of that first person's actions? Were they breaking the rules. Did they write more on the paper than they had on the card, how verbose were their messages?

Discussion points

- **How problem solving relies upon shared information**. This is especially clear if some members of the group did not possess all the information by the end of the game. At this stage of the discussion each member of the group will normally see himself as a problem solver faced with the problem of data collection.
- **Relationship between Data, Problem and Solution**. It is sometimes found that the nature of the problem is interpreted in different ways by people with differing pieces of starting information. The person with D = C – A + B (or similar) will realises that it is a problem in substitution. A player with A + B = 15 has been known to think in terms of equations, and players with C = 12 will sometimes think in terms of progressions and try to work it

out alone without reference to other information.

- **Communications patterns and techniques**. Did the one adopted lead to any frustrations or errors?
- **Draw attention to the two separate problems:**
    - organisation of the group
    - finding the value of D.
- **Role playing**. Emergence of leader, or decision maker (any conflicts between players, and do personality conflicts affect decisions in real life. Emergence of specialist (did everyone try to work out the answer, or did the group concentrate on assembling all information and then hand it over to one person to calculate). Unless the members of the group, are already well known to each other it is unlikely that a specialist will emerge in the first game. Also each member of the group tends to play a competitive game.
- **Instrumental and expressive aspects of groups**. Because they are being timed, groups tend to compete against other groups. This can help the group members to see that a contribution to group efficiency can be as important a strategy as one based upon a desire to compete with all other players.

Versioning History

This page provides a record of changes made to this textbook. Each set of edits is acknowledged with a 0.01 increase in the version number. The exported files for this toolkit reflect the most recent version.

If you find an error in the text, please contact cat kutay at cdu edu au

Version	Date	Change	Details

		Part A • Simulation Resources • Engineering Projects Simulation • Scenario Teaching Through Vignettes • Caring for Land Country • Caring for Water Country • Water Transport • Songlines and Transport routes Part B	
1.0	Feb 25	• Cooling and Energy Saving • History of Technology in Australia • Aeronautics • Materials and Construction • Materials and Strength • Navigation • Indigenous design: Water Country • Humanitarian engineering skills: A perspective from Engineers Without Borders, Australia Part C	Published first chapters

- Sustainability and Systems Engineering
- Process to Develop Your Project-based Unit
- Governance in Projects
- Narrative Knowledge

Part D

- Participatory Action Research and Co-Development

Review Statement

Engineering with Country was produced with support from CAUL. Critical to the success of this approach is including mechanisms to ensure that open textbooks produced with the Community are high quality, and meet the needs of all students who will one day use them. Hence we asked authors to review other chapters, as they are faculty subject matter experts in Engineering.

We will be seeking further feedback from lecturers who use this work in their classroom and from professionals. Others are welcome to send feedback and have their findings included with credit.

The chapter reviews were structured around considerations of the intended audience of the book, and examined the comprehensiveness, accuracy of the content, as well as academic relevance of the material to teaching in the classroom. Further review by the editors focused on clarity, consistency, organisation structure flow, and grammatical errors. Changes suggested by the reviewers were incorporated by chapter authors in consultation with the editors.

Editors would like to thank the reviewers for the time, care, and commitment they contributed to the project. We recognise that peer reviewing is a generous act of service on their part. This book would not be the robust, valuable resource that it is were it not for their feedback and input.

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