

Engaging with Stakeholders to Identify Threshold Concepts in Indigenous Engineering Education: A Research Approach

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ABSTRACT

BACKGROUND AND RATIONALE

Over the past decade, Australian universities and professional organisations have committed to embedding Indigenous Australian perspectives alongside engineering curricula. Efforts to transform these initiatives into real curriculum changes (Kutay et al., 2022; Stephensen & Cunningham, 2023) may be supported by research to identify the stakeholders and threshold learning elements involved in such curriculum transformation. By identifying the most transformative and troublesome threshold learning elements, educators and Indigenous Knowledge holders may focus the curriculum (Baillie et al., 2013; Meyer & Land, 2003). In the broader context of Indigenous studies, Moodie (2019) has outlined potential threshold concepts. However, threshold learning specific to Indigenous Australian engineering has not yet been defined. Before beginning research to describe threshold learning in Indigenous engineering, it is essential to design a respectful and valid research approach that prioritises Indigenous leadership, valid scholarship, and meaningful participatory collaboration with stakeholders.

PURPOSE AND APPROACH

We outline the rationale and research approach for connecting with appropriate stakeholders to describe threshold learning in Indigenous engineering for education of all engineering students. We engage with the Threshold Capability Integrated Theoretical Framework (Baillie et al., 2013) and relevant literature to explore the significance of threshold concepts and capabilities in an Indigenous Australian engineering context. We then identify stakeholders and draw on an Indigenous research paradigm to describe a research approach relevant to this context.

SIGNIFICANCE AND FUTURE WORK

Engineers must account for social, cultural, and environmental contexts to design suitable solutions to increasingly complex problems. Indigenous Australian engineering Knowledges are essential to these contexts in Australia. As such, engineering educators must develop students' appreciation of these Knowledges. Engineering educators struggle to involve appropriate Indigenous Australian stakeholders and begin facilitating this development (Goldfinch et al., 2017). This paper outlines a research approach for connecting with stakeholders in Indigenous Australian engineering and engineering education. This approach will guide our work to identify threshold learning in Indigenous Australian engineering and design appropriate learning experiences and assessment methods. The outlined approach and anticipated findings may also guide other researchers and educators seeking to connect with appropriate stakeholders and weave Indigenous Australian engineering Knowledges throughout the engineering curriculum.

KEYWORDS

Indigenous engineering, threshold concepts, threshold capabilities, Indigenous Knowledges

Background and Rationale

Engineers have a responsibility to understand and account for social, cultural, and environmental contexts in order to design appropriate solutions (Engineers Australia, 2019). Recognising this responsibility, the Australian professional engineering community has committed to embedding Indigenous perspectives in engineering education. In 2017, the Australian Council for Engineering Deans released a position statement to support “Embedding Aboriginal and Torres Strait Islander perspectives into the engineering curriculum” (ACED, 2017). Engineers Australia has committed to further developing its Indigenous Engineers Group (Engineers Australia, 2023).

In their *Indigenous Strategy (2022-25)*, Universities Australia emphasised the need to “move beyond aspiration to implementation” (Universities Australia, 2022, p.17). Engineering educators at over a dozen Australian universities have begun to develop teaching and learning practices that turn these aspirations into praxis (Kutay et al., 2022; Stephensen & Cunningham, 2023). The literature describing these efforts mainly reports on the learning activities, rather than the process and stakeholders involved in developing these activities. Engineering educators have described challenges in developing and implementing learning activities that embed Indigenous engineering Knowledges. These challenges include uncertainty of where to begin, “lack of support,” and “caution in regard to involving the right Aboriginal stakeholder representatives” (Goldfinch et al., 2017, p. 437). Outlining a curriculum development process may provide guidance for educators seeking to connect with Indigenous communities and embed Indigenous engineering Knowledges alongside engineering curricula. The objective of this paper is to describe a process for this curriculum transformation by drawing on the threshold concepts framework (Meyer & Land, 2003) and relevant literature, identifying stakeholders, and outlining an appropriate research approach.

Coming from diverse backgrounds in Indigenous communities, engineering education, academia, and industry, the stakeholders in Indigenous engineering and engineering education may be imagined as navigating a cultural interface (Nakata, 2007) between dominant engineering and Indigenous engineering worldviews. The complexity of this interface necessitates a research process that prioritises Indigenous leadership while demonstrating valid scholarship. Smith (1999/2021) emphasises that the research process may be “far more important than the outcome” (p. 149). This paper describes a research approach for a team of Indigenous and non-Indigenous academics to respectfully connect with stakeholders in Indigenous engineering, including Indigenous communities, academia, industry, and engineering education. The outlined research process will guide our future work to identify threshold learning elements essential to Indigenous engineering education for all engineering students.

Researcher Positionality Statements

AG is a Chinese American woman adopted by working middle class lesbian mothers. Her privileged educational background in biomedical engineering and violin performance, alongside experiences as a member of multiple marginalized groups, have shaped her research approach and commitment to education and social justice. AG positions herself as an ally in reconciliation.

JKP was born in Switzerland to a Croatian father and Slovenian mother and came to Australia at an early age as a refugee. Her education spans many disciplines including microbiology, educational studies and analytical psychology, all of which have informed her transdisciplinary work in higher education. She has spent the past ten years engaging with Indigenous Australians to transform the engineering curriculum.

CC is a Worimi man with an interest in structural engineering and a desire to encourage more Indigenous Australians to enter the engineering workforce. He has worked in manufacturing, construction, structural design, and academia. CC is actively engaged with Traditional Owners in embedding Indigenous knowledges and perspectives in engineering curriculum.

SJB is a Ngemba computer science practitioner, researcher, and educator. SJB grew up on Country in and around very remote Ngemba Aboriginal communities of Brewarrina and Gongolgon NSW, from before the 1967 referendum. Born to a Ngemba father and mother of Irish

descent, and to transgenerational education and other policy complexities, SJB never completed her schooling. Now with the privilege of three degrees across the computer science discipline, SJB positions herself at the cultural interface of engineering and computer science tertiary education and her Ngemba values, perspectives, pedagogy, and Knowledges.

JL is a wajarri yamaji with 6th-generation Australian-Irish and English ancestry. He has experience in aspects of Indigenous Affairs, including education, cultural heritage, engineering, and infrastructure consulting. JL holds a bachelor's degree in civil and environmental engineering and has lived and worked across remote, regional, and urban areas of Australia. Through culturally appropriate engagement, JL's work focuses on Indigenous Knowledges and perspectives within engineering and the built environment.

SM has multiple generations of Australian ancestors, of English, Scottish and Irish backgrounds. She is qualified in engineering, and is an engineering education researcher. She has lived in regional and urban Australia, and in the UK.

Terminology

Indigenous – First Nations, Aboriginal, or Torres Strait Islander peoples in Australia. We acknowledge this is a contested term, and Indigenous peoples do not belong to one homogenous group. We respectfully use this term as we collaborate with peoples from many First Nations.

Indigenous research paradigm – a research approach guided by Indigenous epistemology, ontology, axiology, and methodology. We use the term 'Indigenous' rather than 'Indigenist' to respect the view that only Indigenous scholars can indigenize (Eaton, 2024) and use an Indigenist paradigm (Rigney, 2001), whereas non-Indigenous scholars may draw upon an Indigenous paradigm and work to decolonise (Chilisa, 2011/2020; Wilson, 2008).

Indigenous engineering Knowledges, perspectives, and value systems – recognition of Traditional Custodians' Knowledges of Country through observance of nature and cultural values that influence Indigenous engineering and enhance engineering education curricula.

Contextualisation of Threshold Concepts

Threshold Concept Characteristics

Threshold concepts (TCs) are understood as *transformative* and *troublesome* learning portals from which students emerge with appreciably transformed perspectives and understanding (Meyer & Land, 2003). While TCs may also be *irreversible* (unforgettable), *bounded* (discipline-specific), and *integrative* (demonstrating interrelatedness), this paper focuses on the *transformative*, *troublesome*, and *reconstitutive* characteristics (Meyer & Land, 2005). We relate the latter TC characteristics to an Indigenous Australian engineering context and provide a rationale for identifying threshold learning in Indigenous Australian engineering.

In developing the TC framework, Meyer and Land (2003) described the *liminal space* as the zone of uncertainty and transformation that a learner enters when encountering a TC. Meyer and Land's conception of a learner's ritualistic journey through the liminal space (2005) stems from anthropologists Victor Turner's and Arnold van Gennep's work on liminality and ritual processes (Turner, 1969; Van Gennep, 1906/2019). The relationship between threshold learning (Rattray, 2023) and ritual described in the TC framework harmonizes with Indigenous perspectives around learning and ceremony (Wilson, 2008). From both perspectives, learning is *transformative*. Learning "leaves an indelible change within the person" (Wilson, 2008, p. 124).

Building on Perkins's (1999) description of knowledge in the constructivist classroom, Meyer and Land (2003) outline various ways TCs may be *troublesome* to understand. Given the contrast between a dominant and an Indigenous engineering worldview, students may encounter "foreign knowledge [that] comes from a perspective which conflicts with [their] own" (Perkins, 1999, p. 10). For instance, concepts of Country and relationality may be entirely foreign to an engineer trained

in objectivity, efficiency, and reducing complex systems to discrete, simplified models.

Learners who cross the liminal space may experience a “repositioning of the self,” due to the *reconstitutive* nature of TCs (Meyer & Land, 2005, p. 374). For threshold learning in Indigenous engineering, reconstitution builds students’ capabilities to value, connect, and interact with Indigenous engineering Knowledges when identifying problems and designing solutions.

Threshold Capability Integrated Theoretical Framework

Integrating the TC framework with Capability Theory (Bowden & Marton, 1998/2003), Baillie et al. (2013) proposed the *Threshold Capability Integrated Theoretical Framework* (TCITF) to highlight threshold capabilities students need to “deal with previously unseen situations in their professional, social, and personal lives” (p. 227). This ability—to develop innovative solutions to current and emerging problems—is a central requirement for professional engineering (Engineers Australia, 2019; National Academy of Engineering, 2004). Given the value of identifying TCs to focus curricula (Baillie et al., 2013; Land et al., 2005), extensive literature defines TCs in various disciplines, including engineering and Indigenous studies (Land et al., 2016; Moodie, 2019).

Threshold Learning in Indigenous Engineering

In the context of Indigenous studies, Page (2014) argued for identification of threshold concepts to better facilitate student-teacher interactions focused on transformative learning. Expanding on this work, Moodie (2019) proposed five TCs in Indigenous studies: *race, Country, relationality, policy, and evidence*. In a pilot study on the relevance of TCs in Indigenous engineering education, Wyllie-Runner et al. (2024) examined case studies of two students’ experiences with Indigenous Knowledge in an engineering course. The study identified elements of Moodie’s proposed Indigenous TCs in the course content; it also found transformative, reconstitutive, troublesome, and integrative TC characteristics in the students’ descriptions of their experiences (Wyllie-Runner et al., 2024). Further work is needed to describe the threshold learning and threshold learning experiences (Rattray, 2023) that students must undergo to transform their understanding of engineering and appreciate both Indigenous and Western perspectives.

The interface between Indigenous engineering and engineering education is itself emergent and liminal. We posit that the TCITF (Baillie et al., 2013), with its emphasis on transformative, troublesome, and reconstitutive learning that prepares students to solve problems in unfamiliar contexts, is an appropriate framework for bridging Indigenous engineering and engineering education worldviews. This paper describes a research approach for collaborating with stakeholders to identify threshold learning in Indigenous Australian engineering.

Stakeholders

To begin identifying threshold learning in Indigenous engineering, we have considered key stakeholders in the research process. Understanding the importance of consulting stakeholders both inside academia and in the broader community (Barradell, 2013), we have grouped these stakeholders into four broad categories: an Indigenous community of interest, academic institutions, industry organisations, and accreditation bodies (Figure 1). Rather than being geographically based, the identified Indigenous ‘community of interest’ (Smith, 1999/2021, p. 148) involves Indigenous peoples interested in transforming curricula to value Indigenous engineering Knowledges. In this Indigenous community of interest, we will connect with Indigenous Elders, Knowledge holders, and engineers in industry who understand community goals in engineering and have cultural responsibilities to engineered landscapes. Within academic institutions, we will interview educators whose courses embed Indigenous engineering Knowledges. We will also interview students who have taken such courses. This will enable us to understand the student perspective on learning they found transformative and troublesome. We will also consult representatives from Engineers Australia (the engineering curriculum accreditor in Australia) to

align key engineering competencies with threshold learning in Indigenous engineering.

Although these are the initial stakeholder groups we have identified, we recognise that additional groups may emerge during consultations. This 'relational recruitment' approach (Bell, 2015, p. 72) may identify additional categories. We will include representatives from all stakeholder groups.

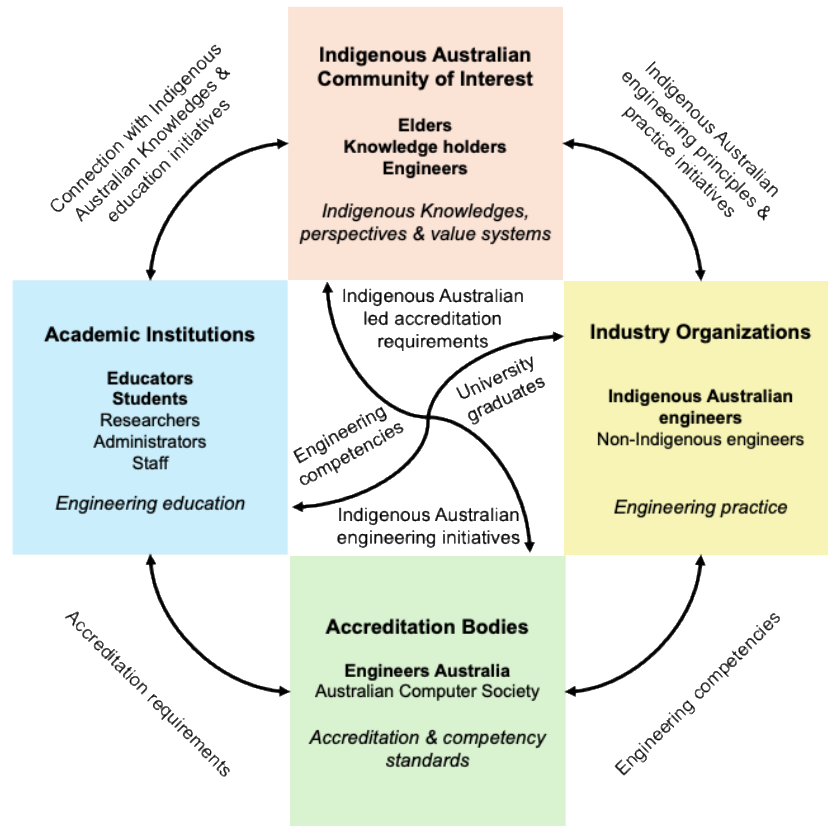


Figure 1: Stakeholders Indigenous Engineering and Engineering Education. Bold text denotes which stakeholders within each broad group we plan to consult during the initial research stages.

Research Design Process

Before connecting with stakeholders in Indigenous engineering and engineering education, we describe a research approach for responsible engagement. We aim to enable stakeholders to “communicate their experiences from their frames of reference” (Chilisa, 2011/2020, p. 47). In research with Indigenous Knowledges, it is crucial to connect and relate “with Indigenous standpoints and methodologies and decolonising methodologies where appropriate” (Baynyi, 2020, p. 18). We draw upon an Indigenous paradigm to outline an integrative (Chilisa, 2011/2020, p. 30), emergent research approach.

Indigenous Research Paradigm

Indigenous scholars have practiced Indigenous research processes, paradigms, and methodologies for millennia and have been articulating and translating these Knowledges for Western academic audiences for decades. Within engineering, however, published literature rarely describes or applies Indigenous research processes. To meaningfully weave Indigenous engineering perspectives alongside engineering education, the research process must be led by Indigenous stakeholders and respect Indigenous research methodologies.

While some qualitative methods texts nest Indigenous perspectives within pragmatic or transformative paradigms (Creswell & Creswell, 2017/2023; Denzin et al., 1994/2024), others elevate an Indigenous paradigm to stand independently alongside other methods of inquiry (Chilisa, 2011/2020; Wilson, 2008). In our research process, we embrace the latter approach. We

recognise that ethical connection with Indigenous engineers, Knowledge Holders, and communities requires consideration of an Indigenous research paradigm (Baynyi, 2020).

Some essential epistemological, ontological, axiological, and methodological tenets of an Indigenous research paradigm are outlined in Table 1. In describing epistemological egalitarianism, Wilson notes that it is culturally unacceptable to criticise and judge whether another person’s knowledge is valid, because it is impossible to fully know their perspective and relationships (Wilson, 2008). Each perspective must be respected. In relational ontology, reality is defined by relationships (Wilson, 2008): relationships between humans, between humans and nature, and between the living and non-living (Chilisa, 2011/2020). With respect to axiology, relational accountability requires that the relationships are respected, as well as accurately and holistically represented in the research (Chilisa, 2011/2020; Wilson, 2008). Integrating epistemological egalitarianism, relational ontology, and relational accountability, Indigenous methodologies require respectful relationality and may incorporate decolonising methods.

Table 1: Basic Beliefs Central to an Indigenous Research Paradigm

Basic Beliefs	Indigenous Research Paradigm
Epistemology (Ways of knowing)	'Epistemological egalitarianism' (Wilson, 2008, p. 134)
Ontology (Ways of being)	Relational ontology (Chilisa, 2011/2020, p. 103; Wilson, 2008, p. 73)
Axiology (Ways of valuing)	Relational accountability (Chilisa, 2011/2020, p. 24; Wilson, 2008, p. 77)
Methodology (Ways of doing)	Methods must adhere to and build on respectful relationality (Wilson, 2008, p. 77). Decolonising methodologies may be utilized (Chilisa, 2011/2020, p. 25).

Based on our understanding of an Indigenous research paradigm and our research context, we present a research design that prioritises ongoing connection with Indigenous leaders throughout the research process and relationally accountable ethics practices (see Figure 2).

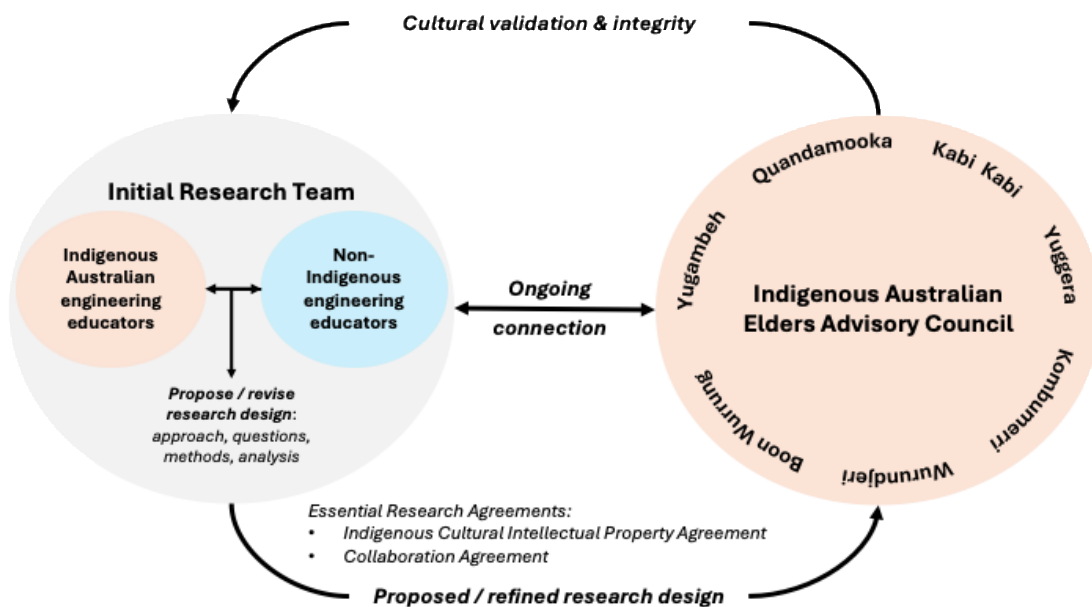


Figure 2: Research Design Process with an Indigenous Australian Elders Advisory Council.

Research Approach to Methods

Drawing on Male & Baillie's (2011) methodology for identifying TCs in engineering, we plan to collect data in two phases: the diverging interview phase and the integrating focus group phase. During the diverging phase, we will interview stakeholders from each of the groups identified in

Figure 1. From these interviews, we will develop a preliminary threshold learning 'inventory' (Male & Baillie, 2011, p. 912). During the integrating phase, we will bring together members from each stakeholder group to negotiate and come to consensus around the threshold learning inventory.

An Indigenous research paradigm requires participant input throughout the research process, including the research design. Initial discussions with stakeholders are crucial in determining the methods for data collection and analysis. Respecting that this research must prioritise Indigenous leadership, we will connect with an Indigenous Elders advisory council (Figure 2). The Indigenous research team members will relationally recruit the Elders from the lands where the research and student learning activities take place. This Elders advisory council will provide cultural validation and integrity throughout the research through ongoing connection with the initial research team.

Limitations

One limitation stems from researcher positionality and relationality. As a non-Indigenous migrant who first travelled to Australia in February 2024, the first author has limited relationships with Indigenous and Australian peoples and communities. Outsider positionality may present both advantages and disadvantages, depending on research and community context (Holmes, 2020; Secules et al., 2021). In Indigenous research, "bonds or relationships with others in the community" are vital throughout the research (Wilson, 2008, p. 81) Given this, the first author is focusing on building relationships with community and Country throughout the research.

We also acknowledge that, although the three Indigenous co-authors provide Indigenous leadership throughout the research design, the initial threshold concepts framework was developed by non-Indigenous researchers (Meyer & Land, 2003) and thus informed by Western research perspectives. Indigenous leadership is an ethical requirement "both in the 'why' as well as the 'how' of research, from conceptualisation to communication of' Indigenous research (Baynyi, 2020, p. 17). This paper describes and practices a research approach that both respects Indigenous leadership and demonstrates valid scholarship. As the project proceeds, we will connect with more Indigenous Elders, Knowledge holders, and engineers to continue refining the research design based on their guidance, thereby prioritising Indigenous leadership (Figure 2).

Significance and Future Work

Engineering education must prepare students to account for social, cultural, and environmental contexts when developing appropriate solutions. Indigenous engineering Knowledges are essential for developing this competency in all engineering students. For Australian universities to uphold their commitments to embedding Indigenous engineering Knowledges in the curricula (Universities Australia, 2022), strategies are needed to transform current engineering education.

To support this curriculum transformation, we draw on the Threshold Capability Integrated Theoretical Framework to illuminate elements of Indigenous engineering Knowledges that all engineering students must understand. Moodie (2019) has outlined threshold concepts in Indigenous studies and Wyllie-Runner et al. (2024) argue that the threshold concept framework is appropriate for Indigenous engineering and engineering education. However, threshold learning specific to Indigenous Australian engineering has not yet been thoroughly described.

Informed by the research approach outlined in this paper, our future work will develop a threshold learning framework with experiences and assessment methods to facilitate student learning. This framework will provide guidance on how to weave Indigenous engineering Knowledges alongside engineering education. Such guidance is crucial for engineering educators struggling with this curriculum transformation process (Goldfinch et al., 2017). Stakeholders may draw upon the framework to facilitate sustained connection as well as meaningful, relevant, and aligned contributions by Indigenous Australian Elders and Knowledge holders. Additionally, this framework will support capacity building with Indigenous Australian Knowledge holders in relation to both Indigenous Knowledges and dominant Western perspectives in engineering.

Positioned at an interface between contrasting worldviews, this research must respect both

Indigenous engineering and engineering education perspectives. Our research approach highlights the importance of designing research with stakeholders in Indigenous engineering and engineering education to prioritise both Indigenous leadership and valid scholarship. Designed to emphasise these key elements, our research works toward engineering education transformation to ensure emerging engineers understand and appreciate Indigenous engineering Knowledges.

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