

Indigenising the Australian University Science Curriculum

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DECLARATION

I declare that this thesis, as a whole or in parts, has not been submitted for a higher degree to any other university or institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

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This thesis is formatted as a manuscript for submission to the *Journal AlterNative*, with some exceptions to meet the requirements of the Macquarie University. This includes the requirement of an abstract of 200 words, 2cm margins, 1.5x line spacing, figures and tables embedded within the text.

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Candidate's statement about the impact of COVID-19 changes on the thesis

Dear Examiner,

Many of our HDR candidates have had to make changes to their research due to the impact of COVID-19. Below you will find a statement from the candidate, approved by their Supervisory Panel, that indicates how their original research plan has been affected by COVID-19 restrictions. Relevant ongoing restrictions in place caused by COVID-19 will also be detailed by the candidate.

Candidate's Statement

The original aim of the research was to review learning on Country programs with a focus on the Wuyagiba Bush Study Hub, located in Wuyagiba, South-East Arnhem Land. Unfortunately, due to strict border restrictions and the vulnerability of First Nations Peoples during the outbreak of COVID-19 I was unable to complete this project.

Abstract

In 2017, Universities Australia committed to the first national Indigenous Strategy which called for universities to be more inclusive, representative, and respectful of Indigenous Peoples and their knowledges (Universities Australia, 2017). Central to the strategy was teaching Indigenous knowledges and perspectives in curricula. To gauge how Australian university science faculties have responded to this strategy, this study embarked on a desktop review of Indigenous Science units across all university faculties, and further explored, through primary research, pedagogies and content of units in the Science Faculties. The desktop review of Indigenous Science units across all Faculties revealed that there was a total of 72 units, with only 19 of these units in the discipline of science. Of these units, 12 convenors (only four Indigenous) participated in an online questionnaire and eight unit convenors (three Indigenous) and a First Nations Elder participated in online interviews. The results provided key recommendations including the need to develop frameworks and policies that guide educators on how to include, teach and create appropriate assessment tasks and First Nations Community engagement.

Terminology

In this research project, the term 'Indigenous' is used to refer to First Nations Peoples, in Australia this refers to Aboriginal and Torres Strait Islander Peoples. The term 'Indigenous' is often used in educational policies and practice to describe Australia's First Nations Peoples; however, this collective definition ignores the many distinct and unique Aboriginal and Torres Strait Islander Nations, clan groups, ancestral and kinship relationships, and customary practices. The terms Indigenous and First Nations is used interchangeably throughout my thesis, however reference to Aboriginal and Torres Strait Islander Peoples Country and clan groups will be acknowledged where relevant.

I have interwoven Wiradjuri language throughout my thesis as a way of cultural expression and the importance of cultural revitalisation in maintaining our language. Whilst I have provided the English translation in the main text, a list of these terms is provided below.

Wiradjuri Language Words

- baladhu - am
- bangalang - autumn,
- dhandhanbiyang - winter
- gadyil – bowls
- gana - doing
- garra - being
- garru - magpie
- gulaman - coolamon
- gulbhana - knowing
- marga – shield
- milawa – Murray River
- murrin – canoe
- ngadiyinbuladhi - from
- ngurambang - Country
- ngurruwigarra – seeing
- wudhabarbidyabu gulbalaabu - listen deeply
- yalbilinya - learn
- yarraga - summer
- yarran - Red River Gums
- yarrowulay - Red Gum blossoms
- yinna - Woman
- yirabang - spring
- yuwin – name

Chapter 1: Indigenous Standpoint

1.1 Conceptual Framework - Indigenist Relational Responsive Standpoint

I draw upon on my standpoint as a Wiradjuri *yinna* (woman), and the positionality and relationality of my cultural identity as a researcher in this study. My position is informed by a collective consciousness of social and cultural knowledges, politics, and history (Menzel & Cameron, 2021). I have conducted my research using a both-ways approach where I have used Western scientific survey techniques that are replicable and provide quantitative and qualitative data, in combination with Indigenous yarning methodologies for Indigenous interview participants. To interpret the data, I drew on my Wiradjuri positionality and priorities with a focus on identifying ways that Indigenous science units can be improved to enhance Indigenous content, pedagogies, and assessments. As such, I took a relational responsive standpoint incorporating Indigenous philosophies, epistemology, ontology, and research methodologies in my research practice (Yunkaporta & Shillingsworth, 2020).

Using Indigenous methodologies provides an opportunity to challenge the Western scientific approaches to research from the focus of objects or subjects to focus on the relationships between people and place (Tuck & McKenzie, 2015). This approach makes room for the inclusion of Indigenous cultural and spiritual ways of knowing to guide and shape research in rigorous ways (Wilson, 2008). I am a daughter, sister, mother and aunty and my research is always going to be from my perspective as a First Nations Woman. I consider my thesis as kin, incorporating the relationality of Country, kinship and story expressed through Indigenous ways of knowing (Bawaka & Suchet-Pearson et al, 2016; Martin, 2008; Tuck and McKenzie, 2015; Wilson, 2008; Tynan, 2020). I also draw on Aileen Moreton-Robinson's *Indigenous Women's Standpoint* theory, which identifies the intersecting oppressions of Indigeneity and womanhood which reflects my positionality (2013). I also acknowledge my non-Aboriginal family and understand how my mixed heritage has allowed me to walk within both worlds. Hence, I draw on the work of Martin Nakata who described the intersection of these two knowledge systems as the cultural interface theory (2002). Nakata (2002) describes this as 'the place where we live, learn and are active agents in our own lives' reiterating the interconnecting realities at the intersection of Indigenous and Western knowledge systems and walking in both worlds (p.28).

1.2 The Cultural Interface – Yarran (Red River Gum)

I draw on Indigenous theories and research practice through my connection to Country, my identity as a Wiradjuri yinna, including Wiradjuri language and cultural practices of art and storytelling to interpret my research. I am a freshwater woman whose ancestors lived and thrived along the Murray River in Albury, NSW, the largest river system in Australia. The Murray River is nestled in between the Red Gum Forests leading up to the meandering mountains and hills. The Red River Gum, *Eucalyptus camaldulensis*, is a riparian tree growing along the riverbank, it has a wide trunk covered in smooth creamy coloured bark that extends to form numerous overhanging branches with long curvaceous green leaves. It is known for its ability to withstand both flooding and periods of drought, speaking to its strength and resilience (Bacon et. al., 1993). During spring and summer, white flowers bloom and produce sweet nectar that attracts many native birds and bees. This tree can live from 500 to 1000 years old and if you were to walk by the river and sit under one of the old large red river gums, if you look closely, you will see the branches begin to sway and the leaves begin to rustle, dancing majestically in the wind like a choreographed performance, but if you listen deeply, you will hear, the songs they sing and the stories they tell.

The bark from the *Yarran* (Red River Gum) was used by my ancestors to make *murrin* (canoes), *gulaman's* (coolamons), *gadyil* (bowls) and *marga* (shields). This tree was not only used to make tools, it, was also used for medicinal purposes, the leaves are soaked and steamed, and the vapour is inhaled to help relieve the symptoms of coughs and colds. The bark also produces a gum that contains antibacterial properties and is applied to heal braises, cuts and wounds and to tan animal skins. However, this tree also has other cultural significance through its connection to Country and its ecological and environmental impacts of the health and vitality of *Milawa*, the Murray River System.

In my thesis I use *Yarran* as an analogy of the cultural interface; as a tree of knowledge where First Nations and Western scientific knowledge systems interconnect to form new growth, new knowledge. First Nations knowledges are grounded through Indigenous ways of *gulbhana* (knowing), *ngurruwigarra* (seeing), *gana* (doing) and *garra* (being) and are the seeds of knowledge production. Knowledge is expressed in art, song, story, dance, law, lore, and our kinship structures which intertwine to form the root system of cultural knowledge. These knowledges are embodied through our social roles and responsibilities to care for Country (Land, Sea, and Sky) and one another and form the trunk of the tree.

The trunk then narrows into an overhanging canopy of branches, which represent the way Western Science separates science into disciplines. The *yarrowulay* (Red Gum blossom) act as an ecological indicator for spring and symbolise where these two-knowledge systems interconnect representing the change, growth, and formation of new knowledge (See Figure 1).

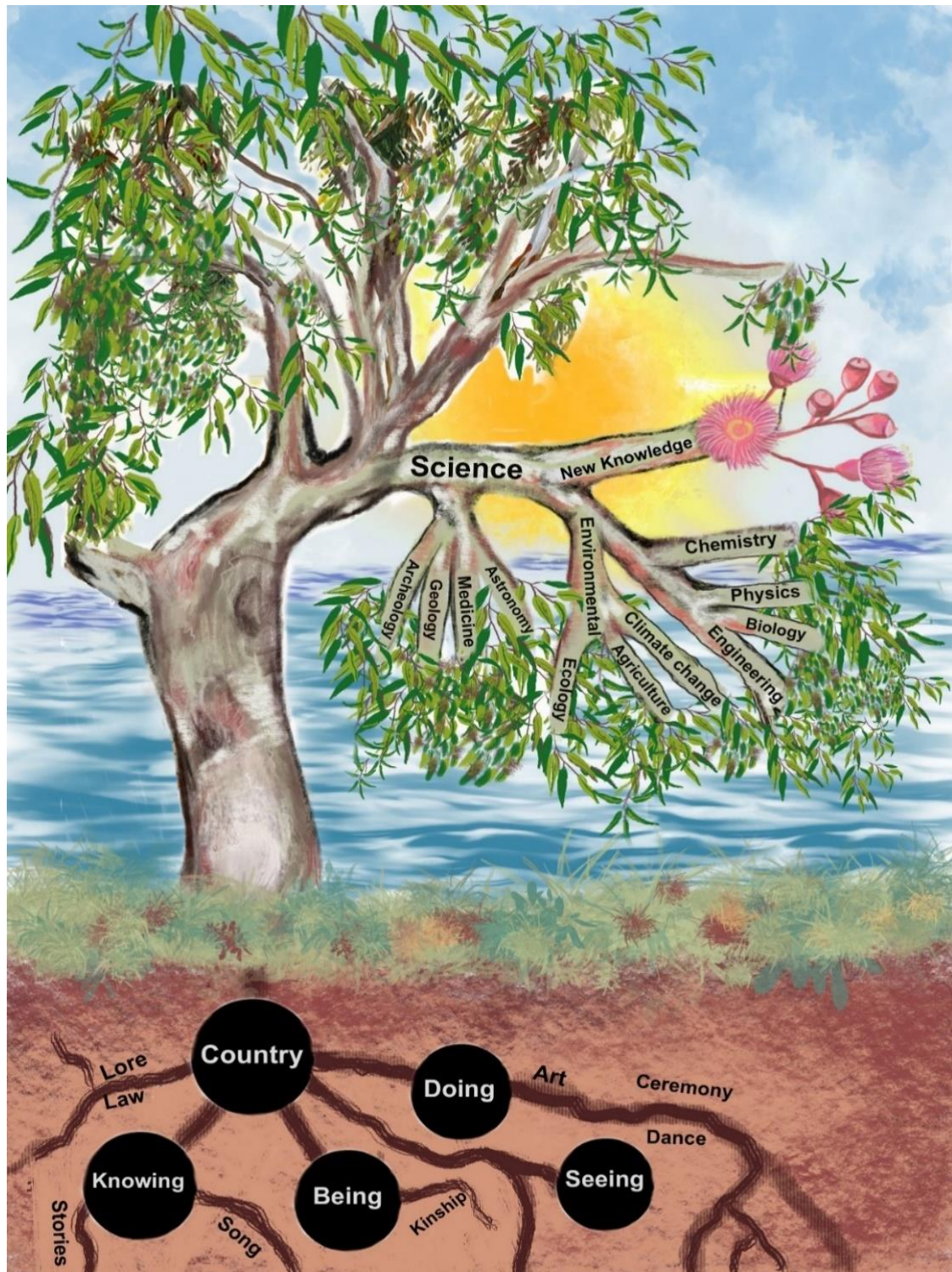


Figure 1: *Yarran* (Red River Gum) – Cultural Interface theory; the intersection of First Nations Peoples knowledges and Western Science. Artist: Renee Cawthorne

This theory is grounded at the cultural interface, the interception of Western and Indigenous knowledge systems and it is within this space that one can begin to deconstruct and reconstruct knowledges to develop a broader and deeper understanding and develop new and innovative practices that connect Indigenous and Western epistemologies and ontologies (ways of knowing and doing). This is the space I aimed to work in through my thesis.

1.3 Project Standpoint

My research is rooted in my personal journey of coming to know; to know myself as a First Nations mother, daughter and aunty and as a cultural and science educator. As an Indigenous science educator, I am constantly working through the complexities of Indigenous and Western knowledge systems and crossing the cultural interface to create a deeper understanding about the world around us for a shared and sustainable future. Underpinning this project is the right to quality education; to create an appreciation of cultural diversity, and of First Nations Peoples contribution to sustainable development and conservation practices. More importantly, Indigenous education is vital for the continuance and celebration of First Nations Peoples knowledges and customary practices. As described in the United Nations Declaration of the Rights of Indigenous Peoples (2007) and Sustainable Development Goals (2015), this is founded in the rights to self-determination, the right to express who we are, our knowledges, our histories and cultural sovereignty; the right to restore, maintain, develop, control, and protect First Nations Peoples cultural and intellectual property. Allowing or enabling these rights of Indigenous Peoples is a national priority as identified in the Australian Government's *Inspiring Australia* Strategy (Australian Government, 2013) and *Closing the Gap* Policy (Australian Government, 2017), the Uluru statement from the heart (Lowitja Institute, 2022), and university Indigenous Strategies and Reconciliation Action Plans (Universities Australia, 2017).

Chapter 2: Introduction

2.1 Indigenous Science

In a contemporary sense, Indigenous knowledge originates from the traditional way of life of Indigenous Peoples and reflects an appreciation and deep understanding of the human place in relation to the universe (Legat, 1991). However, it is important to note that these knowledges are not static, they are living, evolving bodies of cultural knowledge that are

influenced by the historical, social, and political positioning of First Nations Peoples realities. The United Nations Educational, Scientific and Cultural Organisation [UNESCO] describes Indigenous knowledge as the local understandings, skills and philosophies developed by societies over time through a deep association and interaction with their natural surroundings (UNESCO, 2021). This knowledge also encompasses languages, systems of classification, resource use practices, social interactions, rituals, and spiritual beliefs. However, Battiste and Youngblood (2000) caution using a global definition to describe Indigenous knowledges as it creates an understanding that knowledge is homogenous across all First Nations People and ignores the diverse knowledge systems that are unique to the local place, people, traditions, culture, and environment in which they are practiced (Synot et al., 2021). For Australia's First Nations Peoples cultural knowledges are centralised in place and founded upon our spiritual connections, social roles, and responsibilities to care for Country and one another and is expressed through languages, narratives, arts and performance, kinship structures, totemic relationships, customs, beliefs, laws, lore, customary practices, and ceremony. These knowledges are communal, and the sharing of knowledge is based on a system of cultural relationships and responsibilities that have been practiced since time immemorial. First Nations People's knowledges are not owned by any one person and access to this knowledge is governed by social structures and strict cultural protocols for the dissemination of this knowledge; to whom it is taught, when it is taught, what is taught and how it is taught. This can depend on several factors such as your clan membership, age, gender, and kinship relationships. Some knowledge can also be restricted to certain Peoples and contexts such as men's or women's business or as secret or sacred information (Morphy, 2008).

Australia's First Nations Peoples have the oldest living, continuous culture in the world, we are the world's first scientists, with a myriad of knowledges acquired through the intergenerational accumulation of observations and tested hypothesis developed through cultural knowledge systems and customary practices that have evolved over millennia (Cajete, 1999; Berkes et al., 2000). Like Western science, Indigenous knowledges apply methods to systematically build an understanding of the world around us, based on evidence acquired through generations of observation, pattern recognition, logic, prediction, scepticism and deduction through critical, rational, receptive thinking and application of expertise to sustainably manage, sustain, and conserve a particular place or landscape, in Australia, known as Country. Indigenous knowledges are multidisciplinary, and encompass scientific understandings from astronomy, physics, chemistry, biology,

environmental and ecological sciences, medicine, and other social science disciplines. These knowledges are interconnected and include the tangible and intangible elements such as spirituality, which can often be questioned, dismissed, or referred to as mythical by Western science because it can't be 'objectively' measured as a phenomenon. Hence, Western Science has excluded Indigenous views because Indigenous knowledges are identified as intrinsically connected to the spiritual which inform Indigenous worldviews. Indigenous knowledges become fractured and fragmented when they are viewed through a paradigm of measurement, classification, and nomenclature embedded in the frameworks and structures of Western Science. In this way science reduces Indigenous knowledge to incorporate it into the 'scientific' method. However, I like many others such as Berkes et al (1994), Aikenhead & Ogawa (2007) consider Indigenous knowledges as a distinct form of science, built up over millennia of observations, trial and error and testing.

The definition of what constitutes science has been dominated by Western world views, which often inadequately understand the epistemology, diversity and complexities of Indigenous knowledges and customary practices (Miller et al., 2008; Zidny et al., 2020). Furthermore, Western science has often romanticised, misappropriated, devalued, disregarded, or exploited First Nations Peoples and their knowledges often with little or no benefits going back to the community (Janke, 2005; Turner, 2018; Krakouer, 2015). There has been a plethora of studies on the differences between Western or Eurocentric science and Indigenous knowledges and one theme is apparent, we must not try and translate or validate Indigenous knowledges using the rigid, streamlined, frameworks, language, and structures embedded in Western science (Nakata, 2004). It is time to shift the paradigm, to recognise, respect and value First Nations Peoples scientific knowledges and practices and gain a broader perspective and deeper understanding of the world around us.

2.2 Indigenising Science

The term 'Indigenising Science' involves the disruption and deconstruction of institutions, systems, processes, and policies embedded in science knowledge frameworks, which continue to invalidate Indigenous knowledges (Tsosie & Claw, 2020). It comprises questioning the role of science as a cultural, social, and political construct in Australia's history, including the role of science in colonisation and its contribution towards the inequalities and injustices that First Nations Peoples continue to experience today. Indigenising science shifts and redistributes the power back to First Nations Peoples through recognising our epistemology, ontologies,

axiology, pedagogies and praxeology through Indigenous-led initiatives, research, projects, partnerships, and engagement that amplifies Indigenous voices and promotes the determination and advocacy of First Nations Peoples (UNDRIP, 2015). This approach goes beyond deficit models; towards the constructive inclusion of Indigenous knowledges alongside Western science and embedding Indigenous cultural capabilities in the curriculum. It recognises and legitimises Indigenous knowledges as a science within its own right. This is supported by Martin (2008) who argues that “Aboriginal knowledges should be recognised as a valid body of knowledge and not treated as an ‘add on’ to western scientific Knowledge” (p.56). Indigenising science is a means and opportunity to transform learning, teaching, research, policy, and practice in ways that critically interrogate, evaluate, and even unlearn the coloniality that is embedded in science education.

Decolonising methodologies are about including Indigenous knowledges through deconstructing the colonial structures and challenging the ideologies that privilege western knowledge (Mackinlay, 2014; Hendrick & Young, 2017; Le Grange, 2016; Smith, 2005). For non-First Nations Peoples this involves examining and challenging one’s views, opinions, beliefs, prejudicial and unconscious bias that they have about First Nations Peoples and their cultures (Mackinlay, 2014; Race et al., 2022). Whilst decolonisation informs processes of Indigenisation, Indigenising the curricula involves a fundamental shift in the pedagogical approaches for including Indigenous knowledges and perspectives. Indigenisation involves the inclusion of Indigenous knowledges through the values, beliefs and experiences that inform the cultural identity of First Nations Peoples. This involves meaningful engagement with First Nations Peoples to develop culturally appropriate educational policy and practices that shape and inform universities core business processes including student engagement, learning and teaching, research and employment (Perry & Holt, 2018).

First Nations education in Australia is entrenched in deficit approaches to improving participation, engagement and learning outcomes for First Nations Peoples. This plague of deficit discourses within education settings can transfer onto Indigenous students as the failings of the education systems attribute blame to First Nations Peoples. Griffin and Trudgett (2018) note the impacts of this practice, “generating a negative self-image, low self-esteem and disengagement from education altogether” (p.1). Indigenising science provides an opportunity to convert science and education policy, towards a strength-based

approach that improves education outcomes for First Nations Students in Science. This aims to shift the historical discourse of the marginalisation of First Nations Peoples in academia and the epistemological erasure of our cultural knowledge systems (Rich, 2012). This involves restructuring education policy and practice making institutions consciously reflect on; what they believe to be factual, valid and authoritative knowledge, how these knowledges and perspectives are conveyed to students, and the impact that it has on their perceptions of, and interactions with First Nations Peoples.

Indigenising the curriculum is an initiative for universities to be more inclusive, representative, and respectful of Indigenous Peoples and their knowledges. Although, Indigenising the curriculum was first proposed in the 1990, it was not until 2007 with the recommendations from the Indigenous Higher Education Advisory committee (IHEAC), the ministers Advisory committee and Universities Australia to develop a cultural competency framework that this movement gained momentum (Hill & Nolan, 2011). This was followed by recommendations in the Behrendt review (2012) and the development of Reconciliation Action Plans and Indigenous strategies in Australian universities. These policies outline a plan for what universities intends to do, to promote and enact reconciliation with Australia's First Nations Peoples (Behrendt et al., 2012). A major focus of these strategies has been to increase the participation and engagement of universities with First Nations Peoples through integrating Indigenous knowledges and perspectives into the curriculum. Whilst there is a plethora of research that focuses on education pedagogies for teaching First Nations students in Australia (Baynes, 2016; Booth, 2014; Harrison, 2019; Yunkaporta, 2009). There is little research on pedagogical frameworks for teaching Indigenous knowledges and perspectives. This raises concerns, as to what knowledges and perspectives are being conveyed to students and how they are represented and embedded within the learning space.

2.3 Indigegogy

Indigegogy is a term first coined by Opaskwayak Cree Nation Elder Stan Wilson, as an Indigenous pedagogical approach to education for First Nations Peoples (Wilson & Schellhammer, 2021). This is expressed through an Indigenist paradigm, which recognises that we are all related; 'the people, plants, animals, rocks, the air we breathe, the constellations we see, the waterways that sustains our life, and the soil on which we tread' (Wilson & Schellhammer, 2021 p.100). This approach does not simply mean taking university students off campus, but rather embodies a deeper concept of learning, using

land as text and students reading Country, interpreting, and rationalising their own meaning of their observations and experiences (Wilson & Schellhammer, 2021). Indigegogy involves contextualising knowledge through the multiple dimensions and interconnected relationships embedded and learnt through the experiences and teachings of Country or place, and by our Elders, and knowledge holders (Cameron, 2022). Australia's First Nations Peoples have the oldest education system in the world, and Country is our teacher, we *wudhabarbidyabu gulbalaabu* (listen deeply) and *yalbilinya* (learn) on, from and through *ngurambang* (Country). Country is our classroom and, our education system is our knowledge systems, learning through ways of *gulbhana* (knowing), *ngurruwigarra* (seeing), *gana* (doing) and *garra* (being). Indigegogy engages localised Indigenous knowledges, perspectives and practices that offer new diverse and alternative ways of learning and knowing. However, it is important to note that Indigenous knowledges and customary practices are localised and taking specific examples of Indigenous ways of learning and suggesting that it is applicable to all Indigenous Peoples is problematic as it homogenises Indigenous Peoples as a collective group ignoring the unique and diverse ways that one comes to know (Nakata et al., 2012; Battiste, 2002; Santoro et al., 2011).

Australia has a monocultural education system with a conventional teaching and learning framework where learning environments are often confined to a classroom with the traditional lecture and textbook model (Horsley, 2012). This is an outdated approach that has been proven to be ineffective for diverse learning styles and multicultural learners (Horsley, 2012). Moreover, the confinement of knowledge within a classroom takes away the relationality of its context in the 'real' world and discourages a connection to people and place. This is emphasised in numerous educational pedagogies such as place based learning (Mackinlay & Barney, 2014; Gruenewald, 2008; Harrison & Greenfield, 2011; Mills et al., 2021; Woollorton et al., 2022), outdoor, environmental, and sustainability education (Demssie et al., 2020; Lozano et al., 2017; Thomas 2018; Thomas, 2019; Evans & Acton, 2021), learning on Country (Fogarty, 2010; Spillman, 2017, Harrison et al., 2017; Jackson-Barrett & Lee-Hammond, 2018; St John & Edwards-Vandenhoeck, 2022), and inquiry based and experiential learning (Bates, 2019; Blessinger & Carfora, 2015; Fogarty & Schwab, 2013; Hastuti et al., 2019; Kidman & Casinader, 2017; Mackinlay & Barney, 2014; Wildcat et al., 2014; Acton 2017) where Country is 'teacher'. Indigenised approaches to education can promote cultural exchange, shared understandings and belonging through connectedness and kinship relationships providing new ways of

knowing, seeing and experiencing the world (Baldwin et al., 2013; Langton & Ma Rhea, 2009; Reid & Reid, 2019).

2.4 Indigenous Pedagogies

Indigenising the curriculum involves teaching Indigenous knowledges through Indigenous pedagogies; ways of *gulbhana*, *ngurruwigarra*, *gana* and *garra* embedded in the teachings of Country, Elders and cultural knowledge holders. The *8-ways pedagogy* provides an Indigenous lens to educational practice through eight interconnected methods including story sharing, learning maps, symbols and images, land links, non-verbal communication, community links, non-linear, and deconstruct/reconstruct to teach Indigenous knowledges and perspectives (Yunkaporta, 2009). Traditional First Nations teaching and learning processes use experience and personal interaction focused on stories that we share, about the Dreaming (creation), our ancestors, Country, and kinship. Through learning maps, learning is visualised through non-verbal and artistic expressions, using symbols, imagery and body movements which conveys connection to Country and local community to deconstruct and reconstruct knowledge, this process is interconnected continual and evolving. The 8 ways pedagogy provides examples of the various ways one can learn by interconnecting ideas to develop deeper meaning and a holistic understanding of the world around us. Whilst Yunkaporta's (2009) 8-ways was created with a New South Wales (NSW) primary and high school context, its applicability can be extended beyond, into higher education. It is recommended by the NSW Department of Education, Australian Institute for Teaching and School Leadership (AITSL) and Australian Council Deans of Science as a useful resource for university academics and educators wanting to include and teach Indigenous science knowledges (Australian Institute for Teaching and School Leadership, 2017; Australian Council of Deans Science, 2022).

Buxton (2020) noted that educators don't often use the 8 ways pedagogy in a way that promotes an interconnected understanding of Indigenous knowledges and perspectives. Yunkaporta (2009) suggested that this can be overcome by recognising Indigenous processes of knowledge production rather than Indigenous content. By recognising Indigenous axiology, ontology, epistemology and methodologies that are expressed in the local values, systems, processes and protocols that govern Indigenous knowledges (Yunkaporta, 2009). Dr Ernie Grants framework incorporates a cultural matrix that focuses on six elements: land, language, culture, time, place, and relationships that represent aspects of Indigenous ways of valuing, *gulbhana*, *ngurruwigarra*, *gana* and *garra* that are

embedded in the intangible processes, systems, values, and protocols of First Nations Peoples cultures (Lowe & Yunkaporta, 2013). Utilising this framework with the 8 ways pedagogy provides an opportunity to deepen the understanding of Indigenous knowledges not just by including Indigenous knowledges, but through Indigenous ways of teaching and learning to Indigenise the curricula.

Despite the significant advances in the development of Indigenous pedagogies described. Nakata (2004) argued that attempts to Indigenise the curriculum may present an “impoverished version of Indigenous pedagogy” that does not express the complexity of Indigenous knowledges (p.11). Recognition of these complexities lies within the cultural interface, where there is constant negotiation between Indigenous and western knowledges to identify the places where these systems intersect, interconnect and co-exist to form a deeper and broader understanding, new knowledge, and innovative science practices (Nakata, 2004). This process does not look at the two systems in opposition to each other rather it is a “two-ways” or “both ways” approach to science education, acknowledging the similarities and differences between Indigenous and Western knowledges and seeks different ways to combine these seemingly disparate systems (Ober & bat 2007; Purdie et al., 2011; Wunungmurra, 1989; Marika et al., 1992). Brayboy and Castagno (2008) advocate that students should learn about both Indigenous knowledges and Western science, as both these paradigms are useful and necessary for understanding the complexity of the world around us and imperative to creating a shared and sustainable future.

Viewing Indigenous knowledges through the cultural interface provides an opportunity to breakdown the barriers and challenge the negative stereotypes of First Nations Peoples and their cultural knowledges and practices contributing to student’s critical conscious (Baynes, 2016; Cobern & Loving, 2004; Ladson-Billings, 1995). However, it is crucial that this is done in a way that does not fragment bits and pieces of Indigenous knowledge with existing western knowledge in the curricula or through trying to merge these two systems together. Indigenising the curricula goes beyond tokenistic gestures of decolonising methodologies, and the inclusion of Indigenous knowledges to meaningfully change the systems and processes, to resituate Indigenous epistemologies, ontologies, and customary pedagogies. First Nations Peoples should be actively involved in determining the content, educational practices, pedagogies and have the opportunity to share their experiences and perspectives which are too often unknown, hidden and silenced (Ewen,

et al., 2012; Page et al., 2016) due to ongoing settler colonialism.

2.5 Indigenous Science in Australian University Science Curricula

There is a growing body of literature about the inclusion of Indigenous knowledges in the Australian university curricula (Anning, 2010; Prehn, 2020; McLaughlin, 2013). However, there is little research about the inclusion of Indigenous knowledges within the university science disciplines, including what Indigenous knowledges are taught, how they are taught and the learning outcomes and assessments that demonstrate students understanding of Indigenous science knowledges. Much of the research on the inclusion of Indigenous knowledges stems from faculties outside of the Faculty of Science, such as the faculties/departments of Education (Hair et al., 2012; McLaughlin, 2013; Peralta et al., 2016), Health (Delbridge et al., 2022; Forsyth et al., 2020; Wolfe et al., 2018), Geography (Delbridge et al., 2022; Nursey-bray, 2019), Mathematics (Hughes, 2021; Mousley & Matthews, 2018), and Arts and Humanities (Williamson & Dalal, 2007; Prehn et al., 2020). The literature tends to focus on the challenges academics face when including Indigenous knowledges in curricula and their understanding of Indigenous knowledges as science (Green et al., 2003; Snively & Williams, 2016). McLaughlin and Whatman (2007), maintain that most universities accept that Indigenous knowledges exist, but they have no idea how it relates to western knowledge systems. There is an emerging body of research focusing on the inclusion of Indigenous knowledges in learning outcomes and graduate capabilities in compulsory units to promote student's cultural competence (Harvey & Russel-Mundine, 2019; Page et al., 2019; McLaughlin & Whatman, 2007; Rossingh & Dunbar, 2012). However, little research has been conducted on the methodological and pedagogical approaches educators use to include Indigenous knowledges in the university science curriculum and furthermore, little of this research has been published by First Nations Peoples (however see; Harrison et al, 2017; Bodkin-Andrews, 2013; Nakata, 2007; Rigney, 2001; Yunkaporta, 2009, 2012).

Research has shown that Indigenous knowledges should be done as a stand-alone subject/unit or as specific programs rather than content added into existing units (Kickett et al., 2014) and that knowledge should be implemented through; scaffolded learning (Michie & Linkson, 1999; Davis, 2015; Lloyd, 2015), reflective learning (Mudaly & Ismail, 2013; Kilada et al., 2021), peer learning (Restoule, 2019), and hands on, experiential learning practices (Overmars, 2010; Santoro et al., 2011; Peralta 2016; Kilada et al., 2021). In

Prehn et al., 2020 study, he mapped the Indigenous content in the Faculty of Arts in Australian Universities and found that most units do not include Indigenous knowledges and perspectives in the learning content. Furthermore, most of these units taught Indigenous knowledges either as an added component to current lessons, as a single lesson within the unit, or through including research published by First Nations Peoples (Prehn et al., 2020). There has been no formal national review and there is limited research about the number of Indigenous science units in Australian universities, and how many of these units are represented within the science disciplines. This presents the need for further research to determine the number of Indigenous Science units in the Faculty/Department of Science in Australian Universities and to investigate the Indigenous knowledges included in the unit, the pedagogical approaches to teaching, learning and assessment and the involvement of First Nations Peoples in the design, development, and delivery of the content.

2.5 Research Questions

This introduction has identified that the inclusion of Indigenous knowledges and perspectives in the Australian university science curriculum can provide opportunities for employment, partnerships, and participation in two-way science transfer for First Nations Peoples and is an important step in decolonising the curriculum and towards reconciliation. This project aims to provide a review of Indigenous science units in Australian Universities to identify appropriate pedagogies for teaching First Nations Peoples scientific knowledges and perspectives including the strengths, challenges, and opportunities of units that already exist. Ultimately, the aim of the research is to provide recommendations for curriculum developers and evidence for Indigenous educational policy development.

As such, my research questions are:

1. In which faculties is Indigenous science taught across Australian universities?
2. What pedagogies are used to teach Indigenous science in Australian university science faculties?
3. What Indigenous science content is taught and how is it assessed in Indigenous science units of Australian university science faculties?
4. How are First Nations Peoples engaged in Indigenous science units?

5. What support and resources are needed for educators wanting to Include Indigenous knowledges in their teaching?

Chapter 3: Methods

3.1 Overview

This study focussed on a comparative review of Australian university Indigenous science units to explore the content, pedagogies and challenges for teaching Indigenous science. A mixed method approach was taken to produce quantitative and qualitative data that aligns with an Indigenist relational responsive approach at the cultural interface (yarran theory). The research included four methods:

1. Desktop review of Australian university Indigenous science units;
2. An online questionnaire with Indigenous science unit convenors from the Faculty/Departments of Science;
3. Semi-structured interviews with unit convenors; and
4. A collaborative yarning methodology to explore First Nations community's involvement in the university partnerships.

3.2 Ethical Considerations

Historically, scientific research has positioned Australia's First Nations Peoples and their knowledges as inferior to other races and knowledge systems (Nakata 2007). Research was often conducted without the consent, consultation, or involvement of the research subjects and very little, if any, resulting material was attributed or repatriated to First Nations communities (Nakata 2007). In a contemporary research environment, there are several ethical policies that are used to attempt in preventing the exploitation of research participants, this also applies to research conducted with First Nations Peoples. Strict guidelines ensure that consultation and consent is sought prior to engagement (Martin & Mirraboopa 2003; Martin, 2008). Research that is conducted with First Nations Peoples in Australia is guided by the 2015 Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) Guidelines for Ethical Research in Australian Indigenous Studies (GERIAS) principles (Aboriginal and Torres Strait Islander Studies, 2015). My research project has been approved by Macquarie University Higher Research Ethic Committee (HREC) number: 11239. All participants in this study have been identified as to provide recognition to their contribution to my research, this is particularly important for First Nations Peoples who have often not been acknowledged in the research in the past.

3.3 Research Methods

3.4 Desktop Review of Indigenous Science Units

A list of Australian Universities was obtained from the Universities Australia website. On each university webpage the terms “Indigenous” AND “Science” were searched using boolean search commands to identify Indigenous Science units. If the search did not reveal any results the term “Indigenous” was used. Although the term First Nations is used throughout this thesis, Australian Government and Education policies refer to Australia's First Nations Peoples as Aboriginal and Torres Strait Islander or Indigenous, therefore First Nations was not used as a search term. Units were selected for further study based on the following criteria:

- The unit was an undergraduate study unit
- The unit contained Indigenous Science content
- The Indigenous science content was not a component of the unit, but made up the whole course

The unit's name, course code, Faculty/Department and unit convenor were recorded on an excel spread sheet.

3.5 Questionnaire

The questionnaire focussed on Indigenous science unit convenors from the Faculties/Departments of Science. These units were identified from the desktop review described above. All the convenors were initially contacted via email to see if they would be interested in participating in the research. The questionnaire focused on the unit content, design and delivery, the engagement of First Nations Community, the challenges, and recommendations for incorporating Indigenous knowledges in the Australian university Science Curricula. The questionnaire was uploaded into LimeSurvey, and a link emailed to unit convenors. The questionnaire comprised of semi-structured open-ended questions as shown below.

Introductory questions

1. What is the name of your “Indigenous science” unit?
2. Why did you give it this name?
3. How long has the course been running?

Content/Unit design and delivery

4. What teaching pedagogies did you use in

- a. the planning and development of learning content and
- b. the assessment tasks??
- 5. How did the unit incorporate Indigenous knowledge?
- 6. What are the Indigenous Science topics/knowledge is covered in the unit?
- 7. How did you identify appropriate Indigenous scientific knowledge?
- 8. Is there a learning on Country component in the unit?
- 9. What are the intended learning outcomes for students?

First Nations community engagement

- 10. Which First Nations Elders, Community members or Organisations were involved in the development of the unit?
- 11. How did you form these relationships?
- 12. What did they contribute to the unit, and how?

Challenges

- 13. Were there any challenges in development and delivery of the unit? And if so, what were they?

Recommendations

- 14. Do you have plans to improve the unit and if so, how?

Other comments

- 15. Do you have any other comments in relation to the unit?

3.6 Interviews with Unit Convenors

At the end of the questionnaire, unit convenors were asked if they would be interested in participating in a more detailed interview about their unit. If they agreed, in accordance with best practice human research ethics, the purpose and use of the interview was discussed with participants, and they were asked to provide written prior informed consent before conducting the interviews (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2015). Questions were semi-structured and open-ended to allow the participants to elaborate on topics as required. The semi-structured interview questions focused on five areas: Content/unit design and delivery; First Nations community engagement; Challenges; Outcomes; and Recommendations. The specific questions asked in these categories are outlined below.

Semi-structured/open-ended interview Questions - Unit Convenors

Content/Unit design and delivery

- 1. What methods did you use to incorporate First Nations Peoples cultural knowledge into the Indigenous science unit?*
- 2. What pedagogical techniques can create a deeper understanding of First Nations Peoples scientific knowledge and customary practices?*

First Nations Community engagement

3. How did you form the relationship with First Nations Elders, Community members or Organisations involved in the project?
4. What are the key methods/components to building a successful partnership between the university and First Nations Peoples?
5. What are the challenges to building successful university and First Nations community partnerships?

Challenges

6. What challenges did you face in design and delivery of the course?
7. What support is needed for educators to engage in Indigenous science?

Outcomes

8. Has there been a review/evaluation of the course? If so, what did it reveal, what were the reported outcomes?

Recommendations

9. What recommendations would you provide to other Universities and First Nations Peoples wanting to teach Indigenous science in their units?

3.7 Yarning with First Nations Cultural Knowledge Holders

Indigenous yarning methodology is a communication technique used by First Nations Peoples to come together through strict protocols of respectful dialogue to discuss sensitive topics in a culturally safe space (Bin-Sallik, 2003). Collaborative yarning has been recognised as an emerging practice in research which provides an opportunity for engagement, the sharing of information and the exploration of different ideas leading to the development of new concepts and deeper learning (Bessarab & Ng'andu, 2010). Interviews with First Nations participants were conducted through collaborative yarning using semi-structured and open-ended questions. The information collected during the

yarning sessions will provide insight into culturally appropriate and relevant educational pedagogy for incorporating Indigenous knowledges into university Science Curricula.

3.8 Yarning Questions for Indigenous Community Members

Introductory questions

1. What's your name and what mob are you from?
2. How did you become involved in the project/partnership?
3. How long have you been involved in the partnership?

Content/unit design and delivery

4. How were you involved in the development and teaching of the unit?
5. Where were the cultural lessons taught?
6. Do you think learning on Country was important for the transfer of cultural knowledge?

University partnership

7. What were the key methods/components to making the partnership between the university and First Nations Peoples successful?

Challenges

8. What were the challenges to building successful university and First Nations community partnerships?
9. What support is needed for First Nations Peoples to engage in Indigenous science?

Recommendations

10. What recommendations would you provide to universities or other First Nations Peoples wanting to teach Indigenous science in their units?

3.9 Data Analysis

This section will present the data analysis techniques for the four research methods identified above.

3.9 Desktop Review of Australian University Indigenous Science Units

The Indigenous Science units (or courses) were analysed and organised into university faculties/departments. The data were uploaded to excel, and graphs were constructed to

display the number of Indigenous Science Units in Universities across Australia and the number of Indigenous Science units across university faculties/departments.

3.10 Online Questionnaire

The online questionnaire responses from LimeSurvey were exported into an excel document. The questionnaire data using quantitative data (from Questions: 1,3,8) was analysed in excel to produce graphs and the qualitative data (Questions: 2,4,6,7,9,10,11, 12,13,14,15; and the Interview transcripts were analysed in NVivo (version 12) using the autocode analysis to identify common themes, key terms, methods, and trends in the data. Auto-codes are autogenerated labels that highlight single words, phrases, or whole paragraphs in segments of interview transcripts that relate to a particular theme (Green et al., 2007). Sometimes, in this sorting process, a word, phrase or paragraph may be attributed to more than one code (Green et al., 2007). However, when auto-code did not reveal the key themes, a manual thematic coding method was conducted by identifying key words, ideas and phrases. To illustrate the topics covered in the Indigenous Science units (From Question 6), I used the online program word.art.com to produce the Word Art tree diagram which allowed for the visual interpretation of information analogous to an 'information tree' and congruous with my thesis yarran concept.

3.11 Interviews

All interviews were recorded and automatically transcribed in zoom. The zoom text data was exported into a word document and manually edited for grammatical and syntax errors. Any information not relating to the research question was deleted. The transcripts were uploaded to NVivo where key themes and ideas were identified by the number of similar responses. I also drew from an Indigenous standpoint to manually select data of interest.

Chapter 4: Results

This chapter presents the key findings of the desktop quantification of Australian university Indigenous science units, followed by a summary of the people who responded to the Unit convenor questionnaire and interviews. I then present a combined qualitative analysis of the questionnaire and interview data to explore the following themes: Indigenous Science Content, Pedagogical Approaches to Teaching Indigenous Knowledges, First Nations Community Engagement, Challenges and Recommendations.

An online questionnaire was completed by twelve-unit convenors of ten Science units in Australian Universities in April 2022 (table 1). Follow up interviews were conducted with eight unit convenors in June 2022. One interview was conducted with First Nations project partner Dharawal Elder Aunty Fran Bodkin in June 2022. All Interviews with First Nations participants were conducted using the research topic yarning method (Bessarab & Ng'andu, 2010). Only one yarning session was conducted with an Indigenous Elder. Four of the Unit convenors were First Nations Peoples and academics formed relationships with two of them to develop the Indigenous Science Unit. Giles was a student at the university, Backhaus and Yasso were employed as academics and Venables was not involved in the development of the unit and had only recently been hired as the unit convenor.

Table 1: Summary of research participants and form of participation

Participant	University	Unit code	First Nations	Q*	I**	Y***
Bodkin	Western Sydney University	300959.1	Yes	No	Yes	Yes
Venables	Western Sydney University	300959.1	Yes	Yes	Yes	Yes
Ziebell	Monash University	SCI2030	No	Yes	Yes	No
Stacey	Charles Darwin University	ENVS317, ENVS517	No	Yes	Yes	No
Giles	Monash University	SCI2030	Yes	No	Yes	Yes
Backhaus	James Cook University	IA1012	Yes	Yes	Yes	Yes
Yasso	Curtin University	NPSC1003	Yes	Yes	No	-
Rohl	Curtin University	NPSC1003	No	Yes	Yes	No
Hamacher	University of Melbourne	PHYC10010	No	Yes	Yes	No
Heckenberg	Curtin University	NPSC1003	No	Yes	No	-
McBurnie	Deakin University	SLE218	No	Yes	Yes	No
Prpic	Melbourne University	MULT30022	No	Yes	No	-

Thomlinson	Australian National University	INDG1002, ENVS2025	No	Yes	No	-
Kennedy	University of New England	ENSC220	Yes	Yes	No	-

* Questionnaire, ** Interview, *** Yarning

4.1 Indigenous Science Content

A search of the Universities Australia online database identified 72 Indigenous Science Units in 23 out of 38 Universities in Australia (Figure 2). The majority of units/courses are offered in Universities in NSW followed by VIC, and WA.

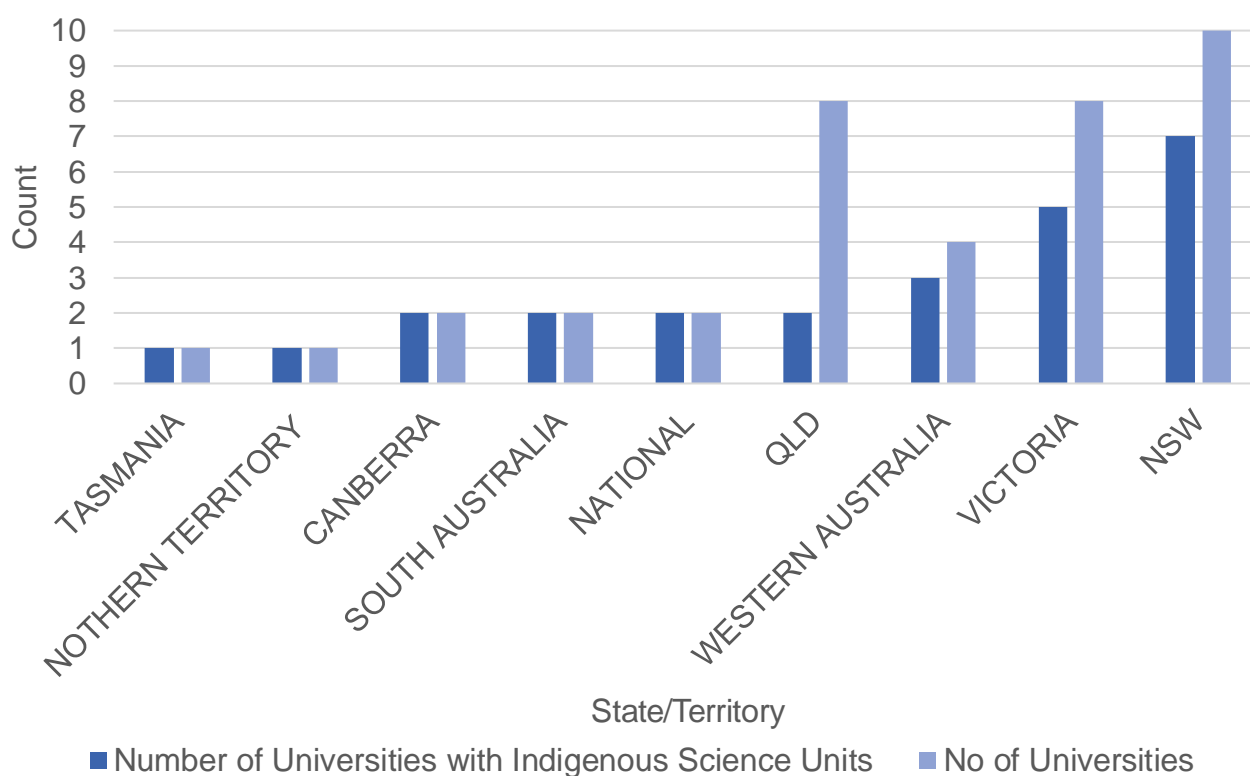


Figure 2: Indigenous science units taught in each Australian State and Territory and the total number of Universities in each State and Territory.

The Indigenous science units were mainly offered through Faculties/departments of Arts and Humanities, which collectively across Australia, offered 31 units relating to Indigenous science (Figure 3).

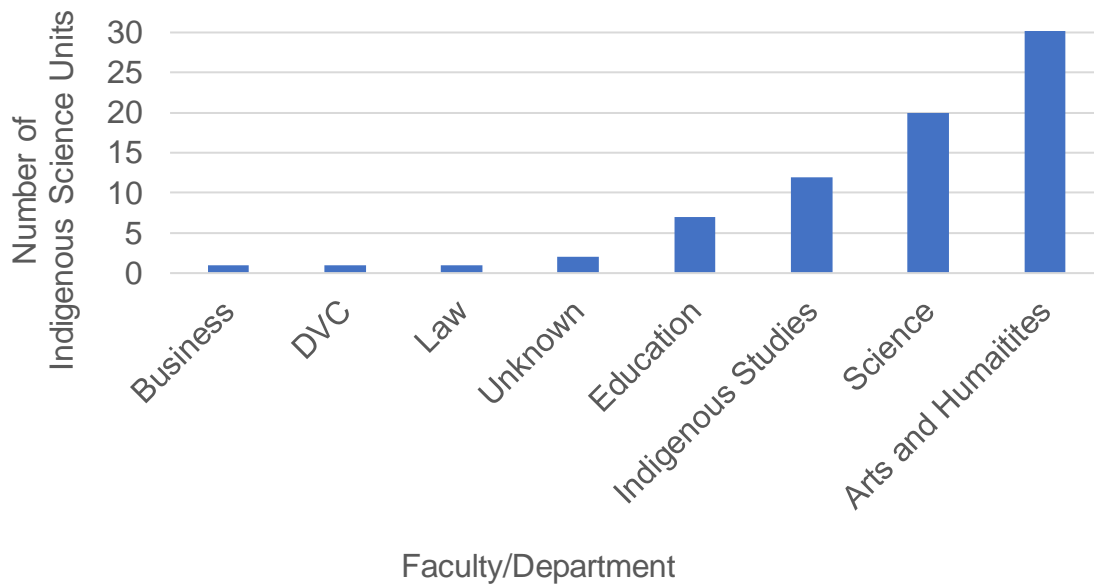


Figure 3: Indigenous science units in faculties/departments in Australian Universities

4.2 Unit Design, Content and Delivery

Eleven unit convenors participated in the online questionnaire. Participants were asked what discipline of science the unit was in, and they could select one or multiple options from the science disciplines as well as the interdisciplinary option. The most common response was that Indigenous units were interdisciplinary. This was reported by eight unit convenors. Whilst six of the units were in the earth and environmental sciences disciplines, three of the units were from astronomy and two of the units were in the biology, chemistry, and physics respectively (Figure 4).

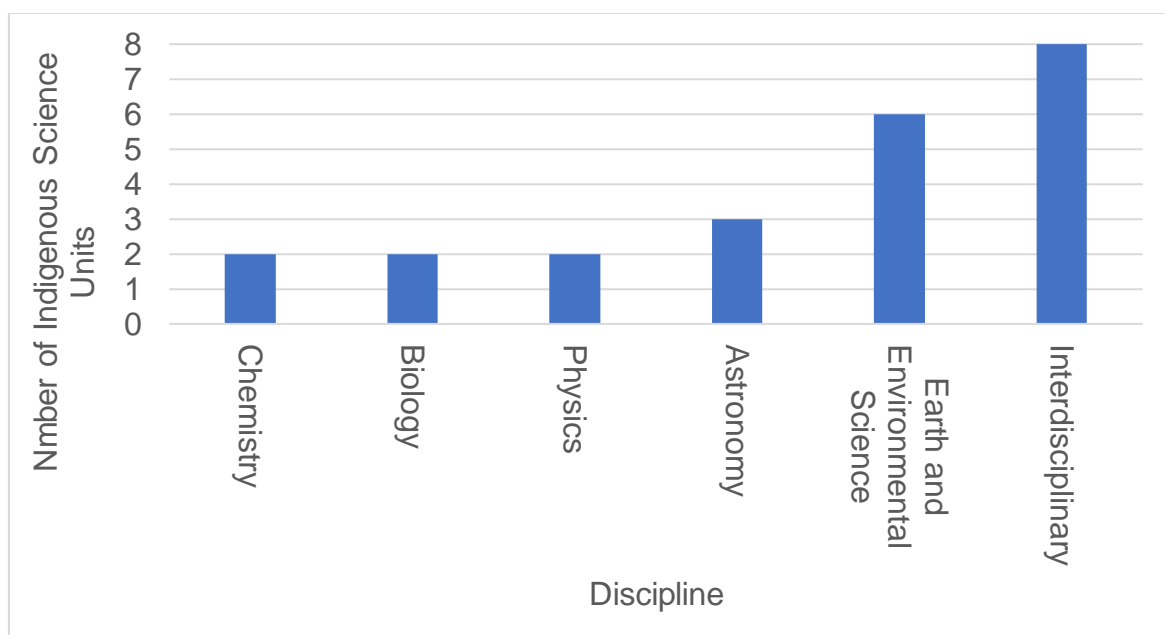


Figure 4: Indigenous knowledge units in the science Disciplines in Australian Universities.

To understand the stage of development of the Indigenous science units, participants were asked how long the course had been running. Five units had been running for less than five years: one for 12 months, three for two years, and one for three years. Seven units had been running for more than three years: three for four to six years, two for seven years, one for eight years, and the longest had been running for 12 years. The longest running course was originally from the University of New South Wales (UNSW) but is now taught at Monash University. It should be noted that the time the unit has been running does not necessarily reflect the development time, or if any redevelopment had occurred during this time.

4.3 Pedagogies

In order to understand how Indigenous knowledges are being taught, in the questionnaire unit convenors were asked about the teaching pedagogies they used in the planning and development of the learning content and assessment tasks. The eight unit convenors interviewed reported they use a variety of pedagogical approaches to teaching Indigenous knowledges including: reflective praxis; peer learning; critical learning; hands on learning; and active learning pedagogies. Four of the eight unit convenors mentioned using specific Indigenous pedagogies: decolonising, 8-ways of learning, learning on Country and yarning pedagogies. Three of the eight unit convenors said that they use the cultural interface to teach Indigenous and western scientific knowledges.

To gain a deeper understanding of the pedagogies that educators utilise to teach Indigenous knowledges and perspectives, unit convenors were interviewed about what methods they used to include Indigenous knowledges. There were many different approaches to including Indigenous knowledges. Two of the eight convenors who were interviewed used Nakata's cultural interface theory as Backhaus explained:

"We really try and disrupt and unsettle that notion of "what is science?" because when we use that word it already is operating from a position of contestation and invariably associations of Peoples. We're the ones who must make the compromise to thinking about and thinking through, what is science. And then attaching it to an Indigenous science unit adds another layer of complexity and problem to them [students]. What are the epistemological foundations that we need to be mindful of when we come to an Indigenous science unit, to learn about Indigenous science?"

This was reiterated by Hamacher who also used the cultural interface as a framework for the development of the unit content.

“The subject was based around a few major themes one of them is that this knowledge does include science. Martin Nakata said that we are a People of culture, we are also a People of science. That’s one of the foundational themes that runs throughout the subject. Another theme is that knowledge is not some relic of the past this is a living thriving body of knowledge, which evolves and changes over time, this helps to overturn some of the negative stereotypes of a static culture or a culture without science or culture without complexity by engaging the students in these topics”.

Three of the seven unit convenors said they use the Martin Nakata’s cultural interface as Hamacher explains this as:

“The space where they [Indigenous and Western knowledges] connect, where they overlap. [If] Western Science and Indigenous science were a Venn diagram of a perfect circle they are not going to fit perfectly over each other, they are not the same thing. There is a huge crossover between them, but they work in different ways, they often ask different questions and have different applications. But at the foundation, it’s about observation, deduction and trying to figure out how the world around us works and how to apply that knowledge and how it has a predicative purpose and passed down to successive generations. I have tried to focus on the space where they connect where they overlap”.

Four of the twelve unit convenors reported that learning on Country is a pedagogical technique that can create a deeper understanding of First Nations Peoples knowledges and customary practices. Convenors described “doing fieldwork components and going out on country” (McBurnie) and “also using [the] campus as Country itself rather than going to a place” (Backhaus). This was reiterated by Indigenous Elder Aunty Fran who said:

“So, I guess a good example would be when you walk with me through the Country, and I tell you the story. I think that’s the best part, rather than teaching. That’s the best way of allowing people to remember through story and place and then you run a couple of the lectures to deepen that understanding”.

Three of the unit convenors reported that oral/aural learning through yarning. Giles referred to this as:

“Non-judgmental, yarning circles: this is an optional activity where they can come in and they can have a yarn about what they've been learning and what they've been feeling and how these things that they've been learning had been impacting on them. [This is a] no judgment kind of space as to how we have roles and obligations to one another to care for each other but also respect one another and let each other speak. And that's also part of the reflective yarning process rather than having a written form of reflection”.

Only one of the units used the 8-Ways pedagogy and Backhaus mentioned using the trauma informed pedagogy and explained this as:

“[Getting] them unsettled and so that's where we get into the trauma knowledge. The destruction of place to Country, people's intergenerational trauma memories. So pedagogically we must shift and be a bit gentler in the ways that we guide, not only for Indigenous academics who are teaching, because they're really having to relive that trauma, again, but also for the students, it may be first time that they're being exposed to some of these things and so you must have moments of silence and safety which is built into the pedagogy. This is to ensure that as we move through very heavy stuff in here that there's an acknowledgement of trauma on both sides”.

4.4 Mechanics of Indigenous Knowledge Inclusion

Further from the pedagogy types, unit convenors were asked how they included Indigenous knowledges in the Indigenous science unit. A range of methods were described (Figure 5). Five of the 12 unit convenors consulted with First Nations Elders, knowledge holders and community members to identify appropriate Indigenous knowledges. Four of the units had First Nations guest speakers to discuss topics from a First Nations perspective and three of the convenors said that they worked with Indigenous staff to develop the unit. Three of the units reported using academic papers and two of the units used video resources that were written and produced by First Nations Peoples. (Figure 5). Only one unit specifically mentioned Learning on Country (field trips).

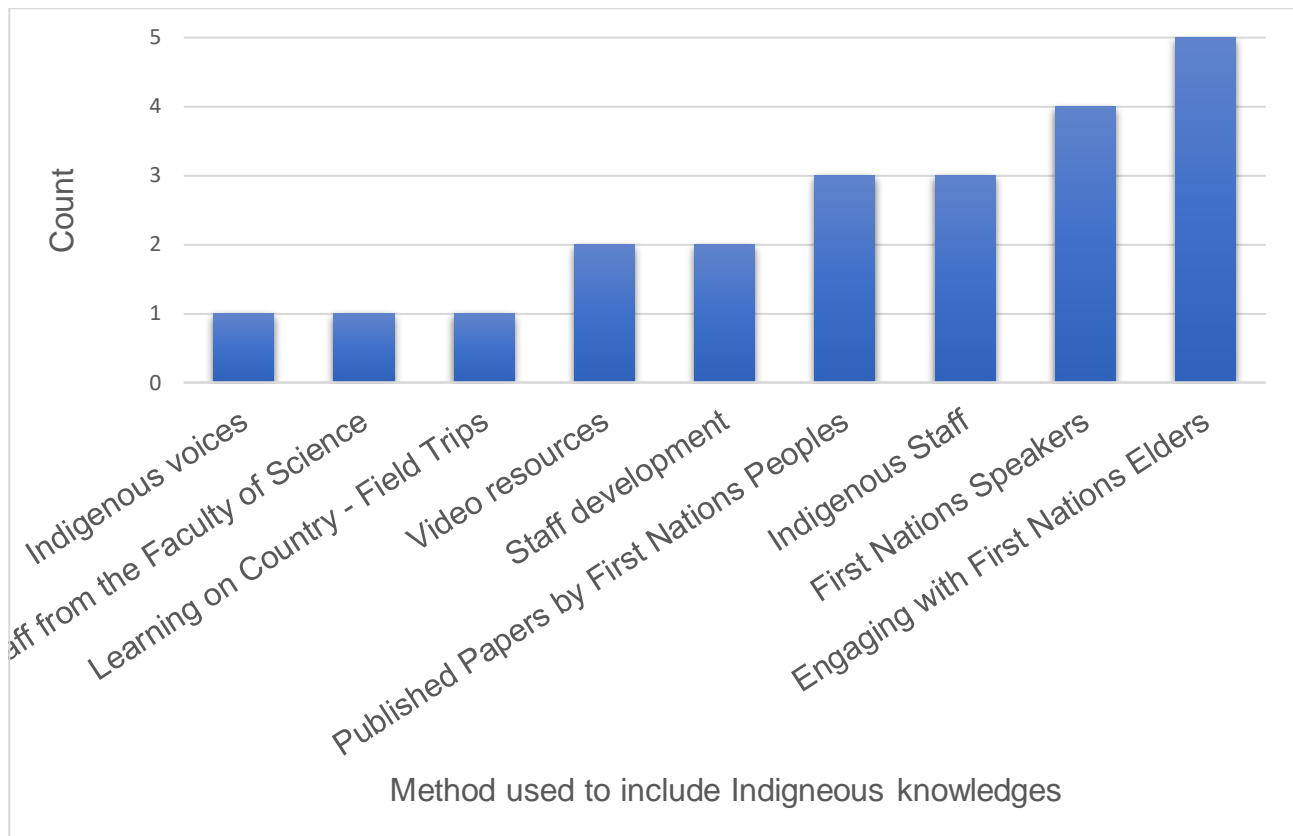


Figure 5: Methods that unit convenors used to include Indigenous science knowledges in their units.

Some convenors described how they used their own personal experiences as Stacey explains: “I’ve been around a lot, I’ve got contacts around NSW (where I’m from), and the NT from my work in remote Aboriginal communities”. Ziebell reported that they used “working groups” and “consulting with First Nations academics, to develop the topics and original outline of the content”.

Backhaus reported the importance of “identifying the appropriate Indigenous partners in the community who were willing to contribute”. Stacey concurred with this reiterating the importance of,

“Seeking permission to share the information with students through lectures, field trips or in published articles that have proper ethical approaches [taking] care to highlight the regional nature of knowledge and the sensitivities of who can share what knowledge”.

Indigenous convenor Venables said that “identifying the links to Western science” and “identifying Indigenous knowledges already in the public domain”. Ziebell reported that in

her unit “70-80% of the teaching materials were from Indigenous voices and perspectives” and she had “Indigenous support staff in all of the classes”.

Two of the unit convenors reported that they incorporated Indigenous perspectives using techniques used from staff development programs that they had participated in. As stated by Yasso:

“The Science Faculty facilitate weekly meetings for both Science and Centre of Aboriginal Studies (CAS) tutors to learn about the different perspectives and to learn how to teach these perspectives to the students”.

This is a way of building cultural capacity and ensuring that all staff become competent in these areas, so the responsibility does not fall solely on First Nations Peoples as expressed by Yasso who stated that otherwise:

“The Indigenous knowledge [is] reliant on the Indigenous tutors having their own cultural learnings and them contextualising it to what is being taught”.

Whilst other unit convenors reported using pedagogical methods such as their personal experience, other Indigenous academics, and Indigenous staff as well as rubrics, multimedia, and videos to teach Indigenous knowledges.

4.5 Types of Knowledge

To understand what form of Indigenous knowledges were being taught, unit convenors were asked about the topical content of the units. A word tree was produced from the questionnaire text and illustrates that the most common responses were: Indigenous Astronomy, Land, Country, Seasons and climate, Medicine, Sustainability, Oral use, Ecology and Plants (Figure 6).

Nakata became a mentor and guided me for the next few years and set the precedent for how to do research with Indigenous peoples...building up these relationships has been done mostly with invitation, research, working on a project, meeting the Elders, public talks, invited to give a welcome to Country, and then we would talk and get excited”.

Four unit convenors stated that the key methods or components to building successful relationships with First Nations Peoples is through developing relationships over time and as Ziebell said: “be willing to do the hard yards”.

This must be done collaboratively where “Elders and community members are stakeholders, not being the research subjects, mutually beneficial on a number of different levels” said Hamacher. Two other unit convenors said that relationships need to be developed using clear communication to build trust and respect through reconciliation processes, promoting self-determination and providing remuneration for First Nations Peoples time and knowledge. This can also be done in other ways such as providing a payment or gift that supports an Indigenous business or enterprise. Stacey said it is important to:

“Always provide a financial payment or offer a gift, and we try and offer a gift that's based on an Indigenous natural resource-based enterprise, so it's more that sort of reciprocity gesture not a token one. I actually think it's more heartfelt and a more thoughtful way of gifting something, you can give a gift card, or you could do something like that but to actually go back and support First Nations organisations or businesses is really important”.

Stacey also recommended showing your appreciation by:

“Thanking them afterwards and providing positive feedback from what the students have said in their evaluations because students always say it's so fantastic being exposed to the perspective's views and knowledge and experience of Indigenous Peoples, we want more Indigenous speakers. Then there's also the opportunity to recognize People's contribution through a media article or something for their own newsletter”.

Others noted the importance of working with the right people in the community - the First Nations custodians and knowledge holders who have the authority and permission to

share Indigenous cultural Intellectual Property (ICIP). Hamacher discussed the historical positioning of Indigenous knowledges in academia and reiterated the importance of collaborative and respectful research to protect Indigenous knowledges.

“Research from the first fleet up until 1980s, information that was secret, or taboo was published and shared with the public and now this is problematic. It may be published but it does not mean its ok to talk about it. You need to understand what you can talk about, [such as] men’s and women’s business, what I can and can’t share. The community that shared that knowledge sometimes aren’t around anymore or the Elders have fragments of knowledge, so I focus on the areas where I have already done collaboration and have been through this process and know what is ok to be shared”.

Understanding what knowledges can be shared and by whom is essential to protecting First Nations Peoples knowledges and customary practices. Venables recommended that academics “undertake cultural competency training to help them understand the cultural protocols, social and political histories and intergenerational trauma experienced by First Nations Peoples”. Indigenous Elder Aunty Fran Bodkin explained that the university:

“didn’t realize a lot of us have been through trauma. A lot of us have been in those days, remember this is universities we’re working with you know, they have told the incorrect stories about us specifically within the scientific space. That’s quite a journey within itself you know, talking about the historical basis of the government and the social policies in removing children”.

This resonated with First Nations convenor Giles who explained that the underlying cause of these challenges are the way that academics or universities approach communities and Indigenous knowledges:

“In terms of developing relationships [and] approaching community, from the perspective as an academic at a university is always met with suspicion, it does not really matter the [disciplinary] background you’re from. Across the board, there’s typically not a lot of engagement. I think part of the reason for that is that universities have had, I think, ignorant relationships with the local community, often in the way universities approach community [who] feel like universities put themselves up as being these big knowledge holding or knowledge sharing

systems, but they don't understand that not all knowledge is supposed to be known by everybody. In the past and they have not respected those people's intellectual property from a community perspective or from a legal perspective, and they have not allowed those people to maintain, not only sovereignty over their land and knowledge of Country, but also [songlines and dreaming] stories. When you're working from and in an institution that is thoroughly institutionalized [you] don't have that data sovereignty, then [you] don't have Indigenous led research. They have researchers come in, study something, maybe throw a bit of cash their way, maybe throwing acknowledgement and then the people don't get anything out of it. They are basically just used for that research and then that knowledge is forever taken away from the community. It partially loses its meaning because it's taken out of community context and disseminated across the public domain and that's not [appropriate] for information that shouldn't be shared. And this is this is a systematic [issue] within universities they don't understand this and so they asked all these questions about why don't we have community engagement? Why can't we? Why are the local Indigenous Peoples not interested in having relationships with us? It's because this is the historical approach that's been taken".

The positioning of Indigenous Peoples and knowledges within academia continues to have an impact on First Nations Peoples engagement and participation with universities. This was also expressed by Ziebell who said:

"Institutions have been around 160 years and the sandstones were around when a lot of really horrendous damage was done. So rightfully they're associated with that but some of the modern universities are associated with things that [just] shouldn't have happened. You don't necessarily know about that as a staff member though, and [you might want to work with communities, but you find out that you] can't work with communities and there was an issue, [you might] have no idea what happened, why, when, and who, so you can't actually work to build up the relationship again. You might be just like, well that didn't work, I guess what I did was wrong, I'll try something else somewhere else and that goes on all the time".

Lack of awareness of the legacy of poor past and ongoing research on Indigenous Peoples rather than with and by Indigenous Peoples, combined with lack of respect,

reciprocity and acknowledgement are also significant challenges for the development of Indigenous science units.

4.7 Challenges

Unit convenors were asked in the questionnaire and interviews if they faced any challenges in development and delivery of the unit. Time, financial costs, and lack of First Nations academic staff were reported as challenges. Hamacher a Canadian convenor said

“There is a lack of awareness among non-Indigenous convenors [of other units] regarding protocols of respect and engagement”.

Several convenors were aware of the challenges inherent to being non-Indigenous and working in this space, as McBurnie explained:

“I was worried about doing this as I am not an Indigenous person but was encouraged by senior Aboriginal staff at my university. I have been challenged by a few students about whether I have the right to teach in this space, but as Professor Rose puts it, we need people to teach in this space as we don't have enough First Nations academics to do this”.

This was reiterated by Yasso who further explained:

“There are always challenges with developing a unit within the third space. On occasion non-Indigenous tutors may find it difficult to grasp the Indigenous perspectives which may cause anxiety for them which can manifest in different ways. The key to dealing with these is to recognise and acknowledge that the 3rd space is a place of constant negotiation, and it takes time to recognise and celebrate differences”.

Another challenge was raised by Venables who reported that she had difficulty with student Engagement and understandings of Indigenous science. She said, “in 2021 I had to invest a significant amount of energy convincing students that the Indigenous stories that they were listening to and reading represented science”. This was also expressed by Rohl who said the “main challenge is student perceptions - that Indigenous Knowledge is not a myth or story”.

Rohl noted that “It has been very difficult incorporating Indigenous knowledge and culture into a main steam science course, where Indigenous knowledge is holistic and western science is very siloed!”. Hamacher said “it has been a major challenge but a lot of fun”.

This was emphasised by McBurnie who said “It is probably the most difficult, but rewarding unit I have been involved in. Also, worth noting that for most of my students they have limited if any knowledge in this area at all’.

Building respectful relationships with Indigenous knowledge holders can also be challenged by university timelines and community constraints. Two of the unit convenors reported that people often come asking for help to incorporate First Nations knowledges into their teaching and expect that this can be done in a short timeframe, not understanding that relationships need to be built over time, as expressed by Ziebell:

“[I would get], several emails like can you help us put something together in three weeks or three months. I literally can’t help you put anything together in three weeks. I can’t help you put anything together in three months”.

This response evokes another challenge as these requests often fall on the very few First Nations academics and staff in the university system, and that universities need to have the capacity to be able to deliver the Indigenous outcomes they are proposing, as expressed by Backhaus:

“I think we're still finding a lot of ignorance in the university. The challenge still is that we have this awareness, there is pedagogically, you know, learned helplessness. We know what to do but will you help us, we don't know how. So, there's still the limitation of how do we engage, we know we have to engage, we know we have to embed this but how? So, the challenge is that it comes back to on only one of three key university Indigenous academics who become these key points of conversation... you don't have the capacity and the university doesn't have the capacity either”.

This was reiterated by Ziebell who also expressed that:

“Staffing is diabolical, I had to deal with something like five levels of the university. And I got approval direct from the Pro Vice-Chancellor to get our first ever Indigenous and identifying academic in the whole of Monash science, history”.

In the interviews, three unit convenors described that these staffing and Intellectual Property challenges were exacerbated by COVID-19 when convenors were required to change the

course, downsize, alter or change the unit content for online delivery. As Hamacher described:

“COVID changed all of this, because we had to do everything online. I don’t think that you or I or anyone who has been working within this space for more than 10 seconds thinks that a classroom or even sitting behind a screen is the best way to teach, the best way is to get students out on Country through multisensory education. Pre-COVID, guest lecturers and First Nations scholars coming in to teach students was extremely useful. During COVID, when I was able to bring people in, many of them online, students loved hearing from the voices that they were learning about, However, now that COVID restrictions are gone, everything has not gone away it has just built up and they don’t have the time or capacity to do this. Last year I had lots of guest lectures, this year I’ll [only] have a couple”.

Other challenges noted by two of the unit convenors interviewed, included developing assessment tasks, and choosing the right content to assess that demonstrate student’s knowledge and understanding. McBurnie explained that:

“Over time I have tried to work out what appropriate assessment is, trying to think how am I going to get them to look more deeply into these areas. Traditionally the unit had to have an exam, so now I have taken that out, and I’m getting them to do a briefing paper, which is just short and concise and explaining the use of fire to different audiences”.

This was supported by Hamacher when he discussed how assessment tasks were not always indicative of students learning:

“The Assessments have changed from when I first ran the course last year. The symmetric and metrics that the education system requires, such as number of words and percentage weights to assessment tasks, is not necessarily indicative of what the student learns. We had quiz’s every second week but there was too much content, no textbook and a lot of readings, lectures and tutorials which forces them to engage in the content, but if it’s not assessed they just won’t bother”.

4.8 Unit Feedback and Evaluations

Unit convenors were asked if there had been a review or evaluation of the course and what it revealed and/or what were the reported outcomes. Interestingly only Hamacher reported that the unit had undergone a formal audit or review by the university but did not go into details about the findings. Although many unit convenors received student feedback through course/unit evaluations where they reported that students often provided positive comments about what they had learned, and as Backhaus explained, how the students valued their interactions with First Nations Peoples:

[students would often] “comment that I wish it could be taught by an Indigenous academic or Indigenous person, that's been the key feedback that we've received from students”.

Similar positive feedback was received by Venables:

“This is the best unit I've ever done; I can't believe that my perspectives have changed so much. I walk around outside now, and I actually look at the wattle trees and I understand that it means the seasons are changing and there was something in one of the stories about how when the acacia [has] the biggest bloom... it's going to be a bad bushfire season in like 18 months' time. The students started to say I've noticed that the wattle have bloomed a lot, but I've never paid attention to it before, so I don't know whether this is the biggest kind of bloom, [but now] they are paying attention. They are starting to think about how that applies in their lives”.

This feedback shows the impact that the unit has had on the student, and their ability to relate their learning and apply it in context.

4.9 Recommendations for Universities and First Nations Peoples Wanting to Teach Indigenous Science Knowledges.

The most common recommendation provided by unit convenors regarded the learning content was the need for more First Nations academics and building relationships with First Nations Peoples. Ziebell provided recommendations about how to resolve the issue of Indigenous speakers' availability and recommends:

“Asking to get an audio recording and pay them each year that its used. Then we will add that, and it will be part of the resources for students. Then we know there’s always a budget to bring back a couple of people, as the university have funding within their budget that is specifically designated to developing the Indigenous knowledges within the different units”.

Giles said that:

“Institutions need to employ more Indigenous People and include Indigenous Peoples’ voices. I always get this question, if I’m approaching an Indigenous community or if I’m trying to build a relationship with an Indigenous community like what’s the best way to go about this? My answer is always employing or give those people positions in your institution to then help you guide your institution in a way that is actually relevant to the community”.

Giles also recommended approaching community members with humility:

“Those people actually know as much as you know, you think that they might be a ‘lay person’, or whatever you might call them. Some of those people that you might find yourself in front of, are extremely powerful people, they know a lot. They’ve been around the place, and they are very knowledgeable people and to treat those people with the utmost respect.”

In the interviews, unit convenors were asked what type of support is needed for educators to engage in Indigenous science. Two unit convenors commented that cultural competency training for educators and a cultural framework or protocols for how to engage with Indigenous Peoples and Indigenous knowledges is of utmost importance, as explained by Backhaus:

“Something that I have recognized as being quite a glaring omission from a lot of the people interested in furthering this idea of communicating Indigenous knowledge to all of the sciences, scientific researchers or even the broader public, is that there is a lack of a framework to do it. There is a lack of a doctrine written by Indigenous Peoples to say that these are the ways that you can approach this, and these are the culturally safe ways to approach this kind of

knowledge, you can include this, and this is the sort of stuff you probably shouldn't include”.

Backhaus went on to discuss recommendations for how and why the university system needs to include other ways of teaching and learning:

“I think there's a systemic issue and this is a design issue in the way we deliver content to students within university settings. We need to rethink the design of how we teach, engage with students. Institutionally we've been unsettled by this new digital introduction over the last couple of years and that's really unsettled a lot of people and you can't always deliver that way. But I'm hopeful that ... it gets them thinking about different ways of engaging, through supporting our knowledge contributors and thinking about those alternative ways of delivering. That may be through masterclasses, it may be on Country programs, or it may be actually having to do the hard work that we do in our masters and PhD, to just rethink the design of how we deliver that content and maybe there's something there that will emerge in the way we teach that next generation coming through, Indigenous and non-Indigenous”.

Chapter 5 Discussion

International and national policy documents are increasingly calling for greater awareness and inclusion of Indigenous knowledges and Indigenous Peoples in all areas of science. This has been particularly prevalent in ecology, environmental management, conservation, medicine, engineering and education (Ens et al; 2012; Ens et al., 2015; Janke & Sentina, 2017). including ecology, environmental management, conservation, medicine, engineering and education. Notwithstanding, First Nations Peoples have been fighting for such acknowledgement, recognition of rights, and collaboration since the pervasive colonisation of Indigenous lands by dominant forces over the last few hundred years. To explore how well Australian Universities have responded to these top down and bottom up call for Indigenous knowledge recognition, this study explored the range of Indigenous science units offered in Australian Universities as well as the content, pedagogies and challenges in the development and delivery of units from within the Science Faculties/Departments. As a Wiradjuri yinna, below I reflect on the results of the questionnaire and interviews and comment on how these units did or could in future promote the intercultural and inter-generational transmission of Indigenous knowledges

and applied customary practices through the development of community relationships and partnerships.

A key finding of this research was that Indigenous science is in fact multidisciplinary and is offered across university faculties. Indigenous science units were most often taught outside of the science disciplines and were mainly apparent in the Faculties of Arts and Humanities. The multidisciplinary, multidimensional and holistic nature of Indigenous knowledge or science is widely known across the literature (Haines et al., 2018; Settee, 2011; Zidny et al., 2020), and this creates significant challenges for incorporation of Indigenous science units in the siloed academic system. Furthermore, the paucity of Indigenous science units developed through the Faculties of Science (in only 19 of 38 Universities) also reflects the historic tendency of Western Science to ignore alternative epistemologies and knowledge systems as containing truth about the way the world works.

The present research revealed that the challenge of multidisciplinary knowledge is compounded by the lack of Indigenous academics who are culturally qualified to deliver Indigenous content, and hence, reliance on non-Indigenous academics who in this study noted personal challenges and inner conflict when trying to teach this material. This has also been noted in previous studies (Abrams, 2009; Page et al., 2016; Wolfe et al., 2018) and was revealed again here where unit convenors reported that students feedback noted that Indigenous knowledges should be taught by First Nations Peoples. Perhaps it is also a result of this conflict and tension between Indigenous and non-Indigenous knowledge systems and the teaching, delivery, communication and hence trust of students, that only just about half of Australian Universities offered at least one Indigenous science unit.

This study revealed that unit convenors included Indigenous knowledges and content in their units through working with First Nations Academics, Elders, knowledge holders and community members, working groups, using their own research and professional relationships. First Nations People's involvement is paramount in every step of the development process to ensure that appropriate and relevant knowledges are included and that they represent the perspectives of First Nations Peoples. This also helps to ensure that culturally sensitive information such as 'Men's and Women's business' or secret and sacred information is not shared publicly, and that information is not used in a way that causes offence. Previous studies have shown that educators often struggle to identify Indigenous science knowledges (Michie, 2002, Burrridge, Chodkiewicz & Vaughan, 2012) and this often causes them to adopt a tick the box approach that incorporates Indigenous knowledges at a surface level; often making generalisations, simplifying and

decontextualising these knowledges from the peoples and places in which they have evolved (Fiedler, 2008). This is problematic as it can reinforce the negative stereotypes and racist views of First Nations Peoples and raises questions as to what Indigenous knowledges are taught to students and how this informs students perceptions of and interactions with First Nations Peoples.

The present research found that some Indigenous science topics were well covered in the university units, including Indigenous astronomy; memory and oral storytelling; climate, weather and seasons; Country, kinship and totems; bushtucker and bush medicines; land management; traditional fire management and ecology; and sustainability. However, some topics were not well represented including Indigenous knowledges in geology, archaeology and engineering. Research about the inclusion of Indigenous knowledges in Australian university curricula is scarce (Smith et al, 2021). However, Smith and Wilson (2020) contend that Indigenous knowledges can be included in archaeological studies through engaging Indigenous Peoples and communities in cultural resource management and research, sharing this knowledge with students through fieldtrips and as field-based researchers through collaboration with Traditional Owners, Elders and knowledge holders on publications and grant applications (Smith & Wilson, 2020).

Furthermore, Kutay and Leigh (2017) suggested including the fish traps at Brewarrina, the construction of stone houses at Budj Bim as well as trade and travel routes in engineering curricula. Goldfinch et al. (2017) have also designed a model of holistic understanding of Indigenous engineering practices grounded in philosophies of Country, kinship, culture, journey, connectedness. Whilst these examples demonstrate that there is culturally appropriate material in the public domain from which educators can draw from, the scarcity of research and uptake in these science curricula presents the need for further study, particularly in geological science which could include topics such as Indigenous stone tools, construction of stone houses, stone/rock fish traps, and trade.

5.1 Indigegogy – Using Indigenous Pedagogies to Indigenise the University Curriculum

While it is important to include Indigenous knowledges, it is imperative to consider the way in which these knowledges are taught. As stated by Gibbs and Simpson (2004) ‘how you learn is just as important or perhaps more important than what you learn, and Indigenous

educational programs must use culturally inherent ways of teaching and learning Indigenous Knowledges'. Indigenising the university science curriculum involves teaching Indigenous knowledges through First Nations Indigegogy; through *gulbhana*, *ngurruwigarra*, *gana* and *garra* that is embodied in customary practices and experienced on Country. In this study, unit convenors reported using Indigenous pedagogies such as the decolonising, yarning, trauma-informed, and *8-ways pedagogy*, as methods to teach Indigenous science knowledges. Surprisingly, only one convenor reported using the *8-ways pedagogy* of Yunkaporta (2009) in university curricula. In the literature however, Gajendren et al (2022) reported that the University of Newcastle incorporated the *8-ways pedagogy* into an architecture course. They found that it supported students understanding of Indigenous knowledges through the development of culturally relevant pedagogy and assessment tasks that promoted interactions with First Nations Peoples and a connection to Country (Gajendren et al., 2022).

Whilst other convenors in this study reported using the cultural interface to include both Indigenous knowledges and Western science, many of them failed to explain how they navigated the complexities of this space. Previous studies have shown that at the university "cultural interface is influenced by the multiple complexities, tensions and negotiations between Indigenous and Western knowledge systems (whether taught by Indigenous or non-Indigenous staff), each competing for validity, authenticity and the right to be in the pedagogic space" (Hart et al., 2012, p. 710). Navigating this complex and contested space requires an understanding of the different cosmological, epistemological, ontological and pedagogical positions and approaches for coming to know. This requires one to sit down under one of the old *yarrans*; River Red Gums, to contemplate, reflect and unpack the complexity of the cultural interface. This is a continual and evolving process, and the tensions can be explained through the changes of the seasons from *yarraga*; summer, *bangalang*; autumn, *dhandhanbiyang*; winter, to *yirabang*, *spring*, to *yarrowulay*; where the River Red Gum blossoms signifying the growth of new knowledge. Whilst there is research about the use of the cultural interface to teach Indigenous knowledges there is currently no research about how the cultural interface is applied in university practice and policies, which limits its ability to be more broadly applied (Street et al., 2022).

Concerningly, two of the unit convenors reported that they came from a research background and don't understand pedagogical practices. The lack of understanding of education pedagogy by academics presents concerns to the quality of teaching and students learning (Burroughs-Lange, 1996; Kember, 1997). This raises significant

questions regarding what Indigenous knowledges/content is taught, how it is taught and how this informs students understanding, perceptions of and relationships with First Nations Peoples. Yunkaporta (2012, p. 37) contends that “tokenism and trivialization of Aboriginal culture in the curriculum” is less likely to occur if Indigenous pedagogies are used to teach Indigenous knowledges in ‘mainstream’ educational practice. This presents the need for universities to develop guidelines and frameworks to guide educators on how to include Indigenous knowledges in their teaching and learning practice, this is especially important for academics who come from a scientific and research background and have limited understanding of educational pedagogical practice.

Indigenising the curriculum involves institutions to consciously reflect on the historical destruction and their ignorance of First Nations Peoples, knowledges and customary practices, and how this has been and continues to be embedded within institutional policies, processes and education curricula, and the resultant impact on teaching and learning (Burgess et al., 2019; Lowe et al., 2019; Vass et al., 2019). This involves critically and ethically evaluating the privileging of certain knowledges, worldviews and educational practice and to work with First Nations Peoples to empower Indigenous connections and teaching about their lands, traditions, knowledges, customary practices, and languages (Wildcat et al., 2014). This learning must be contextualised through Indigenous epistemologies embedded in Country (place) (Sutherland & Swayze 2013; Burgess et al., 2022). Whilst decolonising pedagogies presents an opportunity to shift the coloniality embedded in education, it can also be a contentious and difficult space for both First Nations Peoples and non-First Nations Peoples who have experienced trauma. In the present study, Backhaus discussed the use of trauma informed pedagogy as a method of creating a culturally safe space for the discussion of sensitive topics that might cause distress not just for First Nations teachers and students, but also for students from Countries who have similar experiences of invasion, colonisation, massacres, cultural desecration, genocide, and removal of children policies. Whilst decolonising pedagogies recognise the historical trauma experienced by Indigenous Peoples, trauma informed pedagogy recognises the ongoing and current effects of trauma and attempts to actively reduce harm to one’s emotional and physical wellbeing through re-telling and reliving these traumatic events (Harrison, 2021). This pedagogical approach is important because it acknowledges the historical and contemporary social and political injustices experienced by First Nations Peoples and provides a safe space for truth telling.

In this study, several of the unit convenors noted using yarning pedagogy as a methodological approach to teaching Indigenous knowledges and this allows space for trauma informed pedagogies. Yarning is founded on the principals of respect and reciprocity and is guided by cultural protocols of inclusiveness, providing the opportunity for each person to speak and share their stories and lived experiences through the processes of deep listening and personal reflection. Yarning allows for the exploration of ideas leading to deeper learning and the development of new understandings and concepts (Bessarab & Ngandu, 2010; Kameniar, Imtoul & Bradley, 2009). In an education context it can be used in the delivery of lessons, tutorials or even as an assessment task; however, this should be non-graded, as it may impact student's involvement in the topics discussed during the yarning session (Carlson & Frazer, 2018). Yarning offers an opportunity to include methods of oral transmission used by First Nations Peoples and shift away from dominant Western education pedagogies where the teacher is the knower and the student the learner. Yarning allows teachers and students to come together in a non-hierarchical structure to share ideas and come up with new understandings of the world around us. This provides a social constructivist approach to teaching and learning which advocates that student learn as active participants in the constructing of their own knowledge, rather than through absorbing ideas or memorising concepts that are presented by a single teacher (Vygotsky, 1978). Therefore, yarning and trauma informed pedagogies offer an Indigenist approach to teaching First Nations knowledges and a platform for transformation, from a decolonising method to self-determined Indigegogy.

5.2 The Benefits of Learning on Country

Learning Indigenous knowledges should be done through Indigegogy; Indigenous pedagogies, in the way in which these knowledges have evolved, through the teachings from, of, and on Country, of our Elders and knowledge Holders (Harrison & Skrebneva, 2020). Although learning on Country pedagogy was not specifically mentioned by unit convenors, when asked about the pedagogies they used to teach Indigenous knowledges, four of the unit convenors identified learning on Country as a pedagogical technique used to create a deeper understanding of First Nations Peoples knowledges and customary practices. However, techniques are strategies used to teach Indigenous knowledges, pedagogy, means teaching through Indigegogy, ways of *gulbhana*, *ngurruwigarra*, *gana* and *garra*. Indigenous science knowledges are not learnt through pre-planned lessons, in a sterile laboratory, or confined to the classroom, they are learnt from, on, and through Country (Harrison et al. 2019). This involves the processes of forming a deep connection

to the world around us through immersive experiences that evoke interconnected understandings through the process of continual observation, critical evaluation, experimentation, and personal reflection to understand the diversity and complexity of Indigenous knowledges and the multiple ways one comes to know (Harrison et al., 2019).

Unit convenors reported that Country can be utilised through fieldwork and participating in cultural tours on Country and as stated by Backhaus, by “using [the] campus as Country itself rather than going to [another] place”. Utilising the campus as Country avoids the necessary paperwork and funding required for field excursions and provides an opportunity to deepen students understanding by teaching Indigenous knowledges from a localised perspective and the teachings of Country (Darug Ngurra et al., 2021). To overcome the administrative barriers of on-Country trips, new technologies can be used. For example, the University of Tasmania created a virtual reality on-Country experiences where students are guided by a Palawa Elder or knowledge holder who shared traditional and historical stories through Palawa worldviews of a particular place (University of Tasmania, 2020). This recognises that Country is pedagogy, we learn from Country, and it teaches us (Harrison et al., 2017). Whether in person or virtually, learning on Country allows students to observe and engage with the natural elements through experiential learning, engaging the physical and emotional senses, to understand the multiple ways in which one comes to know (Harrison et al., 2017).

Learning on Country has the capacity to promote strong relationships of reciprocity with the land by shifting the “relationships that people experience, and what they believe about who they are, in relation to and with the land and what they believe to be true” (Wildcat et al., 2014). However, learning on Country also presents a barrier for both First Nations and non-First Nations Peoples as a result of colonial dispossession, cultural breakdown and intergenerational trauma. These injustices have hampered Indigenous Peoples ability to access those with cultural authority and knowledge to speak for Country due to dispossession or dispersal of First Nations Peoples from Country, barriers which are further compounded by cultural and environmental destruction.

In an effort to address these past atrocities and injustice against Indigenous Peoples, knowledge and Country, it is essential that Indigenous knowledges are taught through Indigegogy, Indigenous ways of *gulbhana*, *ngurruwigarra*, *gana* and *garra*, that are embedded in the teachings of Country and our Elders and cultural knowledge holders. To truly Indigenise the curricula, a shift in the current university pedagogical approaches and

methods is required, as well as the willingness of university decision-makers to devolve power and truly acknowledge and allow space for alternative worldviews and ways to flourish within what has been a very rigid and siloed system. This includes creation of appropriate content, communication tools and assessment tasks that enable and can assess student's knowledge and understanding of Indigenous science. Of note here, were the complications of the COVID pandemic raised by Hamacher who highlighted that, Indigenous preferred ways of teaching and learning on Country can be vulnerable when Country and Elders cannot be accessed. Again, this demonstrates that benefit of drawing in new technologies to mimic on Country learning, such as virtual reality tools, that safeguards teaching of Indigenous science when resources or social situations create a barrier.

Whilst the decolonising, yarning and 8 ways pedagogies present culturally appropriate, authentic, and engaging ways of including First Nations Peoples knowledges in the university science curricula, it is essential that Indigenous knowledges are taught through Indigegogy, Indigenous ways of *gulbhana*, *ngurruwigarra*, *gana* and *garra* that are embedded in the teachings of Country, and our Elders and cultural knowledge holders. To truly Indigenise the curricula requires a shift in the current pedagogical approaches and methods to the teaching and learning of Indigenous knowledges. This includes developing appropriate assessment tasks however unit convenors in this study reported several challenges in the design and development of the unit content including creating appropriate assessment tasks that demonstrate student's knowledge and understanding of Indigenous science. This was further exacerbated by the impacts of COVID-19 in which content and assessments had to be re-developed for online learning.

5.3 Indigenising Assessment Tasks

Previous research has argued that an often overlooked component of Indigenising the curriculum, is that assessment tasks that also tend to be dominated by Western worldviews, relying on cognitive tests, metrics and linguistic assessment practices which disadvantage Indigenous students, and students where English is not their first language (Klenowski, 2009; Preston & Claypool, 2021). As expressed by Hamacher, these tests don't really evaluate students learning and their ability to relate the knowledge within a real-world context. McBurnie had to alter the assessment tasks from the traditional exam to a briefing paper to get the students to think more deeply about the concepts. Little research has been conducted into how students make connections and interpret these relationships. However, Friesen and Exeife (2009) recommend that assessment practices need to

address the socio-cultural context of knowledge production that shapes students thinking. Others also argue that assessments can incorporate Indigenous paradigms by; scaffolding learning, group and project-based work; personal reflection using journals and portfolios; student interviews; observational studies; experiential assessment and community-centred research (Iseke, 2013; Kanu, 2007; Riley & Johansen, 2019; Preston, 2017). Indigenous pedagogical assessments could also include the use of yarning circles and oral assessment tasks, where evaluation and reviews are conducted by Elders, knowledge holders, community members and peers (Johnston & Claypool, 2010). Whilst these offer alternative ways of assessment, tasks need to reflect the diverse and multiple ways in which one comes to know (Gardner, 1983; Johnson, 2013). First Nations knowledges should be assessed through the various ways in which these knowledges are expressed for example through Indigenous ways of *gulbhana*, *ngurruwigarra*, *gana* and *garra*; customary practices of storytelling, art, song, dance, that express our lore, law, kinship, and connection to Country; and recognition about how these inform our values, beliefs attitudes and identity. Incorporating these elements in assessment tasks may help to create culturally relevant and appropriate curriculum and assessment that offers an alternative to the current standardised western model of education and help to provide a greater understanding of all student's learning (Solano-Flores & Nelson-Barber, 2001; 2003; Johnson, 2013).

5.4 The Need for More Indigenous Academics

The majority, of unit convenors who participated in the present research were non-Indigenous. These participants noted this as their main challenge in the development and teaching of Indigenous science. One of the unit convenors explained how she was often challenged by students who thought that Indigenous knowledges should be taught by First Nations Peoples. This was also expressed in student feedback where students valued learning from First Nations People and said that this deepened their understanding of Indigenous knowledges and ability to relate this knowledge in a real-world context. Indigenising the curriculum must always include a “discernible Indigenous voice as First Nations Peoples insert their own narratives, critiques, research, and knowledge production into the corpus” (Nakata, 2007, p.8).

Indigenous academics are under-represented in the university system, especially in the sciences (Universities Australia, 2022). Therefore, responsibility to include Indigenous knowledges and perspectives into curricula either falls on non-First Nations academics or one of the few First Nations staff employed by the university who are rarely in the

discipline of science (Andersen, Bunda & Walter, 2008; McLaughlin, 2013; Asmar, Page & Radloff, 2015). Universities need to establish more employment opportunities for First Nations Peoples, across faculties to increase the interdisciplinary understanding of Indigenous knowledges, customary practices, and perspectives. Including Indigenous knowledges should also be strengthened through engagement with local Elders, knowledge holders and community members who are the cultural authority and can provide permission to share this knowledge.

5.5 Building Relationships That Produces Mutual Benefits

Building relationships with First Nations Peoples is imperative for the inclusion of First Nations People's knowledges and perspectives in the university science curricula. In this study unit convenors reported developing relationships through their personal networks, or through other First Nations academics and their networks, research partnerships and through networking and attending events. However, very few academics in this study stated that they worked with local First Nations Elders, knowledge holders or community members to develop their science units. The majority relied on their existing research partnerships or First Nations staff employed by the university. There is a wealth of information about how to build successful relationships with First Nations communities (Behrendt et al., 2012; Maurrasse, 2001; Sandmann & Simon, 1999; Walshok, 1999; Zlotkowski, 1998; Universities Australia, 2022). The most apparent themes reported in this, and previous studies was the need to build trust, respect, and rapport, and that these relationships need to be developed over time.

Relationships between academic and Indigenous communities need to be meaningful, developed through a 'two-way', 'bottom-up' approach that first and foremost identifies and responds to the wants and needs of the community, through flexible and shared governance structures, shared staff positions and committee representation (Behrendt et al., 2012; Bringle & Hatcher, 2000; Johnson et al., 2017; Pearce et al., 2018; Sarkissian et al., 2012). However, Walshok (1999) argued that this must also involve the evaluation of the relationship/partnership which is crucial in establishing a sense of ongoing commitment to participants. Universities engagement with first Nations Peoples must go beyond inviting them to perform a welcome or acknowledgement to Country at special ceremonies and events, and from research and education that is about us not by us, to meaningful engagement that provides shared, knowledgeable, equitable and sustainable outcomes for

the community. These processes support reconciliation and self-determination through mutual benefit sharing and the repositioning of First Nations knowledge holders as experts (Weerts & Sandmann, 2008; Wynberg et al., 2009).

Research has shown that developing relationships between universities and First Nations Peoples can be constrained by a number of contributing factors, including limited funding, tight budgets, short timelines, and project deadlines, which are often confounded by cultural protocols, community concerns and availability (Booth, 2014; Solomon & Randall, 2014). This was also reported by unit convenors in this study who expressed that there is often not a lot of engagement with communities and when universities do approach community, it is often met with suspicion because of the way universities have marginalised, trivialised, romanticised, devalued, excluded, and exploited Indigenous Peoples knowledges and customary practices in the past (Nakata, 2007). This has been noted in previous studies where community members perceive that universities and/or academics are using the partnerships to benefit the university or academic without regard to how the community might benefit (Cherry & Shefner, 2004; Williamson et al., 2016). This causes reluctance and avoidance of community members to engage with universities (Gelmon et al., 1998; Fitzpatrick et al., 2016).

Furthermore, when these relationships can be established, they are often confounded by limited funding and tight budgets that impact project outcomes, this is also impacted by short timelines and project deadlines that don't allow for the development of relationships and respectful engagement with First Nations Peoples to produce the associated outcomes (Putt, 2013). Research has shown that time is rarely invested to ensure that people understand the information provided to them about a research study, this poses significant risks with consent for non-English speaking, Indigenous and vulnerable communities (Janke, 2005; Fitzpatrick et al., 2016). Beyond the issue of consent, is the issue of ownership of the cultural information and research findings which often reside within and benefit the universities (Janke, 2005). These are complex issues that present the need for policy development to include the protection of Indigenous customary knowledges and the dissemination of this information and any associated benefits back into the community (Martin, 2008; Martin & Mirraboopa, 2003; Janke, 2005; Smith et al., 2017; United Nations, 2007; Universities Australia, 2022). Until there is a shift in the way the research is conducted, there will continue to be a lack of participation and engagement by First Nations Peoples.

5.6 Key Recommendations

This study provided several key recommendations for science education policy and practice including:

1. Undertaking of a national review to audit and evaluate current inclusion of Indigenous knowledges in Australian university curricula.
2. Development of a framework of practice that guides university teachers how to include Indigenous knowledges.
3. Development of a framework that guides teachers on how to teach Indigenous knowledges and perspectives drawing on Indigenous pedagogies.
4. Resource guides to assist university teachers to develop and administer appropriate assessment tasks that reflects students understanding of Indigenous knowledges.
5. A national review of university student's understanding of Indigenous Science.
6. A national review of university staff participation in cultural awareness and cultural competency training.
7. Creation of university positions for First Nations Peoples in teaching, academia and research in all science areas.
8. Development of respectful and reciprocal relationships between universities and First Nations Peoples through knowledge and benefit sharing.

These recommendations demonstrate the need for the development of frameworks to support the inclusion of Indigenous knowledges in the university science curricula. This requires changes in National science, and educational, policies and practices, to recognise Indigenous ontology, epistemologies and Indigegogy through gulbhana, ngurruwigarra, gana and garra to create a greater understanding of the world around us.

5.7 Future Directions

There are currently no cultural frameworks or policies for how to include Indigenous knowledges in Australian university education curricula and there are very few guidelines developed by First Nations Peoples that provide recommendations on how to identify appropriate customary knowledges, what knowledges to include and more importantly what knowledge should not be shared. There is an emerging body of research that tends to focus on pedagogical practice and partnerships between education providers and First

Nations Peoples (Fullan & Langworthy, 2014; Lloyd et al, 2015; Mellor 2004), however, this research often fails to incorporate cultural protocols around the protection of Indigenous cultural and Intellectual property (ICIP). Universities have incorporated cultural awareness and cultural competency training and employed policies and guidelines for community engagement. Yet there is limited research about the implementation of these policies in Australian universities. This raises concerns about what content is taught in the training, the duration of the training, how many university staff have completed this training and about how they apply this in their research, curricula, teaching and learning practice. Cultural awareness and competency training requires an ongoing process of personal reflection, to reveal the inequitable structures of power and privilege of race and challenge the negative stereotypes and the individual and institutional racism and prejudices of white privilege (Behrendt et al., 2012; Curtis et al, 2019). This involves balancing the organisation's priorities with that of the community, through a conscious awareness and constant evaluation and negotiation between the differing power relations (Clifford & Petrescu, 2012). Ma Rhea et al (2012) reported that generic cultural competency training provides superficial support for educators and has not improved educator's confidence in including Indigenous knowledge in the curricula. This was supported by the convenors in this study who highlighted the need for the development of a cultural framework to guide educators about how to include Indigenous knowledges in Australian university curricula.

Whilst there are challenges to Indigenous community engagement, it is an essential process that is imperative for the inclusion of Indigenous knowledges in the university curricula. However, this needs to be done in ways that promote cultural connection and support cultural safety, collaboration, capacity building and benefit sharing by respecting the cultural protocols for the safeguarding of Indigenous knowledges (Janke, 2018; Burgess et al, 2019). Furthermore, Indigenous engagement in university curricula should also provide opportunities for First Nations Peoples, not just through involvement in the planning, development, and delivery of the unit content, but through provision of employment opportunities and positions for representation on boards and committees to build effective governance and capacity for both First Nations Peoples and Universities.

Furthermore, research into students' experiences and understanding of Indigenous knowledges would be very beneficial to guide further development of these units to enhance the intercultural and intergenerational transfer of customary knowledges and practices. Only one of the unit convenors who participated in this study had sought out structured feedback from students. Student feedback and unit evaluation is essential for

determining students understanding of Indigenous knowledges and perspectives. In addition, the feedback from Indigenous students is of utmost importance from my Indigenous standpoint. As a Wiradjuri yinna and Indigenous researcher, I like other Indigenous leaders and knowledge holders deserve to know how Indigenous youth perceive Indigenous knowledges teaching from within university structures, that have a history of subjugation and harm to our communities and knowledge systems.

5.8 Limitations of This Research

There were several limitations to this study. Firstly, the desktop review may not have identified all Indigenous Science units in the Faculty of Science in Australian Universities, for example, private universities were not listed on the Universities Australia website. Also, restriction of the boolean search terms to “Indigenous” AND “Science” may have excluded Indigenous Science units that were named using the terms “Aboriginal”, “Torres Strait Islander”, or in an Indigenous Language. Furthermore, only 12 of the 19 unit convenors of Indigenous science units were able to participate in the research. The short timeline of my project meant that some unit convenors were not able to take part in the research due to teaching commitments and workload which means that the results are not reflective of all unit convenors of Indigenous Science units in Australian Universities.

The results of my study may also have been affected by participant bias as I declared my cultural identify as a First Nations Person. It may be that the participants did not want to be offensive, and this could have influenced what information they revealed to me. Moreover, my identity as a First Nations Woman and the way I interpreted and explained the information was always going to be from an Indigenous Women’s standpoint and could be considered biased towards Indigenous inclusion and empowerment. However, this is the directive from international to national policies – for enhanced inclusion and respectful engagement. I have thoughtfully reflected in the convenors responses and integrated them with what I read in the literature and have learnt growing up as a Wiradjuri *yinna*. Therefore, I see my potential bias as a real strength of this research and hope to influence how Indigenous science is developed and taught in university settings.

Unfortunately, the lack of responses from convenors with regard to contacts for Indigenous Peoples they worked with to develop and deliver the units, prevented me from researching Indigenous perspectives and experiences from First Nations Elders, Knowledge holders and community members. However, I was able to capture the perspectives and

experiences of four Indigenous Academics who were convenors of units, as well as Aunty Fran Bodkin as an Elder involved in development of the Western Sydney University subject. However, similar to the lack of Indigenous representation in the university system as a whole, the disproportionate responses of Indigenous participants left a significant gap in my research that can hopefully be filled through future research.

Chapter 6 Conclusion

Inclusion of Indigenous knowledges in the Australian university science curriculum is faced with many challenges from poor delivery and recognition of the value of Indigenous knowledge in science faculties. To the pedagogical methods used to teach Indigenous knowledges and the limited engagement of Indigenous Peoples in these processes. However, inclusion of Indigenous knowledges in the science curriculum can provide an opportunity to celebrate Indigenous Australian history that pre-dates European colonisation and provide a foundation for innovative approaches to teaching and learning that promotes social change for a shared and sustainable future for everyone.

Academics and educators wanting to teach Indigenous knowledges need to be open to considering other ways of investigating and understanding of how knowledge is created. The cultural interface, although a complex and challenging space, provides a useful concept for understanding Indigenous and Western science and could leverage new knowledge and innovative practice, which is considered vital to addressing the challenges of environmental and climate change. However, to truly Indigenise the university curricula Indigenous knowledges must be taught through Indigegogy - Indigenous ways of *gulbhana*, *ngurruwigarra*, *gana* and *garra* - by the teachings of our Elders, knowledge holders and on and by Country. This study provided several recommendations that demonstrate the need for the development of frameworks to support the inclusion of Indigenous knowledges in the university science curricula. This requires changes in National science, and educational, policies and practices, to recognise Indigenous ontology, epistemologies and Indigegogy through *gulbhana*, *ngurruwigarra*, *gana* and *garra* to create a greater understanding of the world around us.

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Appendix 1

Partnerships between Universities and First Nations People in the development of the Indigenous Science Unit

Name of Unit	Which First Nations Elders, Community members or Organisations were involved and what did they contribute and how?	How did you form these relationships?
Indigenous Engagement: Natural Resources Management	Worked with TO from the Taungurung Land and Waters Council, as well as staff from NIKERI: The National Indigenous Knowledges Education Research Innovation at Deakin University. I also have consulted with the WATHAURONG Aboriginal cooperative and carried out some research work with them on their grasslands.	Some have been past students, others through staff at NIKERI, and through introductions from other people.
Mangamai'bangawarra: Indigenous Science	Aunty Dr Frances Bodkin, a Dharawal knowledge holder and storyteller, was involved with Dr Trevor Bailey to bring the unit into being. Aunty Fran and her son Prof Gaiwain Bodkin-Andrews were involved in the recording of the Dharawal stories that are the centrepiece of the unit and form the 13 modules (an audio file along with the written transcript).	I believe that Dr Bailey and Aunty Fran began talking at a university event and forged the partnership from there. I have since connected with Prof Bodkin-Andrews through WSU staff events and look to re-establish his relationship with the unit again in 2022.

	<p>As the unit has evolved, Aunty Fran remained in contact with Dr Bailey and regularly provides additional stories that can be used for the main assessment piece in the unit which is designed around oral knowledge transmission.</p>	
IA1012, Indigenous People of North Queensland.	<p>Not appropriate to name as I do not have permission protocols in place regarding this questionnaire request.</p>	<p>Community engagement, academic engagement</p>
<p>UNSW (2014-2016) ATSI 2015: Indigenous Science ATSI 3006: The Astronomy of Indigenous Australians University of Melbourne (2021-Current) PHYC10010: Indigenous Astronomy</p>	<p>Meriam - Torres Strait (Ron Day, Segar Passi, Alo Tapim, Elsa Day, Andrew Passi, John Barsa, William Bero, Lilah Noah, etc) Mualgal - Torres Strait (David Bosun) Kamilaroi/Euahlayi - NSW (Ghillar Michael Anderson) Boon Wurrung - VIC (N'aweeet Carolyn Briggs) Wiradjuri - NSW (Scott Sauce Towney and others)</p> <p>Direct consultation with Elders and Knowledge Holders. These Elders also co-authored academics papers and a book on the subject, which are required reading.</p>	<p>Years of collaboration, invitation, and work.</p>

	<p>Maori - NZ (Rangi Matamua and Pauline Harris)</p> <p>Lakota - USA (Annette Lee)</p> <p>Secwépemc - Canada (John Paul Eagleheart)</p> <p>Northern Dene - USA/Canada (Chris Cannon)</p> <p>Collaboration with scholars in these fields - all of which (except for C. Cannon) are Indigenous to those communities.</p>	
Indigenous Cultural and Natural Resource Management	Sam Provost	long-time relationships...
Indigenous Science: Science through the eye's of Australia's first People's	<p>We asked permission to develop the unit from the Monash Indigenous engagement group (William Cooper Institute) and worked with them throughout the development for guidance. We were unable to have the involvement of Auntie Diane who is the Elder in residence as she was on extended sick leave. We worked with two Aboriginal teaching associates who taught on the class and helped develop material and we had a Torres Strait Islander project student help with some of the question development and</p>	<p>I had met Damien Bell before, and we had some contacts in common including him working with the mother of one of the teaching assistants. So, we developed the relationship from there including a visit down.</p> <p>Murrundindi was an introduction from a student.</p>

	<p>electronic resources. We had two guests from Victoria. Damien Bell who at the time was the CEO of the Gunditj Mirring traditional owner's Aboriginal corporation and Wurrandjeri Elder Murrundindi.</p>	
NPSC1003 Integrating Indigenous Science and STEM	<p>1.The Center for Aboriginal Studies - co teach the unit Tracy Kickett - employed to write the content.</p> <p>2. In development and teaching Elders from the Swan River and Ballardong Nations of the Noongar People of the Southwest were and are consulted. There are also contributions from other Aboriginal and Torres Strait Islanders Peoples via publications and resources they have developed over the years.</p> <p>3.Nyungar</p>	<p>1.Both faculties are at Curtin university.</p> <p>2. They relationships with the local Elders have been in place as a part of CAS's normal engagement processes. The other Elders knowledge is identified and sourced via the diverse cultural knowledges of the Indigenous tutors employed by CAS.</p> <p>3. The writer is Nyungar</p>
Indigenous Engineering and Design	NO RESPONSE	NO RESPONSE
Natural resources and Indigenous livelihoods	I am not sure how people were initially engaged in the content to first develop the unit, but we do have a number of	Our university and research institute has a long involvement with research with Indigenous

	<p>Indigenous organisations who present to the students about their livelihoods and enterprises - these vary from year to year but include organisations from Darwin region and outer Darwin Arnhem land, Kakadu National Parks, land councils, Indigenous land management organisation and NGOs, individual scholars, and tourism guides.</p>	<p>organisations in the NT. We work together on a range of collaborative research and teaching areas.</p>
Australian Aboriginal Sustainability Systems	NO RESPONSE	NO RESPONSE

08/04/2022

Dear Dr Emilie Ens,

Reference No:520221123937107

Title: 11239 Indigenous science unit review

Thank you for submitting the above application for ethical and scientific review. Macquarie University Human Research Ethics Committee HREC Humanities & Social Sciences Committee considered your application.

I am pleased to advise that ethical and scientific approval has been granted for this project to be conducted by Dr Emilie Ens and other personnel: Miss Renee Cawthorne, Dr Leanne Holt.

Approval Date: 08/04/2022

This research meets the requirements set out in the *National Statement on Ethical Conduct in Human Research* (2007, updated July 2018) (the *National Statement*).

Standard Conditions of Approval:

1. Continuing compliance with the requirements of the *National Statement*, which is available at the following website: <http://www.nhmrc.gov.au/book/national-statement-ethical-conduct-human-research>
2. This approval is valid for five (5) years, subject to the submission of annual reports. Please submit your reports on the anniversary of the approval for this protocol.
3. All significant safety issues, that adversely affect the safety of participants or materially impact on the continued ethical and scientific acceptability of the project, must be reported to the HREC within 72 hours.
4. Proposed changes to the protocol and associated documents must be submitted to the Committee for approval before implementation.

It is the responsibility of the Chief investigator to retain a copy of all documentation related to this project and to forward a copy of this approval letter to all personnel listed on the project.

Should you have any queries regarding your project, please contact the Ethics Secretariat on 9850 4194 or by email ethics.secretariat@mq.edu.au

The HREC Humanities & Social Sciences Committee Terms of Reference and Standard Operating Procedures are available from the Research Office website at: <https://www.mq.edu.au/research/ethics-integrity-and-policies/ethics/human-ethics> The HREC Humanities & Social Sciences Committee wishes you every success in your research. Yours sincerely,

Dr Karolyn White
Chair, HREC Humanities & Social Sciences Committee

This HREC is constituted and operates in accordance with the National Health and *Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007, updated July 2018)* and the *CPMP/ICH Note for Guidance on Good Clinical Practice*

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