Teacher Background Information

This document is designed to be read as further information to the First Nations Australian Counting Systems webinar delivered under the Maths in Schools program in collaboration with ATSIMA. The material has been through a specialist review by Professor Chris Matthews and was developed by Dr Caty Morris, Aboriginal and Torres Strait Islanders Maths Alliance (ATSIMA).

First Nations Australian Navigation and Mapping

For tens of thousands of years, First Nations Australians have skilfully navigated and mapped Australia's vast land, sky and waters:

> '.... the history of this land has been mapped to features and events in the sky' for over 65,000 years through the 'power of language, song and dance' and visual images, and has passed across some 2000 generations. (Noon & De Napoli, 2022, pp. 3-4).

This Teacher Background Information supports educators to showcase the deep time histories, cultures, and knowledges of First Nations Australians, specifically focussing on navigation and mapping. Through this rich context, teachers can engage with mathematics, offering students a rich, cross-curriculum learning experience that aligns with the key concept of Country/Place in the Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority in the Australian Curriculum: Mathematics.

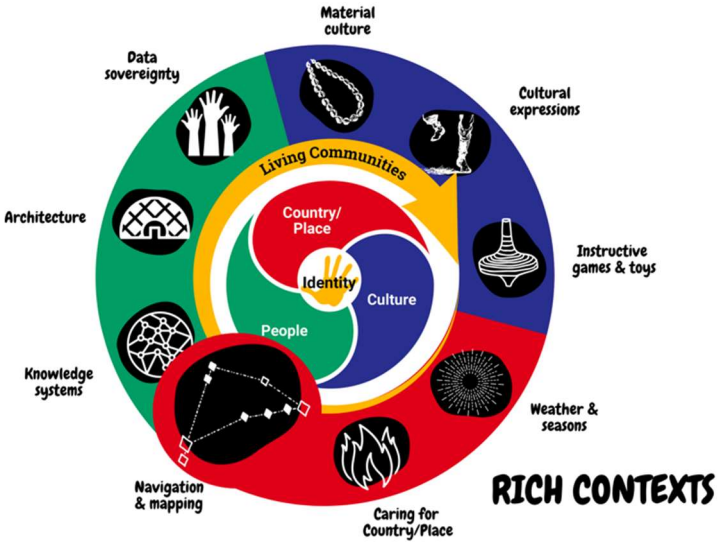

Figure 1: First Nations Australian rich contexts in the Australian Curriculum: Mathematics

While this Teacher Background Information highlights First Nations Australians' traditional knowledges and practices, it also intersects with contemporary practices and modern technologies such as the use of drones and cutting-edge mapping tools. It

brings together the incredible cultural knowledges and understandings of First Nations peoples with Western science, the importance of these knowledge-based relationships, and how they are working together. This Teacher Background Information centres the knowledge and lived experiences of First Nations Australians and foregrounds the work of First Nations people, including Karlie Noon, a Gamilaraay astronomer and science communicator, and Krystal De Napoli, a Kamilaroi educator and astrophysicist, who advise that:

> Integrating Indigenous astronomy into modern, mainstream knowledge systems, such as school and university curriculums…is a way to acknowledge Indigenous peoples' cultural and intellectual significance and conduct truth-telling about this continent's First Peoples (Noon & De Napoli, 2022, p. 128).

This Teacher Background Information also celebrates the important and invaluable contributions of First Nations Peoples and their histories and cultures to the advancement of science all over the world.

Introduction

First Australians' navigation and mapping are based on sophisticated knowledge systems that have been developed over thousands of years. They reflect deep knowledge and understanding of the environment - of Country/Place, sky, waters and the natural world - across vast and diverse landscapes from the deserts to the coastal areas of Australia and beyond.

> Aboriginal and Torres Strait Islander knowledge of the features of the world and navigation methods involved geographical, astronomical and environmental knowledge that was transmitted by various means, including cultural narratives, songs, star maps, and visual designs.
>
> Aboriginal and Torres Strait Islander Peoples developed and used expert knowledge to navigate through country for many reasons – to trade, to find materials for tools, in search of seasonal foods, for social interactions and to find reliable sources of water. This knowledge also had to be shared with others and mapping techniques were developed to achieve this. Significant markers such as the direction of sunrise, unusual geological outcrops and stars were often used for this purpose. Many elements of the Dreaming contain oral maps which allowed the transfer of this map information (University of Melbourne, 2023).

How is First Nations' astronomy different to Western astronomy? Noon and De Napoli (2022) explain:

> What makes Indigenous astronomy different from Western astronomy? How can they complement each other and work expansively together? In the Western system, astronomy is seen as a science, separate from the arts and humanities and even other branches of science, a field of study that belongs to experts and specialists generally known as astronomers. Indigenous astronomy, however, is an integral part of the Indigenous knowledge systems that inform all aspects of everyone's life, visibly refreshing traditions, culture and practices nightly (p. 10).

Connecting maths with culture: What students can learn

First Australians' navigation and mapping are based on sophisticated knowledge systems that have been developed over thousands of years. They reflect deep knowledge and understanding of the environment - of Country/Place, sky, waters and the natural world - across vast and diverse landscapes from the deserts to the coastal areas of Australia and beyond.

> Aboriginal and Torres Strait Islander knowledge of the features of the world and navigation methods involved geographical, astronomical and environmental knowledge that was transmitted by various means, including cultural narratives, songs, star maps, and visual designs.
>
> Aboriginal and Torres Strait Islander Peoples developed and used expert knowledge to navigate through country for many reasons – to trade, to find materials for tools, in search of seasonal foods, for social interactions and to find reliable sources of water. This knowledge also had to be shared with others and mapping techniques were developed to achieve this. Significant markers such as the direction of sunrise, unusual geological outcrops and stars were often used for this purpose. Many elements of the Dreaming contain oral maps which allowed the transfer of this map information (University of Melbourne, 2023).

First Australians' navigation and mapping

First Nations Australians' navigation and mapping are inextricably connected and reflect sophisticated knowledge systems that are based on unique understandings of geography and spatial awareness that guide travel across Australia's vast land and waters.

The Australian Curriculum: Science includes teacher background information for the Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority that connects with mathematics, and explains navigation:

> Aboriginal and Torres Strait islander Peoples have navigated the lands and waters of Australia for many thousands of years using knowledge of astronomical phenomena and the omnipresent patterns in the sky as a navigational system. Aboriginal and Torres Strait islander Peoples have made repetitive observations of the patterns in the sky for thousands of years, collecting a significant bank of astronomical data in the process. As a result, Aboriginal and Torres Strait islander Peoples recognised that many of these phenomena occur in regular, dependable cycles of known intervals (ACARA, 2019, p. 250).

There are a number of types of mapping mentioned throughout this Teacher Background Information and explained below. Note that this is not inclusive of all the different forms of mapping used in traditional and contemporary practices.

Cultural mapping

Cultural mapping is described as:

> ...the process of documenting and representing the cultural resources, heritage, and assets of a specific individual, community, or geographical area. It includes elements such as landmarks, traditions, advocacy tools, and truth-telling.
>
> Winyama employs multiple methods of cultural mapping to document the intricate layers of local traditions and life experiences (Winyama, 2024).

(Examples of cultural mapping methods are discussed further in the Contemporary practices section.)

Songlines and star maps

Noon and De Napoli (2022) explain Songlines in relation to the sky:

> Just as the Songlines that crisscross this continent are visualized as pathways or corridors of knowledge linking natural features – understood as archives of knowledge – so too are the Songlines in the sky...'astronomical highways'. They too contain

> knowledge critical to our physical, spiritual and social survival…they are aids for navigation and seasonal tracking and serve as a calendar for ceremonial events, holding information about the location and availability of resources in any particular season in different parts of the country (pp. 3-4).

First Nations Australian ways of navigation and mapping highlight a deep understanding of the environment and connection to the land, sky and waters that have been developed and maintained over thousands of years. For example:

> Yolngu traditions describe Venus as the morning star, a female spirit who guides other spirits to their destinations. This is a Songline that incorporates Venus's journey across the Top End. It details many of the land's features, such as waterholes, on the terrestrial part of her journey. As such, the Venus or Barnumbirr Songline acts as an oral map for some Yolngu clans. However, it is more than a cartographic map: it is also a cultural map laid down by the ancestors incorporating knowledge and lessons about the spiritual and the ecological, as well as the rules and protocols of not only surviving but living properly. Each site links together to create the Songline and focuses on different lessons (Noon & De Napoli, 2022, p. 98).

Further to this, Noon and De Napoli (2022) discuss star maps:

> Star maps were another technique developed by nations to aid travel. The Kamilaroi and Euahlayi nations used 'patterns of stars to represent routes of travel on land'. For example, each star in a constellation refers to a specific landmark on the ground, while the pattern as a whole indicates direction. The landmarks may be features such as waterholes, or indicators of where direction may need to be adjusted. As shared by Uncle Ghillar in a paper by Robert Fuller and colleagues, one star map describes a 600-kilometre journey from Goodooga, New South Wales, to Carnarvon Gorge, Queensland. Goodooga is represented by Gamma Sagittarii (γ Sagittarii), and the route goes via Dirranbandi (Sigma [σ] Librae), St George (Girtab), Surat (Sargas) and Roma (Eta [η] Scorpii) until it reaches Carnarvon Gorge (Zeta [ζ] Scorppii) (pp. 98-99).

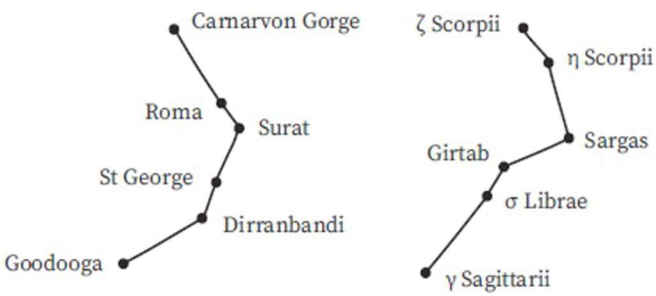

Figure 2: 'Rather than providing to-scale maps of the land, star maps relate to significant waypoints on journeys and often mirror preferred routes. This Euahlayi star map portrays a journey travelling northward from Goodooga to Carnarvon Gorge.' Noon & (De Napoli, 2022, p. 99)

Sand maps

First Nations Australians traditionally utilised a form of mapping called Sand Maps. This form of mapping is generally used in desert communities in the centre of Australia. They are created in the sand using the natural environment and the cultural knowledge of Country and can convey detailed information about, for example, the geography, resources, and significance of the land.

Image source: Mayi Kuwayu The National Study of Aboriginal & Torres Strait

Sand maps can represent the landscape, such as the location of waterholes, landforms and animal tracks. These important features of Country are conveyed through patterns in the sand, where different lines and shapes can represent pathways through the landscape, such as Songlines. Each map is a visual-aid tool that enables people to recall routes and geographical knowledge.

Image: Nyurpaya Kaika Burton OAM, performing Milpatjunanyi at her home, courtesy Tjala (Common Ground, 2021)

Sand maps can also be used for educational purposes through storytelling. They can teach children about the land, its resources, and the stories that are connected to different places by serving as a visual aid to enrich the telling of cultural narratives.

While First Nations Australian navigation and mapping practices are based in oral traditions and deep knowledge of Country, many Communities today continue to use these valuable knowledge systems. Many Elders continue to pass on knowledge that is increasingly being recognised by the Western world as a valuable way to understand the land, sky and waterways rather than overlooked as is often the practice by Western community.

First Nations Australian navigation and mapping generally use a combination of Songlines, natural landmarks, seasonal knowledge, and environmental awareness that deeply reflect an optimal and sustainable connection to Country. Today, the fusion of First Nations Australian knowledge systems in navigation and mapping with new, cutting-edge technologies provides for contemporary practices that help to preserve this rich heritage. This exciting intersection of First Nations Australian knowledge systems in navigation and mapping with innovative, cutting-edge technologies offers a unique opportunity to bring deep time understandings into contemporary practices.

Teachers can showcase this invaluable knowledge by enriching teaching and learning, paving the way for new, culturally responsive approaches to education that honour the past while shaping the future.

Contemporary practices

As new technologies emerge, Aboriginal and Torres Strait Islander people and Communities have been actively working to preserve tens of thousands of years of knowledge and stories through physical maps and traditional mapping methods that safeguard this heritage for future generations. Winyama is one organisation that fuses deep time knowledge with new cutting-edge technologies.

Winyama

Winyama is an Indigenous-owned geospatial consultancy that works with Indigenous people and communities to provide culturally appropriate mapping services and data solutions.

Geospatial technologies are described as:

> ...a term used to describe the range of modern tools contributing to the geographic mapping and analysis of the Earth and human societies. These technologies have been evolving in some form since the first maps were drawn in prehistoric times (American Association for the Advancement of Science, 2024).

Winyama works with many Aboriginal and Torres Strait Islander Communities and groups across Australia. An exciting example of Winyama's work in partnering with Communities is reported by the National Indigenous Times:

> Karri Karrak Aboriginal Corporation (KKAC) has officially launched its Cultural Mapping Project, designed to map and identify sites of Noongar heritage across the Boodja (Country) under the Corporation's stewardship.
>
> The project seeks to capture oral histories, cultural practices, traditional land-use patterns, and significant cultural sites. A key focus is placed on the importance of

waterways, landscapes, seascapes, and traditional sites that hold deep meaning within Noongar heritage.

The initiative is a priority for KKAC, with the goal of creating personalised cultural maps for each participating Elder and Senior Knowledge Holder. The individual maps will be consolidated into a comprehensive digital archive of Noongar heritage, encompassing Wardandi, Bibulmun, and Kaneang Boodja.

The archive will be presented through an accessible digital map, allowing for the interpretation and preservation of cultural knowledge.

In addition to mapping heritage, the project will ensure that cultural protocols—rooted in the wisdom of Elders and Senior Knowledge Holders—are documented and upheld in relation to the lands and waters of Karri Karrak Boodja.

The effort reflects KKAC's commitment to safeguarding and celebrating Noongar heritage, creating a lasting legacy of cultural knowledge for future generations (Clark, 2024).

Winyama also works with First Nations Ranger groups to preserve the environment through 'planning and revisiting traditional cultural mapping techniques, seeking innovative ways to integrate them into new technologies' (Winyama, 2024).

> Winyama works with First Nations rangers to help build their digital skills and equip them with 'cloud-based geospatial technologies to better care for Country…Winyama seeks to upskill these rangers and organisations, training them on mapping technologies and demonstrating how digitising processes lets communities capture valuable First Nations knowledge at scale. (Amazon staff, 2022).

First Nations Ranger groups

There are over 120 First Nations Ranger groups across Australia drawing on knowledge and connection to Country developed over thousands of years to manage and protect land and waters. Many have been established to counter the damaging effects of colonisation and care for Country/Place using a range of digital technologies to assist them.

Traditional Owners are often involved with First Nation Ranger groups and work with scientists and other land managers by bringing together First Nations' ecological knowledge and connection to Country/Place with 'modern' science in a two-way process of effective land and water management that includes the use of digital technologies.

Did you know?

First Nations Australian's mapping and navigation have been used to develop roadways throughout Australia:

> The next time you're driving down a country road in outback Australia, consider there's a good chance that very route was originally mapped out by Aboriginal people perhaps thousands of years before Europeans came to Australia (Fuller, 2016).

Aboriginal and Torres Strait Islander histories and cultures in the Australian Curriculum: Mathematics | Navigation and mapping

While the following content from the Australian Curriculum: Mathematics (ACARA, 2022) outlines options for teaching and learning, there are many, many more opportunities to use First Nations Australians' navigation and mapping as indicated in the *Connecting maths with culture* section in this Teacher Background Information and below:

- ⇒ give and follow directions to move people and objects to different locations within a space AC9M1SP02 | describing a familiar journey across Country/Place using directional language
- ⇒ recognise and use the relationship between formal units of time including days, hours, minutes and seconds to estimate and compare the duration of events AC9M3M03 | exploring how cultural accounts of First Nations Australians explain cycles of time that involve the sun, moon and stars
- ⇒ interpret and create two-dimensional representations of familiar environments, locating key landmarks and objects relative to each other AC9M3SP02 | exploring land maps or cultural maps used by First Nations Australians to locate, identify and position important landmarks such as waterholes
- ⇒ solve problems involving the duration of time including situations involving "am" and "pm" and conversions between units of time AC9M4M03 | exploring First Nations Australians' explanations of the passing of time through cultural accounts about cyclic phenomena involving sun, moon and stars
- ⇒ locate points in the 4 quadrants of a Cartesian plane; describe changes to the coordinates when a point is moved to a different position in the plane AC9M6SP02 | investigating and connecting land or star maps used by First Nations Australians with the Cartesian plane through a graphical or visual way of describing location
- ⇒ represent objects in 2 dimensions; discuss and reason about the advantages and disadvantages of different representations AC9M7SP01 | exploring different two-dimensional representations of objects in First Nations Australians' artworks or cultural maps of Country/Place
- ⇒ describe the position and location of objects in 3 dimensions in different ways, including using a three-dimensional coordinate system with the use of dynamic geometric software and other digital tools AC9M8SP03 | exploring position and transformation through geospatial technologies used by First Nations Australians' communities
- ⇒ solve practical problems applying Pythagoras' theorem and trigonometry of right-angled triangles, including problems involving direction and angles of elevation and depression AC9M10M03 | exploring navigation, design of

Connecting with Community

Learning opportunities can be further contextualised and deepened through a process of engagement and connection with local Aboriginal and Torres Strait Islander Communities, knowledges, and languages. Acknowledging, consulting, and collaborating with Community provides opportunities for two-way learning that is essential for creating, implementing and evaluating resources, teaching and learning strategies, and curriculum content. All students benefit. Figure 3 below was developed by Prof. Joe Sambono and relates to science but can be adapted for mathematics

> Figure [3 below] provides educators some support to know the limit and the distinction between showcasing culture vs overstepping the mark and inadvertently finding yourself teaching someone else's culture. The context could be switched with any number of particular First Nations groups' knowledges, technologies, or processes. This figure would equally work when exploring a particular Nation's medicines, geology, ballistics, fish poisons, skin tanning and so on. In this case I have used the context of cordage (string/rope/twine).
>
> From the graphic you can see that independently. as an educator what you can reveal to students gets reduced as you get closer to your local First Nations context. At this terminal point you become limited to revealing to students only the highest level of information. In this example teachers can explain to students that the muwinina* People had used their scientific inquiry skills to gain knowledge of both natural and processed materials to develop cordage technologies (various ply types) prior to colonisation and it was employed in domestic uses e.g., fishing lines and nets etc. However, you can see from the graphic that if you are able to form partnerships with your respective community that the richness and opportunity for your students can greatly expand. Through community involvement and decision-making of what is shared or approved, students can gain an authentic and deeper understanding of muwinina cordage technologies including cultural aspects, discussions regarding Intellectual Property and potential opportunities for students to conduct inquiries into muwinina cordage performance and the potential for classroom discussions regarding how such knowledges could inform contemporary material science (biodegradable string etc.). However, if I read early colonist accounts of how the muwinina people collected and processed particular plant species for string making fibres and:
>
> independently took my students into the field
> had students collect the identified species plant material
> taught my students how the muwinina people
> processed the fibre
> had students make muwinina string
>
> then of course **I have crossed the line**.
>
> I am without authority teaching a muwinina cultural practice. I am without permission appropriating muwinina Cultural and Intellectual Property. The natural and processed materials context is discussed and demonstrated in this vignette produced by the South Australian Department for Education through its South Australian Aboriginal Contexts in Science Initiative and used here with permission: https://www.youtube.com/watch?v=qllgFracA0o (Sambono, 2021, pp. 11-12)

especially as many of the Aboriginal and Torres Strait Islander content elaborations in the Australian Curriculum: Mathematics connect with science (and other learning areas). Sambono (2021) explains:

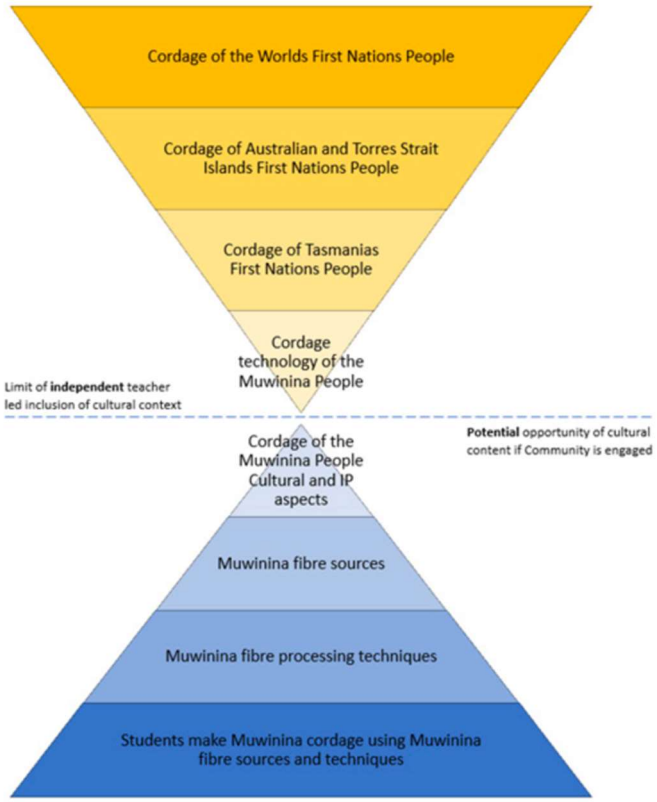

Figure 3: Framework to support educators delineating between showcasing First Nations Australians histories and cultures in classrooms vs unauthorised teaching of culture. (Used with permission from the author, Joe Sambono, 2024)

Selecting resources

When considering culturally responsive mathematics resources, it is recommended that educators use the *AIATSIS Guide to evaluating and selecting education resources* listed in the *Consulted works* section below. The Guide is designed to support educators to make 'conscious and critical decisions when selecting curriculum resources, to ensure they reflect all children, including Aboriginal and Torres Strait Islander students, and cause no harm' (AIATSIS, 2022).

Recommended resources

- Ngarrngga. (2024). Stellar Navigation and Mathematics. https://www.ngarrngga.org/curriculum/stellar-navigation-and-mathematics
- Ngarrngga. (2024). Navigating Our Way Through Country. https://www.ngarrngga.org/curriculum/navigating-our-way-through-country
- Ngarrngga. (2024). Mathematics, Moon Phases, and Tides. https://www.ngarrngga.org/curriculum/mathematics-moon-phases-and-tides
- ABC Behind the News. (2016). Aboriginal Astronomy. https://www.abc.net.au/btn/classroom/aboriginal-astronomy/10523908
- Songlines of Australia podcast featuring Dr Lynne Kelly who discusses how oral societies use songs and stories as memory aides to pass down knowledge and information necessary for the survival of their culture over many millennia (1:01:08): https://songlinesaustralia.libsyn.com/01-dr-lynne-kelly-author-of-the-the-memory-code-2016-talks-about-aboriginal-songlines-and-how-oral-non-literate-cultures-around-the-world-embedded-vast-amounts-of-knowledge-and-information-into-the-landscape-to-act-as-a-memory-aid

Consulted works

In this Teacher Background Information, consulted works or references have been listed, providing evidence of the research undertaken to inform the development of the teacher background information. Please note that some of the sources listed in the consulted works may contain material that is considered culturally offensive or inappropriate as they may have been based on, or influenced by Western beliefs, bias and prejudice. However, they have been used as they include important information. The consulted works are not provided or recommended as classroom resources.

ACARA. (2019). *Australian Curriculum: Science - Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority: Content elaborations and teacher background information for Foundation to Year 6*. ACARA. https://www.australiancurriculum.edu.au/media/5653/ccp-tbi-f-6-ver5-online.pdf

ACARA. (2022). *Australian Curriculum version 9*.

AIATSIS. (2022). *AIATSIS Guide to evaluating and selecting education resources*. Australian Institute of Aboriginal and Torres Strait Islander Studies Retrieved from https://aiatsis.gov.au/publication/118125

Amazon staff. (2022). *Indigenous IT consultancy Winyama helps close the digital gap in remote communities*. https://www.aboutamazon.com.au/news/aws/indigenous-it-consultancy-winyama-helps-close-the-digital-gap-in-remote-communities

American Association for the Advancement of Science. (2024). *What are geospatial technologies?* https://www.aaas.org/programs/scientific-responsibility-human-rights-law/overview-geospatial-project

Clark, R. (2024). Karri Karrak honouring heritage and self-determination with Cultural Mapping Project. *National Indigenous Times*. https://nit.com.au/15-10-2024/14266/karri-karrak-cultural-are-honouring-heritage-and-self-determination-with-mapping-project

Fuller, R. S. (2016). *How ancient Aboriginal star maps have shaped Australia's highway network*. https://phys.org/news/2016-04-ancient-aboriginal-star-australia-highway.html

Noon, K., & De Napoli, K. (2022). *Astronomy: Sky Country*. Thames & Hudson.

Sambono, J. (2021). The Aboriginal and Torres Strait Islander Histories and Cultures Cross-curriculum Priority: Supported cultural responsiveness in education. *SASTA Journal: Teaching Indigenous Science - A resource guide for science educators* (1), 4-13.

University of Melbourne. (2023). *Ngarrngga*. https://www.ngarrngga.org/

Winyama. (2024). *Indigenous geospatial consulting*. https://www.winyama.com.au/