Teacher Background Information

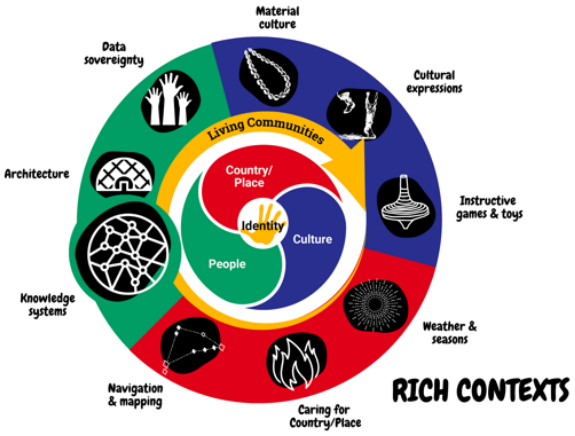
This document is designed to be read as further information to the First Nations Australian Counting Systems webinar delivered under the Maths in Schools program in collaboration with ATSIMA. The material has been through a cultural review by Professor Chris Matthews and was developed by Dr Caty Morris,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

First Nations Australian Knowledge Systems: Counting

For millennia, Aboriginal and Torres Strait Islander peoples have had a detailed understanding of complex mathematical concepts including distance, counting, ratio, symmetry and rotation. This rich mathematical heritage is deeply embedded in the histories and cultures of First Nations communities, offering a unique lens through which to explore mathematics in the Australian Curriculum. By integrating these perspectives, educators can not only enhance student engagement, but also foster a deeper appreciation for the diverse ways in which mathematics is understood and applied.

This **Teacher Background Information** showcases the invaluable knowledges, histories and cultures of First Nations peoples and how these rich traditions can illuminate the Australian Curriculum: Mathematics. The mathematics embedded in Aboriginal and Torres Strait Islander counting systems provides an exciting context for students to explore mathematical concepts while connecting with the lived experiences of First Nations Australian peoples.

In the Australian Curriculum: Mathematics, the mathematics situations in First Nations Australian counting systems are connected to the rich context of *Knowledge Systems* through the key concept of *People* in the Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority.



Knowledge Systems are described by Rona Glynn-McDonald, a Kaytetye woman who grew up in Mparntwe (Alice Springs) on Arrernte Country, as follows:

> Across First Nations communities in Australia are unique and distinct cultures that centre many different types of knowledges. These knowledges are often referred to as 'knowledge systems' and have ensured First Nations communities have lived in balance with the land, other communities and the natural environment for over 80,000 years.

> "When we consider knowledge systems from a First Nations perspective, we are looking at many interconnected relationships or pieces of knowledge that overlap and interact with each other without conflict. This is often referred to as kinship or balance**"** *Bundjalung, Thunghutti And Muagal Man, Leeton Lee* (Glynn-McDonald, 2022).

Introduction

In Western mathematics, counting is straightforward and considered to be 'the process of quantifying the number of objects in a set or collection' (ACARA, 2022). In contrast to this Western notion of counting, for First Nations Australians such as the Yolŋu people, counting is more connected whereby 'mathematics is about the patterns and the rhythms, about counting and time and space' (Lloyd et al., 2016, p. 4). Furthermore:

> There is counting and sharing, physics and measurement, and there are cycles of growth and harvesting. Yolŋu look at the water, at the tides coming and going at the flows of the rivers and the movement of light through the sea and see order and system. There is mathematics in the moon and the seasons, in the rain and the clouds. Yolŋu know these things through the land—morrku mangawu. When a wind starts or a flower opens, that is the land teaching. That is Yolŋu mathematics, a mathematics that places Yolŋu in, with and as Country (Lloyd et al., 2016, p. 4).

Yolŋu mathematical practices emerge from the land itself, teaching them to observe and interpret the world around them in ways that are both practical and profound.

Connecting maths with culture: What students can learn

Learning about First Nations Peoples' rich understandings of number and counting offers a unique way for students to deepen their number sense by exploring connections between culture and mathematics. Through this approach, students can:

- **Connect mathematics with real life**: Engage with Aboriginal and Torres Strait Islander contexts, where counting is applied in relatable, everyday ways that can resonate with students' own experiences.
- **Appreciate diverse mathematical systems**: Discover and value the counting systems used by Aboriginal and Torres Strait Islander Peoples, fostering a broader respect for different ways of thinking about numbers including through body-tallying.
- **Uncover patterns and relationships**: Delve into the elements that shape these counting systems, such as the role of language, structure, and cultural context, unveiling unique patterns and relationships.
- **Bridge to familiar concepts**: Link these cultural counting systems to what students already know about the Base 10 system, helping them see connections with the decimal system and enriching their understanding of mathematical concepts in the Australian Curriculum.

- **Solve Real-World Problems**: Apply Indigenous methods of calculation and estimation to practical problems, encouraging students to make sense of the world through culturally related mathematical approaches.
- **Learn maths with purpose**: Explore how First Nations Australian Peoples use quantification, calculation and estimation to serve real purposes, helping students understand the value of maths beyond the classroom.

By showcasing Aboriginal and Torres Strait Islander mathematical concepts, teachers can create a vibrant and inclusive learning environment that respects and reflects Australia's rich cultural heritage. This approach not only broadens students' mathematical perspectives but also celebrates diversity and strengthens their problem-solving skills.

There are many real-life contexts in Aboriginal and Torres Strait Islander histories and cultures in which students can learn about counting systems and develop number sense. By learning maths through First Nations Australian counting systems, students can learn about:

- First Nations Australians' use of number in caring for living things
- investigating the use of grouping and sharing to manage resources such as how food is procured, distributed, or shared such as turtle eggs (see Yolŋu counting below)
- exploring trading activities
- considering First Nations Australian calendar calculations
- exploring ways of communicating number such as through story and dance
- educative contexts such as First Nations Australian children's rhymes, stories and counting games.

Teaching counting based on Aboriginal counting systems can help students (and educators) to understand what counting is.

Dispelling myths and cultivating understanding

Many non-Indigenous Australians were taught at school that 'all Aboriginal peoples only counted one, two, three, four and many' (Norris, 2016). This myth feeds the "terra nullius" notion that continues in many ways today in mathematics education, and in general. 'Although refuted many times, the commonly accepted story about Indigenous communities in Australia is that they had few counting words and thus were lacking in ways to quantify amounts' (Meaney & Evans, 2012).

> However, the real picture is vastly different and the evidence is in the languages. The vocabularies of Aboriginal languages are in fact permeated with items representing concepts which Europeans would label as mathematics. Of equal significance is the way Aboriginal people use their languages to express mathematic ideas and processes. (Cooke, 1990, p. 2).

Shannon Foster, a D'harawal Saltwater Knowledge Keeper, educator and artist of the Botany Bay and Georges River regions in New South Wales, suggests that:

> When exploring our Indigenous knowledges there are a plethora of myths to wade through from the ridiculous to the downright racist. No subject matter is off the table and even mathematics is no exception. The overruling myth associated with Aboriginal people counting seems to be that we can't or don't count beyond four or five. Basically it is one, two, three, many and that is it.
>
> One of the problems here is the fact that it was often linguists who collected most of the data and research on Aboriginal notions of numeracy and of course they came up against a cultural brick wall when trying to understand Aboriginal people's expression of numbers. (Foster, 2017)

First Nations Australians traditionally use number and counting, and estimation and calculation, for many purposes and in many contexts. This includes the application of counting systems, often in combination with other mathematical thinking processes such as pattern recognition and measurement, again dispelling the myth that there was no counting beyond 'one, two, many' by Aboriginal and Torres Strait Islander Peoples. Contrary to this myth, Harris (1987) comments about the 'ability of Aboriginal and Torres Strait Islander people to manipulate…numbers much higher than five, ten or twenty' (p. 30).

There is a rich variety of First Nations Australian counting systems with different bases for counting traditionally applied by Aboriginal and Torres Strait Islander Peoples across Australia using different number-words, different ways of describing very large numbers, and with different ways of symbolic representation of number.

> The use of five and ten, based on the five-fingered hand, is basic to the vast majority of the world's counting systems. Many Aboriginal and Torres Strait Islander groups traditionally count by fives. Much of the mathematics in the counting systems of First Nations Australians is based on the use of language with body and facial language to reinforce meaning and sub-meaning, as well as intent (McRoberts, 1990, p. 24).

Further to this, Foster (2017).explains:

> Aboriginal people use body-tallying to count. Counting on your finger is the most basic form of body-tallying but the next step along is pointing to different parts of the body to refer to different quantities (Foster, 2017).

To summarise, Christie (1995, p. 1) suggests 'that Aboriginal ontologies and epistemology are exactly where we may find highly developed alternatives to the established body of mathematics'.

First Nations Australian counting systems: some examples

Yolŋu counting

Yolŋu Country is in Northeast Arnhem Land in the Northern Territory. The following information comes mostly from the article '*Morrku Mangawu – Knowledge on the Land*: Mobilising Yolŋu Mathematics from Bawaka, North East Arnhem Land, to Reveal the Situatedness of All Knowledges' that was written by Yolŋu and non-Yolŋu authors.

Two of the Yolŋu authors, Merrkiyawuy Ganambarr-Stubbs and Banbapuy Gamanbarr, explain turtle egg counting in the Community of Yirrkala:

> To find the eggs we use Yolŋu mathematics. We look at the tracks of the turtle—it's important we don't just dig anywhere, because when turtles come up onto the beach they turn around and then they dig over here, dig over there—we need to look at the shape of the track, learning the tracks, to see exactly where the eggs were laid in the buried hole. So we don't just go up there and start digging—otherwise it's just ruining the land, we have a look first—the shape of the track, and then try and find where it is. So the kids learn this and they look at the hole and they dig. By digging the kids learn how to identify the air pockets, about depth and length. Then when we bring the eggs out we use a Yolŋu way of counting—waŋgany, marrma, lurrkun, dämbu miriw, one, two, three, four—and then one on the top, that's one rulu—and then there's two rulu, three rulu—and that's how the children are counting there—so learning their way of mathematics. Then they decide, how many will I be taking—how many eggs shall I take home to my mum and dad. It's a living maths.
> *Figure 1: Merrkiyawuy counting miyaupu mapu with Yirrkala School children (Lloyd et al., 2016, p. 8).*

Wotjobaluk counting

Howitt (1883), an English explorer and natural scientist, investigated the use of the counting system amongst the Jajaurung, Wotjobaluk and the Wurunjerri groups in southeastern Australia. His interpretation is represented below in Figure 2.

Aboriginal name	Literal translation	Translation	Number
Giti mŭnya	little hand	little finger	1
Gaiŭp mŭnya	from *gaiŭp* = one, *mŭnya* = hand	the Ring finger	2
Marŭng mŭnya	from *marung* = the desert pine (*Callitris verrucosa*). (i.e., the middle finger being longer than the others, as the desert pine is taller than other trees in Wotjo Country.)	the middle finger	3
Yolop-yolop mŭnya	from *yolop* = to point or aim	index finger	4
Bap mŭnya	from *Bap* = mother	the thumb	5
Dart gŭr	from *dart* = a hollow, and *gur* = the forearm	the inside of the wrist	6
Boibŭn	a small swelling (i.e., the swelling of the flexor muscles of the forearm)	the forearm	7
Bun-darti	a hollow, referring to the hollow of the inside of the elbow joint	inside of elbow	8
Gengen dartchŭk	from *gengen* = to tie, and *dartchuk* = the upper arm. This name is given also to the armlet of possum pelt which is worn around the upper arm.	the biceps	9
Borporŭng		the point of the shoulder	10
Jarak-gourn	from *jarak* = reed, and *gourn* = neck, (i.e. is, the place where the reed necklace is worn.)	Throat	11
Nerŭp wrembŭ	from *nerŭp* = the butt or base of anything, and *wrembŭl*= ear	Earlobe	12
Wŭrt wrembŭl''	from *wŭrt* = above and also behind, and *wrembŭl* = ear	that part of the head just above and behind the ear	13
Doke doke	from *doka* = to move		14
Det det	Hard	crown of the head	15

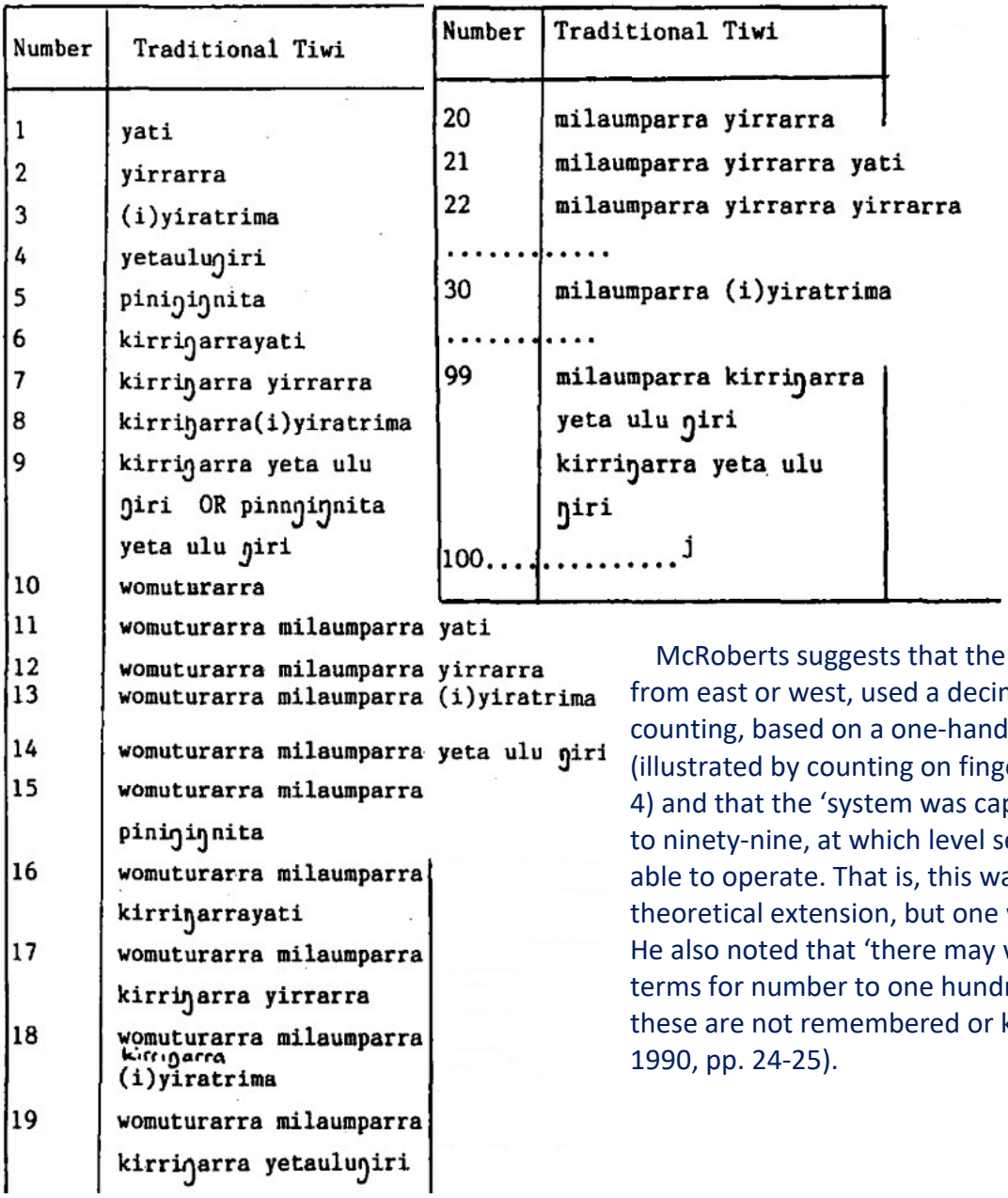
Figure 2: Howitt's (1883) interpretation of a counting system amongst the Jajaurung, Wotjobaluk and the Wurunjerri groups in southeastern Australia.

Howitt (1883) noted that after the count to 15 shown by touching the crown of the head, the count then continued down the corresponding part of the opposite side of the body. Foster explains Howitt's representation as:

> When studying the counting systems of the Wurunjjeri people of Victoria, Australian anthropologist Alfred Howitt found that the system of counting on your fingers up to five was then continued on up the arm.
>
> The numbers took on the often metaphoric names of the body parts for example: Number 7 is expressed by pointing to your forearm and given the name boibŭn meaning a small swelling like that of your forearm; number 8 is bud-darti meaning hollow like that of the inside of your elbow joint and number 9 is gengen dartchuk - the upper arm which takes its name from a strip of possum skin which is worn on the upper arm. Clever, hey? (Foster, 2017).

Pularumpi counting system

The information below derives mostly from research conducted by non-Indigenous person, Robert W. McRoberts, who was an adult educator in 1984-85 at Pularumpi on the Ratuwati Yinjara (Tiwi Islands), Northern Territory. McRoberts (1990) determined that the Tiwi people 'used a decimal system of counting, based on a one-hand base system' (p. 24) as represented in Figure 3, counting on the fingers/hands. He noted the traditional Tiwi numbers as: (see next page)



Number	Traditional Tiwi
1	yati
2	yirrarra
3	(i)yiratrima
4	yetaulugiri
5	pinigignita
6	kirrigarrayati
7	kirrigarra yirrarra
8	kirrigarra(i)yiratrima
9	kirrigarra yeta ulu giri OR pinngignita yeta ulu giri
10	womuturarra
11	womuturarra milaumparra yati
12	womuturarra milaumparra yirrarra
13	womuturarra milaumparra (i)yiratrima
14	womuturarra milaumparra yeta ulu giri
15	womuturarra milaumparra pinigignita
16	womuturarra milaumparra kirrigarrayati
17	womuturarra milaumparra kirrigarra yirrarra
18	womuturarra milaumparra kirrigarra (i)yiratrima
19	womuturarra milaumparra kirrigarra yetaulugiri

Number	Traditional Tiwi
20	milaumparra yirrarra
21	milaumparra yirrarra yati
22	milaumparra yirrarra yirrarra
.....	.....
30	milaumparra (i)yiratrima
.....	.....
99	milaumparra kirrigarra yeta ulu giri kirrigarra yeta ulu giri
100....	.....j

McRoberts suggests that the 'Tiwi, whether from east or west, used a decimal system of counting, based on a one-hand base system' (illustrated by counting on fingers below in Figure 4) and that the 'system was capable of extension to ninety-nine, at which level several old men are able to operate. That is, this was not merely a theoretical extension, but one which was used.' He also noted that 'there may well have been terms for number to one hundred and more, but these are not remembered or known' (McRoberts, 1990, pp. 24-25).

Figure 3: Image from McRoberts (1990, pp. 22-23)

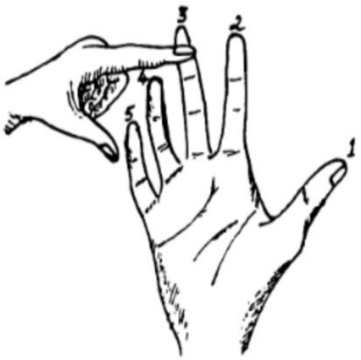


Figure 1: Counting sequence from 1 to 5.

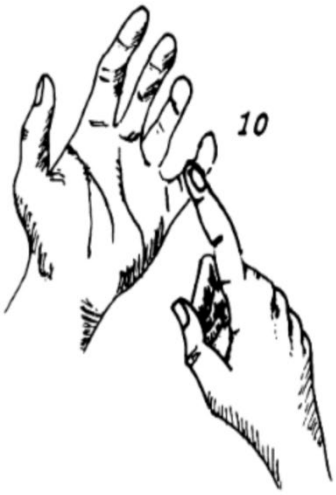


Figure 2: Counting 10

Illustrations by Sally Stott

Old people count from the thumb across the hand to the little finger, usually starting with the right hand. Some people count off 1 to 5 by striking the fingers of the right hand with the left forefinger. Sometimes the right hand is shaken for emphasis, with a pause between each number as that number is counted.

The right hand in this progression is held open, palm uppermost, at an acute yet natural angle, the fingers splayed and slightly bent. As the progression continues the fingers counted off are extended stiffly.

The process is repeated exactly on the left hand and using the right forefinger to count off the numbers 6 to 10. Ten is indicated by holding the right forefinger in the left little finger, which thereby is not held rigid, but is curved. Numbers between 11 and 19 are then indicated either by holding the left little finger with the right forefinger, and then counting off the extra numbers as for 1 to 9; or by lightly hitting the left palm with the right forefinger, and then counting as for 1 to 9. Twenty, 30 and so on are indicated as above, that is, by either holding the left little finger an appropriate number of times with the right forefinger, or gently hitting the left palm below the little finger with the right forefinger the required number of times.

Figure 4: Image from McRoberts (1990, pp. 26-27)

Adnyamathanha birth order system

The Adnyamathanha Peoples' birth order system is like the Kaurna (Adelaide area in South Australia) system and has separate words for referring to first through to tenth born, the words differing slightly depending on the sex of the newborn. Other Aboriginal languages may have words that are equivalent to the Adnyamathanha system. Adnyamathanha people are from the Northern Flinders ranges of South Australia.

The following information comes from Marvyn-anha Frederick McKenzie Snr, an Adnyamathanha man:

Our birth order names are worked out according to order of birth in the family of the Ngami (Mother), irrespective of who the Vapi (Father) is, and regardless of sex. For example, Murnakanha is not the fifth-born girl, but the fifth-born child, who is female. Still-births and miscarriages are also counted.

Our Yakkarti Mityi (Children Names) are as follows:

ORDER OF BIRTH	MALE	FEMALE
First	Virdianha	Arranyinha
Second	Warrianha	Warrianha
Third	Unaanha	Unakanha
Fourth	Marruanha	Marrukanha
Fifth	Marrukanha	Murnakanha
Sixth	Wanguanha	Wangurtanha
Seventh	Yadaanha	Yadandhanha
Eighth	Milanaha	Milakanha
Ninth	Ngarlaanha	Ngarlakanha
Tenth	*Mawaanha*	*Mawananha*

Figure 5: Adnyamathanha birth order system (McKenzie, 2009)

Aboriginal and Torres Strait Islander counting systems in the Australian Curriculum: Mathematics

While the following content from the Australian Curriculum: Mathematics (ACARA, 2022) pertains to Years F-1, there are many, many more opportunities to use First Nations Australian counting systems across the year levels and mathematics strands as indicated in the *Connecting maths with culture* section in this Teacher Background Information and below:

name, represent and order numbers including zero to at least 20, using physical and virtual materials and numerals AC9MFN01

⇒ connecting quantities to number names and numerals when reading and reciting stories and playing counting games or determining and reasoning about the size of sets of objects within First Nation Australians' instructive games; for example, Segur etug from Mer Island in the Torres Strait region

quantify and compare collections to at least 20 using counting and explain or demonstrate reasoning AC9MFN03

⇒ using body-tallying that involves body parts and one-to-one correspondence from counting systems of First Nations Peoples of Australia, to count to 20

partition and combine collections up to 10 using part-part-whole relationships and subitising to recognise and name the parts AC9MFN04

⇒ exploring number groupings in First Nations Australians' counting systems and the different ways of representing these groupings to form and partition numbers, applying this to quantify collections of objects in the environment on Country/Place up to 10

recognise, continue and create repeating patterns with numbers, symbols, shapes and objects, identifying the repeating unit AC9M1A02

⇒ identifying the repeating patterns in First Nations Australians' systems of counting, exploring different ways of representing numbers including oral and gestural language

Other ideas across the year levels of schooling relating to First Nations Australian counting systems that provide teaching/learning opportunities include:

- ⇒ naming and numbering objects in the environment on-Country/Place using subitising, connecting this to Aboriginal or Torres Strait Islander ways of quantifying and comparing collections
- ⇒ comparing and explaining different groupings between an Aboriginal and Torres Strait Islander number system and the Base 10 number system, making connections to collections in familiar contexts and 10-frames

⇒ exploring a base 5 number system used by Aboriginal and Torres Strait Islander Peoples and the many ways whole numbers in the base 10 system can be rearranged and partitioned to this base 5 system, finding similarities and differences with the base 10 number system

⇒ investigating how to use an Aboriginal and Torres Strait Islander number system to create and mentally solve multiplication and division problems using partitioning strategies.

Connecting with Community, histories and cultures

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 6 below was developed by Prof. Joe Sambono and relates to science but can be adapted for mathematics 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 [6] 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

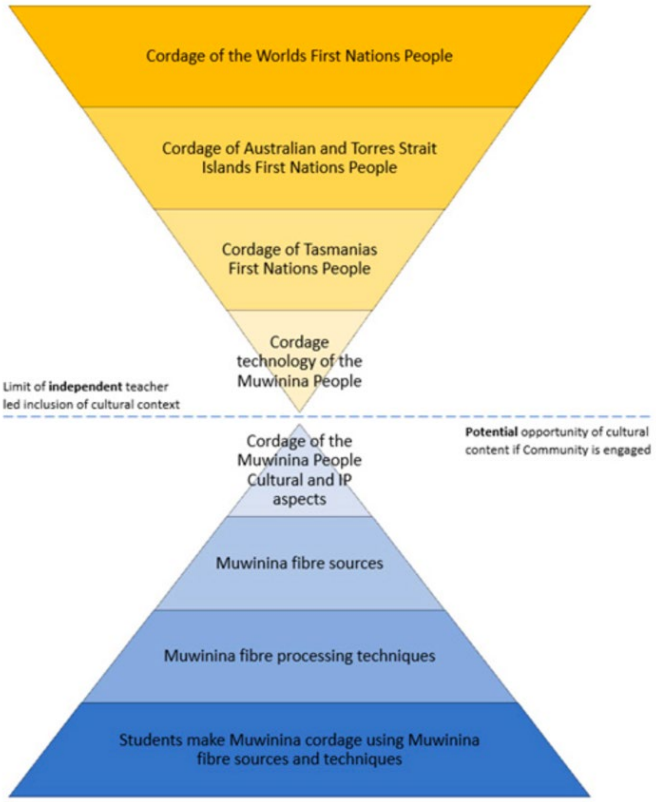


Figure 6. Framework to support educators delineating between showcasing First Nations Australians histories and cultures in classrooms vs unauthorised teaching of culture. (Used with permission from the author, Joe Sambono, 2024)

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=qIlgFracA0o (Sambono, 2021, pp. 11-12)

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

- *Maths in schools project* (2022), Number in Action | What is Number? | Did you know?
    - Maths investigations – Number | Foundation: What strategies can we use to partition a small set of items? | Yolŋu Peoples use of turtle egg counting
- University, M. (2017). *Morrku mangawu - Knowledge on the Land: Yolŋu Mathematics from Bawaka, Northeast Arnhem Land*. Presented by Bawaka Country including Laklak Burarrwanga, Ritjilili Ganambarr, Merrkiyawuy Ganambarr-Stubbes and Banbapuy Ganambarr: https://www.youtube.com/watch?v=wyaOzZmAAl4.
- *Joey Counts to Ten* by Sally Morgan (Author, Palyku – Eastern Pilbara region of Western Australia) and Ambelin Kwaymullina (Illustrator, Palyku – Eastern Pilbara region of Western Australia)
- *On the Way to Nana's* by authors Frances Haji-Ali (non-Indigenous), Lindsay Haji-Ali (Yawuru/Karajarri, West Kimberley region, Western Australia, and illustrated by Indigenous artist David Hardy.
- Watch students from Moree East Public School in New South Wales, in their video *Count to 10 in Gomeroi* (02:22): https://www.youtube.com/watch?v=VpkD4rxBkOc
- Pintyanthi, K. W. (2014). *Kaurna for Kids – Numbers*: https://www.youtube.com/watch?v=xtejyc6bU44.
- *Otis Williams reads 'I can count to 10 in Wiradjuri':* https://www.youtube.com/watch?v=xnYx77rEOcQ

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.

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