Developing Mathematics Registers in Australian Indigenous Languages: Classification and Comparison

Cris Edmonds-Wathen
Charles Darwin University
cris.edmonds-wathen@cdu.edu.au

Sasha Wilmoth
University of Melbourne
sasha.wilmoth@unimelb.edu.au

James Bednall
Charles Darwin University
james.bednall@cdu.edu.au

Kate Charlwood
University of Melbourne
k.charlwood@student.unimelb.edu.au

This paper reports on a multi-site initiative aiming to improve mathematics teaching for Indigenous language-speaking students. The Mathematics in Indigenous Languages Project is developing a framework to identify and use mathematical registers in Australian Indigenous languages. After three years, we provide a cross-site update, highlighting insights from a functional typological approach. Focusing on classification and comparison, we show how this method helps navigate conceptual, semantic, and structural non-equivalence when mapping mathematical expressions across languages.

This paper reports on progress in the Mathematics in Indigenous Languages Project (MiIL), a multi-site, multi-language initiative developing a framework for identifying and using mathematics registers in Australian Indigenous languages to support the mathematical learning of Indigenous language-speaking students. While Indigenous Australian languages have been used in a variety of bilingual school programs for mathematics instruction over the past few decades (Devlin et al., 2017), there has been little investigation and documentation of the structural affordances of Australian languages for formal school mathematics programs. More broadly, little systematic cross-linguistic research has examined how languages vary in their capacity to express mathematical ideas. After three years of implementation, this paper provides a cross-site project update and outlines emerging theoretical implications of applying a functional typological approach developed for cross-linguistic mathematical investigation (Edmonds-Wathen, 2019). We present examples showing how this approach helps address conceptual, semantic, and structural non-equivalence that arises when mathematical expressions are mapped directly between languages, focusing on the language of classification and comparison.

Literature Review

Mathematics education in students' first language can improve the mathematics outcomes of Indigenous language-speaking students because it provides a strong foundation for mathematical thinking and further learning. The use of a language in school also contributes to its vitality, which is significant given the endangered status of most Australian languages (Edmonds-Wathen et al., 2026). However, most Indigenous language-speaking students currently learn mathematics in English, even in some bilingual schools (Devlin et al., 2017).

To teach and learn school mathematics, there needs to be a mathematics register which includes the vocabulary used for mathematics concepts, and the language structures to express mathematics processes and relations (Halliday, 1978). Mathematics is often regarded as difficult to teach in Australian Indigenous languages due to a lack of formal mathematics registers (e.g., ACARA, 2014), thus a key issue being how to develop such registers. Previous international and Australian research that explores theoretical and methodological aspects of language development include Lunney Borden (2011); Meaney et al. (2012) and Wilkinson and Bradbury (2013). Key points of interest relevant to this study include mathematical uses of verbs: in Mi'kmaq (Canada) for describing shapes (Lunney Borden, 2011) and in

(2026). In N. Berger, M. Thompson, J. Ley & C. Wilsmore (Eds.), *Beyond boundaries: Strengthening futures in mathematics education. Proceedings of the 48th annual conference of the Mathematics Education Research Group of Australasia, Sydney* (pp. 122–129). MERGA.

Djambarrpuyŋu for comparison (Wilkinson & Bradbury, 2013). Considering grammatical diversity is important for developing mathematics registers and pedagogy (Barton, 2009).

Early mathematics learning involves foundational relational concepts such as classification and comparison. Classification involves recognising that objects belong to the same category or type because they share common properties. Sorting and classifying activities are central to many early childhood mathematics programs, and the development of these abilities has been widely studied (Sarama & Clements, 2009). Early classification is often based on salient perceptual features such as shape or colour (Gentner & Namy, 1999). However, most research on early mathematical development has been conducted in Western contexts, and less is known about how linguistic and cultural variation may influence these learning trajectories.

Comparison is another foundational mathematical concept. Research suggests that comparison of visual features such as size generally precedes comparison of quantity (Gentner, 2005). Cross-linguistic studies show considerable variation in how languages express comparison (Beck et al., 2009). In Australian mathematics education, comparison in Indigenous languages has sometimes been framed as a deficit. For example, a resource for teachers of students with English as an Additional Language suggested that "many Aboriginal and Torres Strait Islander languages don't have words of comparison" (ACARA, 2014, p. 7). However, comparison remains an understudied area in the linguistics of Australian languages, with only a few detailed descriptions available (e.g., Bowler, 2016; Kapitonov, 2019). Investigating how comparison is expressed in these languages is therefore important both for mathematics education and for linguistic research. Systematic research is needed to examine how mathematical concepts such as classification and comparison can be expressed and taught through Indigenous languages.

Theoretical framework

There are two main elements to the theoretical framework that we apply in this project: it is typological and functional. Typology is the field of linguistics that investigates similarity and diversity amongst the world's languages. Nichols (2007) describes it as a framework-neutral field which enables languages to be contrasted on equal terms, rather than from analytic perspectives that privilege one language over another. While some typological studies involved large numbers of languages, many focus on only a few; Nichols (2007) states that hypothesis-raising is generally done with a small sample of languages, whereas typological hypothesis-testing more likely involves larger numbers of languages and is more data driven. A wide variety of linguistic phenomena are investigated typologically, from phonology (sound systems), morphosyntax (how words are constructed and put together in phrases), and semantics (word meanings).

Language performs communicative functions; functional linguistics take these communicative functions as the basis for analysis (Butler, 2003). Functional linguistics here refers to a core understanding of communicative function: language allows us to make and respond to requests, to develop and maintain relationships and to describe the world and our thoughts, for example. We apply this functional approach to mathematical language and mathematics education, investigating how different languages describe mathematical objects, express mathematical relations and can be used for the teaching and learning of mathematics in school. Because we are looking at languages that have limited history of having been used for school mathematics, this requires a broad definition of mathematics. We delineate the lesson planning for the project by the Australian Curriculum: Mathematics, but we also bring to our investigations a view of mathematics that varies across languages and cultures (Barton, 2009).

A functional typological approach to mathematics register development takes mathematics as the semantic and functional field of interest (Edmonds-Wathen, 2019): we look at how

different languages function to communicate mathematical meanings, and what the similarities and differences are. This approach avoids positioning any language from a deficit perspective.

Project Design and Implementation

The project applies a design-based research approach, where a model based on theory and research is iteratively designed, improved and validated (Collins et al., 2016). It focuses on three main case sites, with each case study taking a participatory action research approach (McTaggart & Kemmis 2005). Activities were co-designed with each community and school to reflect Indigenous research partners' ways of knowing and priorities (Kendall et al., 2011), while remaining aligned with the broader project scope.

Sites and Participants

The project involves three main cases: (1) Areyonga School in Areyonga/Utju community (Pitjantjatjara); (2) Umbakumba School, Groote Eylandt and Milyakburra School, Bickerton Island (Anindilyakwa); and (3) Murrupurtiyanuwu Catholic Primary School at Wurrumiyanga (Tiwi). These cases represent diverse languages and geographic locations, and align with the project team's linguistic expertise and community connections. A project linguist specialising in the relevant language was appointed for each site. Utju is a small community approximately 200 km west of Alice Springs. Areyonga School's long running bilingual (Pitjantjatjara and English) program is closely supported by the Utulu Kutju Nintitinganyi cultural leadership team of Anangu elders. Philanthropic funding has assisted Areyonga to continue project activity since its inception. Sasha Wilmoth is the project linguist for this site. On the Groote Eylandt and Bickerton Island Archipelago, we partnered with Groote Eylandt Bickerton Island Primary College Aboriginal Corporation (GEBIPCAC) which is developing a bilingual, bicultural curriculum in Anindilyakwa. MiIL implementation commenced at Umbakumba School and Milyakburra School. Although partners were committed to continuing the project, damage to mining infrastructure from Tropical Cyclone Megan (March 2024) disrupted funding streams, and activities at this site are currently paused. James Bednall is the project linguist for this site. The third site is Murrupurtiyanuwu Catholic Primary School (MCPS) at Wurrumiyanga, Bathurst Island. MCPS was previously bilingual and aims to become formally bilingual again; the project aligns with that goal. Activities were paused during 2024, but are due to resume following new funding for another three years. Kate Charlwood is the project linguist for this site.

Elicitation

Across sites, key activities included language elicitation, development of lesson sequences, assessment design, educator professional learning, and teaching trials. Elicitation was mostly conducted with elders in groups, facilitated by the project lead (Cris Edmonds-Wathen) and the project linguist for that site. Sessions typically focusses on one main topic using concrete resources as stimuli. Elicitation methods included asking for translations from English, asking for judgments ('does it make sense to say this?'), as well as more open-ended story-telling and discussion based on the stimuli. For example, when shown drawings of lines intersecting at different angles, some elders related this to their experience of travelling through Country, and the discussion followed naturally into how they would describe different types of paths and landscapes, and the language for giving directions. Between these elicitation sessions, Cris developed outlines of sequenced lessons on the respective topic in English, sometimes adapting externally available lesson plans, sometimes developing lesson ideas responsive to the context. Local language versions were then developed, checked with elders, and refined with Indigenous educators before classroom trials. Bilingual assessment tools were also developed in English and the relevant local language.

Mathematical Foci

The project focuses on the early primary years (Foundation to Year Two), although in smaller schools it extended into Year Three due to multi-age classes. The mathematical content was aligned with the Australian Curriculum: Mathematics v9.0. While mathematics can be understood more broadly than school curricula (e.g., Trinick et al., 2014; Xu & Ball, 2024), alignment with the curriculum ensured that teaching programs could be integrated into existing school planning. Initial work prioritised the Space strand, which includes the sub-strands of Shape and Location (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2022). Australian languages have precise ways of describing spatial relations that are used widely in everyday speech, and exhibit considerable diversity between different languages (Palmer et al., 2022). These features made spatial concepts a productive starting point for developing mathematical language. Subsequent work also addressed Measurement, particularly comparison concepts relevant to early mathematical learning. These topics allowed the project to develop foundational mathematical language that could later support learning across other areas of the mathematics curriculum.

Findings

We report on selected findings regarding terminology identified in each of the languages, focussing in turn on the language of classification and comparison. Examples come from lessons sorting and classifying 2D geometric shapes and the creation of attribute paths based on the Patterns: Attribute Trains lesson from *reSolve: Maths by Inquiry* (2020).

Classification

Classification involves the ability to recognize that objects belong to the same category because they share similar characteristics, that is, understanding that something is the same type of thing as another thing. Key language includes naming things or objects, naming groups and the process of putting things in groups and describing similarity and difference.

Difference and similarity

Pitjantjatjara uses adjectives *kutjupa* ‘different’ and *lipula* ‘same.’ It is quite straightforward to say: *Walka kutjupa. Puntu lipula* ‘The colour is different. The shape is the same.’ *Lipula* is a loan word from English ‘level’ but now has quite a different range of meanings, including ‘same’. In Anindilyakwa *adidirrbura* ‘same’ is commonly used to describe people or things that share one or more of the same characteristics. However, an alternative term of *ediyarra* ‘twin or same birth sibling’ was chosen as a more precise term for mathematical usage in sorting and classifying activities to describe two or more identical objects (1):

(1) *Ena alida emininga-kiya. Ena amurndakajika ediyarra(-manja)*
The colour different-two the shape same-locative
‘The colour is different. The shape is the same.’

Anindilyakwa *emininga* ‘different’ takes a dual marker kiya ‘two’ which specifies that two things are different to each other. *Ediyarra* ‘twin/same.birth.sibling’ takes the optional locative case marker *-manja*, reflecting the primary sense of same sibling relationship showing connection through land/Country.

Sameness in Tiwi is indicated using the verb *-wuraparri* ‘be same, be alike, resemble’, as in (2), while togetherness is expressed with the collective pronoun *wutiyati* ‘they.as.one’:

(2) *Kapinaki yuwurrara kurlamari, wutiyati yuwuraparri*
these two circle they.as.one be.same/resemble
‘These two are circles, they are the same.’

Tiwi has a rich repertoire of different pronouns with subtle semantic differences related to sameness and difference. Seeking to find the word for 'together; through direct translation would fail to recognise this important mathematical resource. There is no specific Tiwi term that means 'different'; difference is usually indicated by negating *-wuraparri* 'be the same, resemble.' In some contexts where difference is being described, the contrastive determiner *nyoni* 'other/another' can be used, as in (3).

(3)	*Wuta*	*sheyip*	*karlu*	*yuwuraparri.*	*Ngarra*	*nyoni*	*arramikamini*
	those	shape	not	be.same/resemble	It	another	thing

'The shape is different (not the same). It's a different thing.'

Nyoni 'other/another' modifies nouns but is not a regular adjective. It occupies the same linguistic slot as quantifiers. Distinguishing between "being other" and "being different" is subtle but important.

Grouping

Anindilyakwa uses complex verbs with many affixes to describe putting things into groups (4):

(4)	*Wurru-murndukwa-yi-ji-na*	*ena*	*amurndakajika.*
	you.all(command)-come.together-each.other-cause-present	these	things

'You are going to group these things together.'

The root verb *murndukwa* 'come together' is modified by the reciprocal suffix *-yi* and the causative *-ji* which with the imperative pronominal prefix *wurru-*, package an instruction that grouping should occur and it should be done by the addressees by bringing things together.

For a similar instruction, Tiwi also uses verbs (5):

(5)	*Nyirrapamukuri*	*sheyip*	*ngini*	*purruwuraparri.*
	put.them.together	shape	that.is	they.are.same

'Put the same shapes together.'

Unlike English which uses a basic clause, Tiwi uses a complex clause to express the instruction. Further work will continue to investigate how complex clauses are used to express relations in Tiwi, something which is under-documented in Australian languages but important for expressing mathematical concepts.

Grouping in in Pitjantjatjara can make use of a complex system of noun markers including the semblative *puṟunypa* (meaning 'similar to') and the locative case suffix (-ngka) as in (6):

(6)	*Puntu*	*palu*	*puṟunypa-ngka*	*paraṟa*	*tjura*
	shape	it	to.be.like-locative	dividing	put-command

'Divide up and put down the ones with the same shape together'

A more literal translation might be 'Divide (them) up and put (it) with (the ones which have a) body like it.' While there is no term for 'object' or 'thing', Pitjantjatjara can very freely omit nouns where they are clear from context. E.g. in Pitjantjatjara you say something like "Put with the similar shape" to mean "Put each shape with the ones which have a similar shape (to it)." This instruction also makes use for a pervasive feature of Pitjantjatjara grammar known as clause-chaining, where multiple verbs can be linked together to describe complex events. In this example, "divide and put" are more closely linked as a single complex event than the English translation would suggest. While Pitjantjatjara does not have direct equivalents of many words used in the English mathematics classroom (such as sort, measure, compare), the use of clause chains allows educators to give instructions that explicitly describe the component parts of complex activities.

Comparison

Languages vary with respect to the structure of sentences that express comparison as well as the subtle semantics of those sentence types (Beck et al., 2009). Many Australian languages, including the three languages involved in the MiIL project, express comparison using a 'conjoined construction', that is, two separate clauses with antonymic adjectives. An example from Anindilyakwa is given in (8).

(7) *Ena aruma, umba ena eyukwujiya*
this big, but this small
'This one is big, but this one is small'

Unlike the literal English translation, these do not mean that X is objectively big and Y is objectively small, but rather express a difference in size, that X is bigger than Y. This type of conjoined construction can be used even when this difference is very small, or when both objects are objectively very big or very small. This difference in how the conjoined construction functions form a similar English construction appears not to have been understood in mathematics education previously (e.g. ACARA, 2014). For example, in (8), the Anindilyakwa sentence expresses a superlative height despite there being no explicit superlative marker:

(8) *Wurring-al-akina wurring-ambilyuma wurring-alingajirra,*
she.dual-dual-that she.dual-two she.dual-tall
umba d-akina ding-alingajirra.
but she-that she-tall
'They are both tall, but she is the tallest'

There may also be additional sentence structures used for comparison. While the English preposition *than* is used to mark the standard of comparison, Pitjantjatjara draws on its complex system of grammatical case-marking, and may also recruit spatial language. Example (9) shows the use of the locative case suffix on the standard.

(9) *Nyangatja pul̲ka pala-ngka*
this.one big that-location
'This one is bigger than that one'

A similar use of the locative case also appears to be permissible in Anindilyakwa (10), although how widespread this is requires further investigation.

(10) *Ngayuwa ng-alingajirra d-akina-manja.*
I I-tall she-that-location
'I am taller than her'

The conceptual differences between languages go deeper than finding equivalents for individual words. A sentence such as (11) may superficially appear similar to the English translation provided below (and not simply because the English words are used for classroom items such as 'block' and larger numbers such as 'eleven').

(11) *Ngayuku tjina wa̲ra block eleven-tjara*
my foot long block eleven-having
'My foot is eleven blocks long'

However, a better translation would be 'my foot is long, it has eleven blocks'. The measure phrase *block eleven-tjara* 'having eleven blocks' does not actually modify *wa̲ra* 'long' in the same way that it does in 'eleven blocks long' in English. We can draw on other linguistic evidence to show this difference. In English, if we are measuring a toddler's foot, we might say 'her foot is 4 blocks long' even though her foot is definitely not 'long', whereas it would be odd to say 'her foot is 4 blocks short'. The opposite is true in Pitjantjatjara, where a sentence like (12) is not acceptable (indicated with *) when describing a very small foot, but (13) is.

(12) **Palumpa tjina wara block kutjara-kutjara-tjara*
his/her foot long block two-two-having
Intended meaning: 'His/her foot is four blocks long'

(13) *Palumpa tjina mutumutu block kutjara-kutjara-tjara*
his/her foot short block two-two-having
'His/her foot is four blocks short'

This is not just a difference in individual words, but in the fundamental conceptual structure of the languages, and how adjectives such as 'long' and 'short' work; in the linguistics literature, languages with similar properties to Pitjantjatjara are called 'degreeless', and research over recent years has expanded our knowledge of how different languages conceptualise and express comparison (Beck et al., 2009). This type of difference has a range of other effects in precisely how comparison/measurement is spoken about in the English and Pitjantjatjara mathematics classrooms, at a deeper level than individual words.

Discussion and Conclusion

This paper has presented selected findings from the Mathematics in Indigenous Languages (MiIL) project, focusing on how concepts of classification and comparison are expressed in three Australian Indigenous languages. The examples illustrate that developing mathematics registers in these languages is not simply a matter of translating English terminology. Rather, it requires careful attention to the structural and semantic differences between languages and the ways in which mathematical meanings are conventionally expressed.

Across the three languages examined, classification is expressed through a range of linguistic resources including adjectives, verbs, noun modifiers, and clause chaining. While English mathematics classrooms often rely on specialised verbs such as "sort" or "group," the languages examined here frequently express these processes through descriptions of actions such as "put together," "divide," or "place with similar ones." These constructions demonstrate that the conceptual work required for classification is linguistically available, although it may be packaged differently from English classroom language. In practice, developing mathematical registers therefore involves identifying how existing linguistic structures can be used or extended to express these classroom activities.

Comparison provides further evidence of cross-linguistic diversity. We give examples from two languages of how comparison can be expressed through constructions that differ from English comparative forms. For example, conjoined clauses with antonymic adjectives (e.g., "this one big, but this one small") can convey relative comparison rather than absolute properties. Case-marking constructions may be used to compare. Careful attentions to how comparison operates semantically and grammatically in each language is important. Superficially similar expressions may function differently, and direct translation may obscure important conceptual distinctions, as in the example of measure phrases in Pitjantjatjara.

Our findings support the usefulness of a functional typological approach to mathematics register development. The findings demonstrate that Australian Indigenous languages possess rich resources for expressing relational concepts central to early mathematics learning. By examining how languages function to communicate mathematical meanings, rather than assuming direct equivalence with English terminology, the project avoids framing Indigenous languages from a deficit perspective. Instead, typological comparison reveals both common communicative goals and diverse linguistic strategies for expressing mathematical relations. Throughout these investigations, the importance of collaborative and iterative processes in register development remains crucial, as appropriate terms and constructions are negotiated with speakers, educators, and community authorities. Typological diversity should be understood not as an obstacle to mathematics education, but as a resource for developing more

linguistically responsive approaches to teaching mathematics in multilingual contexts, particularly to support the mathematical learning of Indigenous language-speaking students.

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