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Mawng maths: collaborating to teach mathematics in an Australian Indigenous language

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Abstract

There are both educational and cultural benefits to first language (L1) instruction, particularly in the early years of school, but in Australia, few Indigenous language-speaking students are taught in their own languages. Teaching mathematics in Indigenous languages requires both linguistically capable Indigenous educators and the identification and development of suitable mathematics terminology. This paper reports on the collaborative development of a program reintroducing mathematics lessons in Mawng language at Waruwi Community School. This project developed the capacity of an Indigenous educator to take on more responsibility for the content of the class teaching. Lessons focussing on spatial sequencing terminology were developed to extend students' use of core Mawng grammatical features while also reinforcing important local cultural knowledge. A collaboration between a non-Indigenous researcher and a Mawng educator, the paper concludes with factors contributing to the sustainability of the project.

Keywords Indigenous students · Spatial language · Indigenous educators · Indigenous language · Collaborative research

Introduction

Teaching mathematics in Indigenous languages requires both linguistically capable Indigenous educators and the identification and development of suitable mathematics terminology. Erosion of government support over the past few decades has meant that many bilingual schools in Australia's Northern Territory became English-only (Devlin et al., 2017). This paper reports on the collaborative development of a

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program reintroducing mathematics lessons in Mawng language at Warruwi Community School, a formerly bilingual school. Focussing on using Mawng in mathematics lessons to reinforce and maintain local ways of talking about space and location, the mathematics program provides an opportunity for Mawng teaching staff to take on more responsibility for the content of the class teaching. The program was developed as a collaboration between a non-Indigenous researcher and a Mawng assistant teacher, with the input of other Mawng educators and the support of the school. The paper reports on how a sequence of lessons was developed collaboratively as the program progressed. Cris is a non-Indigenous English-speaking academic who researches mathematics in different languages and who has taught and researched in and with Australia Indigenous communities over the past 15 years. Jacobina is a Mawng Assistant teacher whose other languages include Kunwinjku, Yolngu-matha and English.

Language and learning at Warruwi Community School

Warruwi Community School is located at Warruwi, South Goulburn Island, in northwest Arnhem Land. With a population of around 400 people, mostly Indigenous, Warruwi is on the traditional land of the Mawng people and the Mawng language continues to be used throughout the community. Arnhem Land is one of the world's hot spots of linguistic diversity. There are many languages spoken in close proximity to each other, each language associated with a clan and with the country of that clan, country that is still owned and managed according to traditional laws (Evans, 2010; Garde et al., 2009). Some of these languages are related, as with Mawng and its nearest living relative Iwaidja, but there are also many different language families. Most adults in Arnhem Land are multilingual, aided by an ideology of language diversity and by practices such as marriage across clan boundaries that make it likely that husbands and wives will speak different languages:

In this system, your clan language is your title deed, establishing your claims to your own country, your spiritual safety and luck in the hunt there. Meanwhile, the knowledge of other languages gives you the far-flung network of relatives, spouses actual and potential, ceremonial age-mates and allies, which makes you someone who counts in the greater world (Evans, 2010, p. 9).

At Warruwi, most adults speak between three and eight languages, such as Kunwinjku, Yolngu-matha, Ndjebbana, Burarra, Kunbarlang, Iwaidja, Tiwi and Anindilyakwa as well as English and Mawng (Singer & Harris, 2016).

Since colonisation, quite a few languages of Arnhem Land have died, or are today spoken only by older people, with children no longer speaking them (Evans, 2010). Language shift has been to English but also to other local Indigenous languages. However, Mawng is still being learnt and spoken by young children. It has shown grammatical stability despite being spoken by a relatively small number of speakers alongside other languages with larger speaker bases such as Kunwinjku (Singer

& Harris, 2016). Nevertheless, some Mawng adults express concern that children might not be learning Mawng in the way that previous generations have.

Warruwi Community School had a bilingual English and Mawng teaching program in the 1970s but became English-only as systemic support for bilingual school was reduced due to a government belief that monolingualism is the norm, positioning Indigenous languages and English as being in competition in schools (Devlin et al., 2017; McConvell, 2008). In contrast, the multilingual ideology of the peoples of the Arnhem Land region positions people as lifelong language learners, valuing both languages with which one has a personal connection and the acquisition of new languages in appropriate places or contexts (Evans, 2010).

In 2017, Warruwi Community School re-introduced Mawng language into its literacy program, taught by a senior Mawng assistant teacher, and using materials from the former bilingual program. The 2017 revision of the Northern Territory Indigenous Languages and Cultures Curriculum indicated that systemic support for Indigenous language instruction was increasing, and it was therefore a good time to increase structured use of Mawng language in the school.

Literature review

Collaborative Indigenous education research

Indigenous people need to be agents and authentic collaborators in research that involves and affects them. Collaborative cross-cultural research must ensure that power is shared more equally between researchers and Indigenous research participants, with benefits accruing to both (Gibbs, 2001). These principles apply to mathematics education research as much as to any other research field. However, the specifics of what authentic collaborations look like vary in each community context. Somerville and Perkins (2003) describe cross-cultural collaboration as “border work” that is fundamentally uncomfortable, but that creates a “contact zone” as people get to know each other. Sundbery and Latham (2018) describe a process of “working together side by side” requiring “deep listening”. Participatory action research (PAR), with its basis in an emancipatory paradigm, has long been advocated as an appropriate approach for research in/with Indigenous communities, since it deals with problems that originate and are identified in the community, aims to improve the lives of people in the community and involves full and active participation of the members of the community (Bennett, 2004).

Some argue that collaborative methodology such as PAR is not in itself sufficient, but that the epistemology and ethics informing the research must value Indigenous ways of knowing (Kendall et al., 2011), as is seen in Indigenous research methodologies such as collaborative yarning (Shay, 2021). In mathematics education research, this raises the question of how mathematics is positioned as a field of knowledge.

Collaboration between Indigenous and non-Indigenous researchers remains a contested and uneasy space where differences between researchers cannot and should not be elided (Jones & Jenkins, 2008). Research agreements between universities

and communities have become more common in recent years, and ethical clearance for research in/with Indigenous communities generally requires such an agreement or other indications of how consultation is conducted, where benefits will accrue and how Indigenous knowledge will be respected. Nevertheless, PAR remains a key collaborative methodology focussing on the development of relationships as the heart of collaboration.

Roles of Indigenous educators

Collaboration between Indigenous and non-Indigenous educators is also the heart of two-way (or both-ways) approaches to education for Indigenous students, which bring together Western and Indigenous ways of knowing and doing. Such approaches value and develop both systems of knowledge including the practices and processes of Indigenous and non-Indigenous educators working together to develop and deliver a two-way curriculum (Ober, 2009). In mathematics education, this includes recognising the plurality of mathematics as a cultural practice, including both school or Western mathematics as well as Indigenous mathematics practices (Bishop, 1988), and also valuing and developing Indigenous pedagogies.

Team-teaching has been an integral part of remote schools in the Northern Territory, both bilingual and otherwise, teaming an English-speaking non-Indigenous teacher and an Indigenous language-speaking teacher or assistant teacher. Team-teaching as formalised in the Northern Territory was informed by the principles *teach together*, *plan together* and *learn together* (Graham, 1999). In Northern Territory bilingual schools, a key principle has been for each educator in a cross-cultural team to teach in their own language, and to support the other when they are teaching. However, the relationship between Indigenous and non-Indigenous educators is often unequal, with many non-Indigenous teachers not valuing the knowledge and skills of Indigenous paraprofessional educators (Baturu et al., 2008; Warren et al., 2004, 2010). Expectations of the relationship also vary with individuals, with situation and with jurisdiction (Graham, 2017). Where instruction is only or predominantly in English, assistant teachers may be expected to translate in an ad hoc manner for the teacher, “to make comprehensible to the students the non-Aboriginal teacher’s discourse” (Moses & Wigglesworth, 2008, p. 130), as well as be expected to engage in behaviour control. Some mathematics education projects have focussed specifically on developing capacity of Indigenous paraprofessional educators such as *RoleM* in Queensland (Armour et al, 2016) and *Strong Literacy and Numeracy in Communities (SLNC)* in the Northern Territory (Wilkinson & Bradbury, 2013). Where the role of the assistant teacher has largely been realised as translation and behaviour control, it can be challenging for the assistant teacher to begin to take on more teaching responsibility and leadership (Strangeways, 2017; Thornton et al., 2011). Nevertheless, Guenther and Disbray (2015) found that the presence of more Indigenous staff in a school is advantageous to Indigenous students, even where those staff are not directly involved in teaching. While their most important role was seen to be teaching local language and culture, other important roles such as

building capacity, developing relationships and modelling the importance of education are also performed by office staff, cleaners and grounds staff.

It must be noted that team-teaching that is collaborative and two-way, whether in a bilingual or other situation, is dependent on the provision of shared time to plan together, and also to explore each other's cultural and academic knowledge (Graham, 2017; Wilkinson & Bradbury, 2013). That shared time is generally highly dependent on support from school leadership.

Indigenous language as language of instruction in mathematics education

Indigenous educators have an essential and agentive role in using Indigenous language as language of instruction. The shared agency of the team-teaching approach is fundamentally intertwined with bilingual education, as Graham (2017) argues:

When you work in an English-only program the power is with the English speaker. When you teach in two languages, with two people acting as teachers for the same group of children, not only do the children learn more effectively, but power and control are shared and development occurs. (p. 32)

Home language or first language (L1) instruction, particularly in the early years of school, provides cognitive and educational benefits over instruction in an additional language in which the learner is not fluent (Cummins, 1979; Silburn et al., 2011). Using a language in school can also increase the language's status and hence assist in maintenance of endangered languages (Crystal, 2000). For example, Minutjukur et al. (2019) believe that increased time for Pitjantjatjara in school might "help build a windbreak for the language" (p. 89). Indigenous L1 education in Australia has been fitted into a model of bilingual education, as successive governments informed by a monolingual mindset have regarded it as essential that a substantial proportion of teaching and learning occur in English (Devlin et al., 2017; Simpson et al., 2009). For many Indigenous community members, L1 education is "essential rather than optional" (Disbray, 2016, p. 325). Bilingual education in the Northern Territory reached a low point in 2009 with the *First four hours in English policy* (Northern Territory Government, 2009) which undermined the use of Australian Indigenous languages for meaningful curriculum delivery (Devlin et al., 2017; Simpson et al., 2009). No recent studies of factors that contribute to educational outcomes for remote Indigenous students have investigated L1 education and its outcomes (Guenther et al., 2019).

The benefits of L1 instruction extend to mathematics education. Challenges have been documented in teaching mathematics in English to Indigenous languages-speaking students (Edmonds-Wathen, 2015) and to learners of Standard Australian English as a second dialect (Watts et al., 2017). Responses have included focussing on the development of English oral language for mathematics (McDonald et al., 2011) rather than on developing the language of mathematics in the students' first languages or dialects. Most current Indigenous language programs operate in the Indigenous language and culture curriculum area with attention to L1 literacy and learning local culturally relevant knowledge (Disbray, 2016).

Nevertheless, a variety of mathematics curricula have been developed in Australian Indigenous languages, notably the Yolngu Garma Maths curriculum (Marika et al., 1992; Watson-Verran, 1992). However, there is little published documentation of the language development work entailed, with the exception of the *Talking Namba* project (Wilkinson & Bradbury, 2013). Internationally, Indigenous language development for mathematics has been undertaken in a variety of contexts, such as for a single language, Māori, in New Zealand (Meaney et al., 2012), and for multiple languages in Papua New Guinea and South Africa (Edmonds-Wathen et al., 2019; Schäfer, 2010; Wildsmith-Cromarty, 2012). These studies indicate that while developing the language to teach mathematics is not trivial, all languages have the capacity for development for formal mathematics instruction if this is something desired by the speakers, but it requires a great deal of time and effort (Trinick & May, 2013). Such work must ensure that terms appropriated for mathematics are not stripped of their cultural meanings and be done with the awareness that using terms for mathematics may change their use outside mathematics (Meaney et al., 2008). Halai and Muzaffar (2016) argue that switches in use of different languages for mathematics education redistribute cultural capital and thus should be conducted carefully and gradually to promote distributive justice. Indigenous language mathematics instruction is thus educationally justified, has precedents, but is far from trivial to establish and extend.

Project design and methodology

Cris was introduced to Waruwi Community School by Ruth Singer, a linguist who has worked with Mawng speakers at Waruwi for over 15 years. The project was initiated in 2017, with two researcher visits totalling 4 weeks to establish relationships and to begin pilot interviews and documentation of Mawng spatial language. The project was approved by the Waruwi Community School Council, which includes Mawng Traditional Owners of Goulburn Island. Ethical approval was granted by the Ethics Committee of the researcher's university, and all adult participants and the caregivers of children gave informed consent. The school agreed to collaborate on a research project to develop mathematics lessons focussing on Mawng terminology for spatial sequencing.

Spatial language and thinking are important for spatial areas of mathematics (geometry, mapping), but also for mathematics more generally (Sinclair et al., 2016). Training in spatial visualisation skills can improve other mathematical abilities (Lowrie et al., 2017) although the mechanisms for this are not yet well understood (Lowrie et al., 2020). Spatial metaphors are also used when talking about number sequencing, in the sense of saying that numbers come before or after other numbers, or sometimes that they are higher or lower; these metaphors can be culturally specific and are often mixed (Edmonds-Wathen, 2012). Mawng teaching staff were interested in eventually being able to use sequencing words for teaching number in Mawng, in the sense of being able to say a number comes before or after another number.

The Mawng maths program was designed to operate within the normal routine of the school's mathematics lessons. The Mawng teaching staff and School Council decided that all the children should participate in the Mawng mathematics lessons, recognising that this was a first language for some of the students, a language being learnt additionally by others, and for some a new language. This meant while for some children Mawng was a resource in their learning, for others (such as Kunwinjku and Yolngu speakers), learning Mawng was one of the main purposes of the lessons.

Planas and Civil's (2013) discussion of language-as-a-resource and language-as-political captures some of the tensions that are present in mathematics classroom with Indigenous language-speaking learners of multiple languages. While mathematics lessons in Mawng for Mawng-speaking children may be using language-as-a-resource, introducing Mawng mathematics for children of other language backgrounds such as Kunwinjku and Yolngu speakers recognises Mawng's political status as the language of the land in which the community and school are situated (Edmonds-Wathen, 2019).

The teaching intervention followed a participatory action research methodology where Cris and Jacobina worked closely together designing, implementing and revising a teaching program in a cyclical manner. To some extent, this is a formalisation of what teachers already do in their teaching practice of retaining and refining what works and rejecting what does not. To make it action research, there is both a commitment to change by all parties and formal recording and reporting of results (McTaggart, 1991). The development of the Mawng maths program was not according to a predefined mathematical learning framework but evolved as Cris and Jacobina reflected on each lesson. The program was designed to be practitioner-led and sustainable, so that it could continue if and when a researcher was no longer able to keep working in the community and school.

Warruwi Community School is a small school of less than 100 students from pre-school to middle years. The Early Primary class at Warruwi Community School was a mixed level class from Transition to Year 3, with an age range from 5 to 9 years old. Students are assigned a school year level based on age but may have divergent academic achievement for a wide variety of reasons including amount of time in school (some students attend more than 90% of the time, some students attend less than 20% of the time). Varied systems of grouping students are used in different parts of the school program. Grouping during mathematics was according to school-assessed achievement levels, so some students from the Early Primary class went to the Middle Primary class and some students in Years 4 and 5 joined the Early Primary class. This meant that children's ages in Mawng maths ranged from 5 to 11 years, with around 40 children in total participating over the duration of the program described here.

The teaching program was implemented in 2018 during three visits from Cris: a 5-week visit in February–March, 2 weeks in April and 3 weeks in August–September. Two follow-up visits of 1 week were also made in 2019, in September and November. Jacobina's availability varied throughout those visits due to family commitments. In 2018, Cris was able to extend visits to allow for this—the first visit had been planned for 3 weeks but was extended to cover Jacobina's return from a visit to the

mainland. Cris no longer had this flexibility in 2019 and was only able to schedule two 1-week-long visits.

Although not directly involved in the design or delivery of the Mawng mathematics lesson, the Early Years class teacher and the school provided powerful structural support for the project. While we initially attempted lesson planning at the end of the school day, this was difficult for Jacobina due to family responsibilities. The classroom teacher and school management agreed that Jacobina could be released from class for the final hour of each school day to work on the lesson planning. This enabled her to work on the project without conflicting with her family responsibilities.

A typical mathematics session was structured with students in two rotating groups, spending half the lesson with the class teacher, and half the lesson with Jacobina. Mawng mathematics lessons could be delivered to each group by Jacobina without disrupting the normal routine of the class. If Jacobina was not available to teach the Mawng lesson, the class routine was still not disrupted, with one group doing an independent activity while the teacher took the other group. On days that Jacobina was not available, Cris sometimes took the second group for a mathematics activity in English, which helped normalise her presence in the classroom for the students.

Lesson focus: spatial sequencing words

The teaching intervention occurred concurrently with a study investigating children's spatial language in Mawng. The students participated in pre- and post-assessment of their productive and receptive spatial language in both English and Mawng. These assessments were individual interviews with instructions and questions recorded from a Mawng native speaker, Ms Rachel Ngalwumut Meiyinbara (findings from those assessments will be reported elsewhere). In developing the assessment interviews, documentation of the target spatial language in Mawng had begun, particularly *kiwraka* "in front" and *warrwak* "behind". The interviews also included topological relations such as "above", "below", "beside", "between" and "inside", which were not included in the initial teaching intervention. Pilot interviews were also conducted in Mawng by Ngalwumut with children who were identified as being predominantly Mawng speaking. These revealed a wide range of competency with the target language in the student group.

The focus language was a series of four sequencing terms which are shown in Table 1 with the verbs in masculine singular present tense and with the verb root shown in brackets. In further uses of these verbs, the root is bolded.

This list of terms was developed in the first main planning session, with Jacobina and Cris working with Ngalwumut and other senior Mawng consultants with extensive experience working in the school and on linguistic projects.

All the words other than *warrwak* "last" are verbs that change form according to the number and gender of participants, as well as tense and mood. These terms are much more complex morphologically and syntactically than their English equivalents. Mawng has five grammatical genders for nouns, masculine, feminine, land, edible and vegetation, which have a strong semantic basis for classification (Singer, 2006), so for

Table 1 Mawng sequencing words

Mawng word	Word type	Meaning	Example (from Singer et al., 2015)
<i>Kiwraka (-uraka)</i>	verb	Go first, go ahead, be in front	<i>Kawuraka ta kurrampalk</i> “They’re in front of the house”
<i>Kinilurrku (-urrku)</i>	verb	Follow, stay with	<i>Kiwraka la karrilurrku</i> “He goes ahead and we keep up with him, follow him”
<i>Kimnyayajayatpi (-ayajayatpi)</i>	verb	Next in sequence (age or importance)	<i>Kimnyayajayatpi la yamin</i> “They’re side to side, next to each other”
<i>Warrwak</i>	adverb; does not change	Behind, last person, later on	<i>Ngarri ta warrwak mira ngarrurakangung</i> “We were the last people that got back”

example, *waryat* “rock” belongs to the land gender, *warlk* “stick” to the vegetation and *jel* “shell” (an English borrowing) to the edible. The forms of the sequencing verbs change according to the gender of what is being sequenced, thus for example, *kiwraka* is the masculine form for in front, *kinyuraka* is feminine and *kanguraka* is the land gender, such as *ta waryat kanguraka* “the rock is in front”. *Kinilurrku* and *kinnyayatjayatpi* are also both transitive, requiring both a subject and object.

Kinnyayatjayatpi is a tongue twister even for fluent Mawng-speaking adults. Its inclusion was justified by the consulting team on the grounds that the children need to be learning all Mawng words including those that are challenging to pronounce. These Mawng educators share Pitjantjatjara speakers’ desires for their children, wanting their children to learn their language properly, to learn the “strong old language” (Minutjukur et al., 2019, p. 90) that the elders speak.

The degree of semantic mapping between the Mawng terms and related English terms varies. *Kiwraka* has core spatial meanings “go first, go ahead, go in front, be in front”, and can also be used in a temporal sense as in *pata awurakangung* “those dreamtime people who came before us” (Singer et al., 2015). It also has a secondary meaning “go home”. *Warrwak* is used temporally for “after, later” as well as its spatial meanings of “after, last”. English also has some overlap between spatial and temporal terminology. *Kinilurrku* primarily means “follow” but was used to mean “second”, and *kinnyayatjayatpi* means “next in sequence” but was always used in the place of “third”. While it was decided that *kinilurrku* and *kinnyayatjayatpi* would be used in that sequence, they do not relate to Mawng number words. This is an example of how the use of language in school activities can start to change the meaning of a word (Meaney et al., 2008).

As well as there being semantic differences between the Mawng and English terms, there are mathematical implications to the differences in grammatical category, with Mawng words being verbs, and the English equivalents being adjectives and prepositional phrases. Mathematical language in languages such as English tends to nominalise processes, whereas some other languages such as Navajo (Pinxten et al., 1983), Mi’kmaq (Lunney Borden, 2011) and old Māori (Barton, 2009) use verbs in certain mathematical contexts where English used nouns or adjectives. Barton (2009) notes that the grammar of numbers in Māori has shifted, with some evidence of impact from contact with other languages. Lunney Borden (2011) talks about using a verb-based discourse pattern in mathematics lessons with Mi’kmaq children, focusing on the active properties of geometric objects, rather than identifying and naming their parts. Preserving the “old strong language” (Minutjukur et al., 2019, p. 90) of Mawng includes retaining the verb-based discourse which focusses attention on processes and relationships rather than things.

Planning the lessons

Jacobina and Cris planned together, taking different roles in a two-way practice. As a researcher interested in mathematics in different languages and how different languages can be used for mathematics education, Cris focussed on assisting Jacobina identify and embed appropriate Mawng terminology in the lessons and

supporting her in using Mawng as medium of instruction. She explicitly decided to minimise her input into the choice of pedagogical practices, for example whether lessons would be teacher led, student led or inquiry driven.

Jacobina is an experienced and confident assistant teacher accustomed to leading groups in lessons as part of her normal teaching responsibilities. She uses her multiple languages working with the students in her class (Edmonds-Wathen, 2019). This project was her first previous experience of planning lessons and of formally teaching in Mawng. Waruwi Community School was using the DISTAR program of Direct Instruction for their literacy and numeracy program. While the use of this program in remote Indigenous education has been contentious (Ewing, 2011), practical benefits included consistency of delivery across the school. A behavioural script format of the teacher-led part of the lessons made it relatively simple for teaching staff to take up a lesson sequence with a new group. Jacobina had been trained in DISTAR delivery and was accustomed to lead groups using this method. The structure of DISTAR lessons, which do not include open questions, and where the necessary information is always first provided to students to respond correctly to the teacher's closed questions or prompts, influenced Jacobina's scripts for the bodies of the lessons, although she did include open questions in the early part of some lessons that developed the context and ensured that there was the required shared background knowledge. Jacobina practiced her lesson scripts repeatedly before each lesson, consulted with the elders on them and in one case tested out a lesson with her own children to make sure she was confident before taking the class.

The sequence of lessons was not pre-planned but was developed through the iterative process of collaboratively evaluating each lesson as part of planning the next. As the lessons progressed, the progression of language use extended from that of the previous lessons, extending the scope of how terms were applied, and extending the grammatical forms in which terms were used.

Intrinsic sequencing

Early lessons introduced the key terms to sequencing people in terms of age and size, so there was an intrinsic sequence associated with the activities. A set of four male and four female family terms were chosen: *wulupulu* "(paternal line) great grandfather (father's father's father)", *wawu* "(paternal) grandfather", *punyi* "father" and *kayu* "big brother" for the male family line and *wulupulu* "(maternal line) great grandmother (mother's mother's mother)", *wiwi* "(maternal) grandmother", *kamu* "mother" and *larla* "big sister" for the female. These family terms have an intrinsic sequence based on age: for example, *wulupulu* "great grandfather" is *kiwraka* "first" and *kayu* "big brother" is *warrwak* "last", which was an advantage for initial lessons. Small, laminated picture cards and words cards were made that could be handled and sequenced. As well as the oral and hands-on components, the lessons included writing and representing through drawing.

Extending the scope of sequencing: animals and fish

The next phase involved arbitrarily sequencing objects that did not have an intrinsic sequence. The first topic was farm animals: pig, horse, cow, goat/sheep. Although not local native animals, they are locally known and have Mawng names which are transliterations of English names, such as *pikipiki* “pig”, except for *jarrang* “horse”, a loan word from Bahasa Indonesia. As well as laminated picture cards, there were also numerous small rubber manipulatives of these animals in the classroom, which the children could physically sequence.

Lessons were also developed using local fish. Fishing is a core cultural subsistence activity as well as a preferred recreation for the people of Goulburn Island. Being able to identify and name local fish is important cultural knowledge. Jacobina wanted to use the Mawng mathematics lessons to develop and reinforce this knowledge. These lessons used the terms in the declarative mode, as shown in the extract *Mawng maths 1*.

Mawng maths 1

Teacher: *Jarrang kiwraka*

The horse is first

Pulikang kinilurrku

The cow is second

Nanikut kinnyayatjayatpi

The goat is after that (third)

Pikipiki warrwak

The pig is last

Ngampi ja kiwraka?

Which one is first?

Students: *Jarrang*

Horse

Teacher: *Ngampi ja warrwak?*

Which one is last?

Students: *Pikipiki*

Pig

Teacher: *Ngampi ja kinnyayatjayatpi?*

Which one is third?

Students: *Nanikut*

Goat

As in English, it is acceptable in Mawng to answer simply with the name of the object, that is, to reply to the question *Ngampi ja kiwraka?* “Which one is first?” simply with *Jarrang* “(the) horse”, so while these questions stimulated receptive understanding, they did not always generate student production of the sequencing terms.

Prompting productive language use

In order to prompt productive language use (in the sense of students verbally producing the terms rather than just responding to them), questions were then developed that prompted students to use the location words in their answers, as in the lesson extract *Mawng maths 2*.

Mawng maths 2

Teacher: *Ngampiwarak ja kawirrwa?*

Where is the striped scat?

Kudbina, kinilurrku

Say, second

Students: *Kinilurrku*.

Second

Teacher: *Ngampiwarak ja martali?*

Where is the mangrove jack?

Students: *Warrwak*

Last

Extending modality

Next, Cris suggested using the words in imperative modality, instructing the students to place the items in a specified location. Jacobina waited to implement this until she had confidence with the students’ familiarity with the nominative forms. In lesson extract *Mawng maths 3*, the imperative verb *kurruyutpani* “put” is plural,

addressing a group of children. The three sequencing verbs take an imperative singular form, as they refer to a single object being placed.

Mawng maths 3

Teacher: *Warranyngiw, kurruyutpani ja arilka yurakani*

Children, put the blue tuskfish in front

Warranyngiw, kurruyutpani ja imartuk iwanilurrku

Children, put the black bream second

Warranyngiw, kurruyutpani ja martali iwannyatatjayatpi

Warranyngiw, kurruyutpani ja kawirra warrwak

Children, put the striped scat last

Delivering the lessons—Jacobina’s experience

Although Jacobina was accustomed both to leading groups in lessons and to using Mawng in her teaching, this project was Jacobina’s first experience of planning and teaching her own lessons in her own language. She introduced each of the lessons to the children with strong statements positioning Mawng maths as equal with maths in English. For Jacobina, it is important for the children to learn in Mawng, rather than be learning in English all the time. This was something that she repeatedly emphasised to the children when she introduced the lessons. She was nervous during her first lessons, but she enjoyed teaching the lessons. She sees that the children have fun in the lessons; they ask her “Oh, can we do it again? Can we do it again?” She appreciates the way that the class structure enables her to take the lessons, swapping groups with the class teacher who teaches the English Maths. This evokes Graham’s (2017) statement about how development occurs when the power and control are shared between bilingual teaching team members. Jacobina emphasises the personal value of the planning and teaching for herself, which helps her to develop her teaching practice: she wants to keep teaching Mawng maths because she wants to keep learning.

Discussion

The lessons focussed simultaneously on mathematical content, linguistic content and cultural content, each of which was incrementally developed as the program proceeded. The complexity of Mawng sequencing words and their many inflections means that far more is involved to teach the language of these concepts than in English. Each new lesson extended knowledge from the known to the unknown—from intrinsic sequencing to arbitrary sequencing, from receptive comprehension to productive word use, from declarative linguistic forms to imperative forms and from

the immediacy of family members to lesser known local fauna. Further extension included using the words with objects of Mawng's five different grammatical genders and in beginning to use the words to for number sequencing.

This process of moving from the known to the unknown through introducing one new element to each new lesson highlights the action research nature of the project. We did not start with a pre-designed sequence of lessons. Instead, we developed each new lesson through reflecting on the previous ones and the changes were negotiated between Cris and Jacobina. Cris contributed expertise about linguistics and school mathematics; Jacobina contributed expertise in Mawng and local cultural knowledge, aided by the senior Mawng consultants, and her knowledge of the students. Cris' role was to facilitate and support, making suggestions about possible lesson activities, and gently instigating the extension of the mathematical and linguistic scope of the lessons. Jacobina decided whether she wanted to implement Cris' suggestions and when she and the students were ready for extension, as with the introduction of the imperative forms. While Cris liked using the physical manipulatives of the farm animals and being able to sequence them in three-dimensional space, for Jacobina, teaching and reinforcing the Mawng names of local fish was a greater priority due to the cultural value of fish and fishing. It took time to agree on goals and processes sometimes. As Jacobina was the one doing the teaching, she needed to be happy and confident with the teaching plans including having senior Mawng consultants review the lessons. Sometimes, Cris had to let go of some of her ideas and goals, letting go of the control and outcomes-based planning that is often emphasised in university research.

This collaborative work needed to be done during the school day as once the school day ended, Jacobina's family responsibilities took precedence. The class teacher supported this in agreeing that Cris and Jacobina could work together after lunch each day. If the class teacher and principal had not provided that practical support, the project would not have been possible. This is significant as time for research, study and professional development within work hours is often not supported in remote schools, both by individuals in leadership positions and structurally in how schools are staffed and resourced. Class teachers miss the important support of assistant teachers when they are out of the class doing other things. Any initiative by education authorities to support the increase in capacity of Indigenous educators needs to be backed up by the provision of paid time within the normal work day, particularly in remote communities where local educators invariably have numerous and complex family and community responsibilities.

The student cohort who participated in this program was diverse and began with different prior knowledge and skills in Mawng and in spatial abilities. For the children who spoke Mawng as a first language, these lessons provided them with a new way to participate in spatial mathematics activities. These children already knew terms such as *kiwraka* "in front" and *warrwak* "behind", although for most of them, *kinilurrku* "follow" and *kinnyayatjayatpi* "next in sequence" appeared to be new. These children already had grammatical knowledge of Mawng verbs in general, so the use of different forms for different genders and modalities would have fit patterns with which they were already familiar. For them, the use of Mawng was language-as-a-resource (Planas & Civil, 2013). The benefit to these child speakers

was that the program facilitated their access to the spatial concepts through the use of their first language. For other children, Mawng was a language which they knew somewhat, or were able to understand but not to speak, and for a few students who were new to the community, such as several who were recent visitors from East Arnhem Land and first language speakers of a Yolngu language, it was a completely unknown language. For them, the use of Mawng was language-as-political (Planas & Civil, 2013). The senior Mawng consultants, Traditional Owners of Warruwi and Jacobina recognised that for these students, using Mawng would not provide them with easier access to the spatial concepts but would be the students' key learning challenge. They are proud of the Mawng maths program as one more piece of structural recognition that Mawng is the main language of Warruwi and as a forum to promote the learning of Mawng.

Conclusion and future directions

We measure the success of this project in terms of the sustainability of its delivery, past the direct involvement of the university research in its implementation. The Mawng maths program continues at Warruwi Community School, including assessment using the Australian Curriculum: Mathematics and the Northern Territory Indigenous Languages and Cultures Curriculum. Jacobina has plans to expand Mawng maths across all the school's year levels. The sustainability of the program can be attributed to several factors. The program was developed from a need identified within the community for more Indigenous language instruction. Relationships were developed between the researcher and the educator and we were not in a hurry: sufficient time was allocated in the development and planning stages for input from community elders and experts. The teaching program was developed collaboratively by the Mawng educator and the researcher, ensuring that the Mawng educator was comfortable and competent with her plans. Developing a program that is participatory and collaborative takes time and willingness for the program to develop its own shape and direction rather than being pre-planned by an external researcher. The result is a program that belongs to the community, is sustained by the community and reflects the values and desires of the community. It remains to be seen what impact the program has on the mathematical achievement of the students and on the maintenance of Mawng as a strong language used in the high status domain of school mathematics.

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Declarations

Ethics approval This research had ethical approval from the University of Melbourne in 2017–2018 with approval number 1748561, from the Northern Territory Department of Education approval EDOC2017/92239 and from the Northern Land Council. Letters of support were obtained from Traditional Owners of Warruwi and consent was obtained from Warruwi School Council. Informed consent was granted from linguistic con-

sultants, principals, teachers, parents and caregivers. Participants are de-identified except where they gave express permission for recognition of their contribution as language experts.

Declarations This work has not been submitted for publication elsewhere.

Competing interests The authors declare no competing interests.

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