Speaking Spatially: Implications for Remote Indigenous Learners

Robyn Jorgensen
University of Canberra
<robyn.jorgensen@canberra.edu.au>

Tom Lowrie
University of Canberra
<Thomas.lowrie@canberra.edu.au>

As part of a much larger study where spatial reasoning is the focus, this paper draws on the language aspects of this strand of the curriculum. The quarantined part of the project discussed in this presentation is based in remote Indigenous schools. We draw on the challenges of the concept of symmetry and where the language of instruction (and mathematics) is a foreign language. We pose questions of the nuanced, and often complex, language of spatial reasoning and the impact this has on the performance of Indigenous learners when applied to the enacted practices in school mathematics. We conclude by raising concerns and directions of the subsequent phases of the project.

The Importance of Studying Space

The spatial component of the mathematics curriculum is somewhat different from the other content areas of mathematics. Most notable – unlike number, measurement, chance and data – the space strand does not have a heavy reliance of number. While there are aspects of the space strand, such as angle, that do incorporate the use of number, by and large, this strand focuses on a different way of thinking and is very rich in terms of the spatial vocabulary that is required. It is this language component of the space strand that is the focus of this paper. We draw on one example from our larger project where we were exploring the notion of symmetry and reflection.

There is considerable pressure on teachers to be accountable and to ensure coverage of state-mandated curriculum. This is an international phenomenon, but with an overcrowded curriculum, there is often an emphasis on the study of number with the consequence that the space strand is a poor cousin in the study of mathematics. Newcombe and Frick (2010) have argued that the study of space is an important component in the development of mathematical skills. There is a strong acknowledgement that the spatial skills developed in the early years correlate with spatial reasoning in later years. For example, it has been found (Levine, Ratliff, Huttenlocher, & Cannon, 2012) that when children between 2 and 4 years engage in puzzle play, there is a strong prediction on performance on non-linguistic spatial transformations at the age of 4.5 years. This suggests that early experiences are formative in the generation of spatial reasoning, and language as will be discussed in a subsequent section.

But the study of space has been expanded with new forms of learning made possible in environments not incorporated in conventional paper and pencil work. In their innovative study using robotics, Khan, Francis and Davis (2015) have proposed that the study of space also opens up new forms of knowing through unification of the physical context, biodynamics of the body moving through space; coordination of sensorimotor skills, along with cognitive processing of events and actions. This multiplicity of learning events, they contend, makes for a different set of competencies that are made possible through the other strands of the mathematics curriculum. The space strand opens up new and different possibilities for learning mathematics. We take this importance of space as fundamental to

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this project: “Equity and Spatial Reasoning: Reducing the mathematics achievement gap in gender and social disadvantage”.

Language of Space

There is some debate as to whether language influences performance in spatial reasoning but what appears in the literature is the importance of building a strong spatial language in order to be able to compete successfully on spatial tasks (Dumitru, Joergensen, Cruickshank, & Altmann, 2013). The impact of language on spatial performance was highlighted in a comprehensive study of non-hearing learners whose spatial language was restricted (Gentner, Özyürek, Gürcanli, & Goldin-Meadow, 2013). When students were asked to perform on non-linguistic spatial tasks, it was found that there was a strong link between students’ poor performance and their lack of spatial language. Similarly, other studies have shown the importance of working with families to build spatial language (Polinksy, Perez, Grehl, & McCrink, 2017) and the positive impact these strategies have on students’ subsequent performance on spatial tasks.

The importance of learning, hearing, using the language of space is a critical aspect of spatial understandings and performance. Using relational spatial language (such as top, middle) can enhance performance on tasks where students have had to find hidden cards (Loewenstein & Gentner, 2005). In a study of early years students working with block assembly (Verdine et al., 2014), it was found that students relied on language skills in order to build various assemblies with the blocks. Such studies suggest the importance of having a strong spatial language in order to perform well on spatial tasks.

The importance of parental talk with early years students cannot be underestimated. Pruden, Levine and Huttenlocher (2011) observed (and measured) parental spatial talk with their children. It was found that the level of parental language predicted children’s spatial language as well as their performance on spatial tasks. Miller, Vlach and Simmering (2016) reinforce this view, but extend it to argue that the language relevant to the task was a greater predictor of spatial skills; it surpassed factors such as demographics and language per se. They suggest that the quality of the spatial language needs to be considered rather than just the quantity of spatial terms used. This finding has significance in terms of the research that there is a correlation between the social background of students and their performance in spatial tasks. Many authors noted the importance of language skills in relation to successful completion of the tasks, but also reported that there were differences in the students’ language skills that related to their socio-economic status (SES) backgrounds with low SES families reporting that they used less spatial language than their middle-SES peers (Verdine et al., 2014).

Implications for Equity

It has been recognised that educationally-disadvantaged students are likely to have difficulty navigating the various forms and components of spatial and graphic representations (Heinze, Star, & Verschaffel, 2009) —with such challenges heightened for female students (Hegarty & Waller, 2005). More specifically, students from low SES backgrounds have been found to be more at risk in this strand of study than their middle SES peers (Verdine et al., 2014). At the same time, it is acknowledged that teachers are challenged by the prospect of including spatial understandings in their teaching (Stylianou, 2010) and this can relate to their feelings of anxiety in teaching the content (Gunderson, Ramirez, Beilock, & Levine, 2013).

Equity and Indigenous Learners

When considering the Australian context and the intent of our project for the Indigenous cohort in the larger study, we are cognizant of a number of factors to take into account. We need to acknowledge the cultural context/s within which we work. Here, the notion of space and place are quite unique and different from that represented in the standard school curriculum. Second, we need to recognize that the students in remote contexts speak a home language (or many languages) that are not the language of instruction. As such, the ways of speaking spatially may be very different from that of the school register. The vocabularies of the home and school may be quite different so consideration needs to be made of this difference.

First, consider the cultural and geographical context. In the Australian context there was a wide range of work undertaken in the 1980s that was predominantly ethnographic in orientation. The seminal work of Watson drew attention to Indigenous ways of knowing. In particular Watson-Verran and Chambers (1989) documented the ways that Yolgnu people mapped their land according to historical and cultural events rather than the protocols used in standard mapping taught in schools. They worked extensively to document the intimate connection between land and mathematics among the Yolgnu people. Their corpus of work highlights different ways of thinking and working mathematically, spatially and culturally that needs consideration in these contexts. In work with Warlpiri people, Harris (1991) found that the people tended to use compass points more often than relative terms such as left or right, not only in reference to land, but also in relation to the personal including the body. The findings of Verran-Watson (also known as Watson, Verran, & Watson-Verran) are not unique to the Australian context and have been recorded in other Indigenous ways of knowing (Tsai & Lo, 2013).

Second, in more contemporary work undertaken by Edmonds-Wathen (2011, 2012) where the author explores the spatial language and ways of thinking spatially of the Iwaidja people, the importance of the relationship between language and space for Indigenous learners, and their teachers is highlighted. In her work with a range of remote Indigenous communities across Australia, (Jorgensen (Zevenbergen), 2016, 2017) has documented the impact of Indigenous languages on learning and the importance of language strategies used by teachers to support learning for Indigenous learners for whom the language of instruction (Standard Australian English) is different from the home language(s) that the students bring to school.

Third, we need to acknowledge that the language of the teacher, and hence instruction, may be quite different from that of the learners. In remote contexts, most of the teachers are new graduates or recent graduates, often new to remote teaching and often with little to no experience working with Indigenous learners and community. Collectively, this requires some work to be undertaken with teachers as well as students.

Space within the Australian Curriculum

Within the Australian educational context, there is now a common curriculum that provides teachers and systems across the nation with a framework for mathematics. It is broken down to year levels and content areas (strands, general capabilities, cross curriculum priorities). For the purposes of this paper, we draw on the strand component and focus on the “geometry” component and draw on the content descriptions in order to identify the content and language demands on teachers and learners. The spatial strand co-exists within measurement. The content in Space is broken into two main areas – “shape” and “location and transformation”. In organizing the curriculum, there are explicit learning outcomes that are then broken into elaborations that provide teachers with more explicit descriptions of learning. For example, at the year 3 level (Australian Curriculum Reporting and Assessment Authority, 2017) under “location and transformation” there is a general statement of content:

Identify symmetry in the environment

The elaborations for this outcome were listed as:

Identifying symmetry in Aboriginal rock carvings or art
Identifying symmetry in the natural and built environment

In the year 4 curriculum statements, students expected to be able to “Create symmetrical patterns, pictures and shapes with and without digital technologies” (ACARA, 2017).

Table 1
Content of the Geometry Strand within the Australian Curriculum: Mathematics

Shape	Prism, cylinder, cone, cube, sphere, net, skeleton, cross section
	2d shapes and 3D objects – corners, faces, edges
	Properties of shapes, objects
	Symmetry, angles as measures of ‘turn’
	Regular and irregular shapes
	Classifying angles, measuring angles, comparing angles
	Connecting shapes with nets
	Construction of prims and pyramids
	Angles on a straight line, angles at a point, vertically opposite angles
	Perspectives of 3D objects and combinations of objects
	Classifying shapes via their properties
	Angle sums of triangles and quadrilaterals, co interior angles and transversals
	Parallel lines
Location and transformation	Everyday language of location and direction – turns, directions, distance
	Giving directions
	Transformations – slides, turns, flips
	Grid maps
	Scales and legends on basic maps
	Symmetrical patterns
	Describing routes using landmarks and directional language
	Rotational symmetries,
	Enlargement transformations
	Cartesian coordinates
	Describing translations, reflections rotations on Cartesian plane

Teachers across Australia, regardless of context are expected to teach to this framework. The conservative ideology behind the reform has been to suggest that remote Indigenous students should be exposed to this framework so that ALL Australians have the same opportunity to learn and hence the same opportunity to achieve. Such an approach, while fundamentally flawed in its assumption that all learners start from the same position, has been mandated for all teachers and systems. In examining the elaborations across the geometry component, the content has been noted in Table 1. The content, and by implication the complexity of the inherent language can be inferred. It is beyond the scope of this paper to provide a comprehensive account the linguistic demands of this sub-strand of the curriculum, but suffice to say at this point that it is extensive.

A Case of "Symmetry"

From the larger project, we sought to identify students' understanding of symmetry and reflection. This is part of the Year 3 experiences in the Australian curriculum. As our targeted year levels were Years 3 and 5 it could be assumed that the topic would have been covered in the school context. The task we used was to have a series of photographs of children undertaking activities such as ballet, football, and dancing including one of an Aboriginal boy doing a dance (see Figure 1. for the actual stimulus pictures used). The task was the students to mirror the image, and then to draw it. We found the latter component difficult and time consuming so we have opted to delete this component. The task involved a series of children in various activities. The stimulus pictures were carefully selected so that body parts would be in different positions – e.g. left arm up, right arm horizontal –so that we could assess whether or not students were able to demonstrate their understanding of reflection on a line of symmetry. These pictures were selected to incorporate inclusiveness across the full project where we are looking at urban/rural, high SES and low SES and Indigenous/immigrant students. So, we sought to have stimulus pictures that would embrace the experiences of the students, including genders. Of interest is that the examples in Figure 1. were the only pictures that the remote students selected to draw.

Figure 1. Symmetry Stimulus Pictures.

Findings

Working with three cohorts of students across two remote communities where there were 3-4 students in any one group, we show them the stimulus pictures (n=10). Initially, the approach of the project was to have the students see the images as reflections around a line of symmetry. Working with the cohorts of students, it was unclear the understanding of the concept or language of "symmetry". This meant that the students were initially unable to complete the task. Unlike other cohorts of students (urban, rural) once the term "symmetry" was used, they were able to engage with the task, with minimal intervention or teaching.

Working with the Indigenous students, the concept of symmetry was modelled using mirrors to show the reflection of the images and how they looked different and the reversal of arms and legs. Students struggled with this and the mirrors became a distraction from the task – mostly with the students looking at themselves! When the task was altered so the image was placed in front of the student (either on a desk or the ground) and students were asked to mirror the image or to reflect the image, students were able to do the task. By copying the image in a bodily manner, it appeared that the task was more accessible for the students.

When asked to explain their body position, the students tended to rely on gesture to indicate why, for example, they had a right arm up or the left foot raised. They were more likely to give a flick of the head and/or point to a part of the picture and then show their body position. The gestural explanation/justification appeared to be a preferred mode of explanation. For this part of the project, we were only in the community for a brief period so the time need to build trust and rapport was limited but we were able to have the students elicit non-verbal responses to this task that demonstrated their understandings of the task. It was clear from their body language and mirroring of the stimulus pictures that they were able to mirror the body positions. This suggests to us that the students were cognizant of the concept but the (school) language of symmetry needed to be developed.

Implications

While this project is in its trial year where we are working on tasks/activities to identify spatial reasoning of our targeted cohorts, the initial work in two remote Indigenous communities has highlighted a number of considerations for subsequent phases. At this point, we are unclear as to the role of school language and spatial reasoning when working with remote Indigenous students whose home language is different from the language of instruction. We will spend more time in community in 2018 to build greater familiarity, trust and rapport with the students and families so that we may be better able to access positive interactions with the students. We will also attempt to build tasks that are culturally more responsive to the communities and their activities so as to engage the learners in the tasks. Our attempt in the work cited here (the incorporation of an Indigenous dancer) was a positive step. We note that most of the girls picked the ballerina which has very little connection to this context and so we are curious as to how much 'culturally responsive' activity is needed to better understanding Indigenous ways of knowing around spatial reasoning.

One key consideration for the project is timeliness. The three tasks we undertook were very time intense. The task cited here took more than 30 mins to implement with small groups hence our decision to omit the drawing task from future work. The video and photographic recording of students – for example as they posed in the front of each photograph – was a very positive process as it was quick and easy to implement without stopping the flow of the activities.

Language of Symmetry

What occurred in these testing contexts was that the symmetry task was the most difficult of the three tasks undertaken. In this task, it was clear that students could show symmetry as a point of reflection, but what was problematic was the language of symmetry. Using the term initially was met with blank faces so strategies were need to scaffold the students in order for them to access the task. While terms such as "mirror" and "reflection", and the use of a mirror, did not scaffold the students, it was more apparent that modelling served a better scaffolding technique than the use of language per se.

Using one picture as a catalyst or prompt, students were asked to look at the stimulus picture and look at a particular body part – e.g. the arm of the right side of the picture with a point to the right. Usually two of these prompts was sufficient for the students to crack the code of the game (Zevenbergen, 2000) and engage successfully in the tasks. Through this scaffolding, language did not hinder success per se as students were able to grasp and demonstrate their understanding of the task. What is unclear at this point in time is whether the students have been able to mathematise (in a school sense) the concepts embedded in the task or were they simply copying the actions and engaging in a non-mathematical game. The discussion that followed gave us some indication that they had understood the mathematics of the task which is encouraging, even in the absence of a formal mathematical register.

To date, what we have learned is that we may need to be more open to ways of working spatially – and linguistically – for remote Indigenous learners. The formal language may not be part of their mathematical habitus at this point in time. Teachers may require support to assist them to develop this formal language using strategies identified in the Remote Numeracy Project (Jorgensen, 2017). The Remote Numeracy project preceded the current project and documented the strategies teachers and schools used to support numeracy learning. One of the key learnings from this earlier project was around the scaffolding of language and as such, the outcomes of that project could assist our current students to access and use the formal discourse of school mathematics, particularly in the area of spatial reasoning.

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