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Reintroducing Māori ethnomathematical activities into the classroom: traditional Māori spatial orientation concepts

Reintroduciendo actividades etnomatemáticas maoríes en el aula: conceptos tradicionales maoríes de orientación espacial

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Abstract

Māori mathematical practices were excluded from schooling in Aotearoa/New Zealand for over 150 years as a result of explicit policies precluding the use of the Indigenous language and culture. As a consequence of the range of assimilationist policies, by the 1970s, the Māori language was considered endangered. In response to the perilous state of the language, Māori communities set up their own schools, initially outside of the state system, to support the revitalisation of the language and culture. However, the reintroduction of the cultural knowledge in areas such as mathematics has not matched language revitalisation efforts. Many original ethnomathematical practices are no longer in general use in the Indigenous community and the practices valued by the European majority remain the norm in the state-mandated school curricula. Spatial orientation is an example of the mathematics curricula content that is based on Western mathematical perspectives. To provide a Māori perspective, this paper draws on interviews with elders and historical data to examine Māori spatial orientation terms and the spatial frames of references that they are derived from. Students in a Māori-medium school were tested on their understanding of this traditional knowledge. As a consequence, a series of learning activities based on Māori spatial orientation concepts were developed and trialled. The outcomes of these learning activities showed some increased understandings about Māori spatial orientation concepts.

Keywords: Māori-medium schooling; Spatial orientation; Spatial frames of reference; Wind directions; Landmark orientation

Resumen

Las prácticas matemáticas maoríes fueron excluidas de la escolarización en Aotearoa / Nueva Zelanda durante más de 150 años, como resultado de las políticas explícitas que impiden el uso de la lengua y cultura indígena. Como consecuencia de la gama de políticas asimilacionistas, para la década de 1970, el idioma maorí fue considerado en peligro de extinción. En respuesta a la peligrosa situación de la lengua, las comunidades maoríes crearon sus propias escuelas, en un principio fuera del sistema estatal, para apoyar la revitalización de la lengua y la cultura. Sin embargo, la reintroducción de los conocimientos culturales en áreas como las matemáticas no ha igualado los esfuerzos de revitalización del idioma. Muchas prácticas etnomatemáticas originales ya no son de uso general en la comunidad indígena y las prácticas valoradas por la mayoría de Europa siguen siendo la norma en los programas escolares exigidos por el estado. Orientación espacial es un ejemplo del contenido de los planes de estudio de matemáticas que se basa en perspectivas

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matemáticas occidentales. Para proporcionar una perspectiva maorí, este documento se basa en entrevistas con los ancianos y los datos históricos para examinar términos de orientación espacial maoríes y los marcos espaciales de las referencias que se derivan de estos. Los estudiantes en una escuela Māori-medium school fueron probados en su comprensión de su conocimiento tradicional. Como consecuencia de ello, una serie de actividades de aprendizaje basadas en conceptos maoríes de orientación espacial se desarrolló y probó. Los resultados de estas actividades de aprendizaje mostraron el aumento de algunos entendimientos sobre conceptos maoríes de orientación espacial.

Palabras clave: Māori-medium schooling; orientación espacial

INTRODUCTION

Māori are the Indigenous people of Aotearoa/New Zealand. In common with its sister cultures and languages throughout Polynesia, the Māori language and traditional cultural practices were eventually confronted with the languages and cultures of European explorers, missionaries and settlers, in the late 18th and early 19th centuries (Harlow, 2005). In Aotearoa/New Zealand, after 1840, with more and more European settlers arriving and a British colony being created, European forms of government and schooling were established. The hegemonic function of these forms of schooling in the early 1800s was to provide a formalised context to assimilate Māori communities into European beliefs, attitudes and practices, with the intent to “civilise” the Māori population (Simon, 1998). As a consequence of a range of policies, by the turn of the 20th century, the Māori language and culture were almost excluded from most schools.

Consequently, by the 20th century, the health of the Māori language and associated culture were significantly compromised. In the 1970s, the Māori language was recognised as an endangered language (Fishman, 1991), threatened with possible extinction (Spolsky, 2003) and so in the 1980s, a number of Māori communities set up their own schools outside the state system to support language revitalisation efforts. Ignoring Māori linguistic rights, the state initially resisted revitalising efforts, which often resulted in schools having to exist in substandard conditions.

One of the types of immersion schools, initially developed outside the state system, that evolved in the 1980s was kura kaupapa Māori. Kura kaupapa Māori were set up not only to revitalise Māori language and culture, but also to resist the assimilationist aspects of New Zealand European schooling (Penetito, 2010). Nevertheless, when the schools

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became state funded, they were required to follow the state-mandated mathematics curricula—either the English or the Māori-medium version. The first Māori-medium version of the curriculum was produced in 1995 after a long production process (McMurphy-Pilkington, Trinick, & Meaney, 2013).

Both versions of the mathematics curriculum include geometry topics on location and direction (Ministry of Education, 1991; Te Tāhuhu o te Mātauranga, 1996), but are viewed from Western mathematics perspectives. There are several interconnected reasons for this. Many of the original ethnomathematical practices of Māori are no longer in general use. The elders who practised these activities on a daily basis, such as house and canoe building and navigation, have passed away and much of their knowledge has not been handed down to successive generations. As well, the production of curricula in New Zealand is controlled by the state, which meant that the first Māori-medium version of the curriculum had to “mirror” the hegemonic English-medium version with the same content and a similar structure (McMurphy-Pilkington & Trinick, 2002). While it is surprising on one level that Maori acquiesced to the state’s requirement, considering the long struggle to have Māori-medium schooling recognised as a legitimate schooling option, pragmatically, Māori used the curriculum development process to progress language revitalisation efforts—the primary goal of Māori-medium schools at that time (McMurphy-Pilkington et al., 2013).

With the implementation of state curriculum over the past 10 years, the “Ministry of Education has appeared more accommodating of difference” (McMurphy-Pilkington et al., 2013, p. 357). This has provided an opportunity for Māori-medium schools to be more proactive in reintroducing Māori mathematical concepts and practices into the classroom. This was something that had been noted as missing by immersion schools themselves (Meaney, Trinick, & Fairhall, 2012).

This paper reports on the efforts of one school—Te Kura Kaupapa Māori o Te Koutu—to reintroduce traditional ethnomathematical practices of location and direction into classroom practice, thus honouring the aspirations of families who had committed to this form of schooling. Spatial concepts were chosen because spatial language is still evident in contemporary communicative day-to-day language and some historical data examining

Māori orientation concepts including interviews with elders in the 1990s was available. Thus, a study of the traditional orientation concepts would simultaneously serve two goals: reintroducing traditional ethnomathematical activities into Māori-medium schooling (Barton, 2008) and supporting language-learning goals (Meaney et al., 2012; Planas, 2014).

Te Kura Kaupapa Māori o Te Koutu, is a *kura* (primary school) with an attached *wharekura* (secondary school). All teaching (except the teaching of English and a foreign language) is carried out in the medium of Māori. This school is an example of the outcome of the grassroots Māori language revitalisation initiatives of the early 1980s, and typifies the struggle and history of development of many *kura kaupapa* Māori (Meaney et al., 2012).

SPATIAL THINKING

Different components of spatial ability have been identified in mathematics education research, each emphasising different aspects. Bishop (1980) and Harris (1981) suggested that the major abilities of spatial thinking that are commonly addressed are spatial orientation and spatial visualisation. Spatial orientation is the ability to understand and operate on relationships between objects in space. The second component, spatial visualisation, enables a person to carry out mental movements of two- and three-dimensional objects in space (Clements & Sarama, 2009). Other authors add the ability to understand spatial relations (Lohman, 1988). This paper focuses on spatial orientation.

Spatial orientation and frameworks of reference

Spatial orientation is about knowing where you are and how to get around in the world, at first, in respect to your own position and your movement through it and, eventually, in formal New Zealand school mathematics, a more abstract perspective that includes maps and coordinates (i.e., Cartesian, polar and bearings). Spatial thinking has often been assumed to be based on a natural, innate perception of the world (e.g., Piaget & Inhelder, 1956). However, Gauvain (1993) argued that models and maps of spatial environments are sociocultural tools, as is the language that describes spatial orientation. In support of this argument, Edmonds-Wathen (2011) noted that cross-linguistic research has revealed

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differences in the ways that different groups of people talk and think about space and location. In particular, this involved what is termed “spatial frame of reference”—the conceptual basis for determining where one thing is located in relation to another (Edmonds-Wathen, 2011, p. 219).

A number of different but overlapping typologies have been developed to describe spatial frames of reference. These include the model of intrinsic, absolute and relative by Pederson et al. (1998). One can say, “the child is in front of the house”—intrinsic, using the front of the house as a reference; “the child is to the north of the house”—absolute, using a fixed system that is larger and external to the described scenario; and “the child is to the left of the house”—relative, using our own body as the reference (see also Meara & Pérez Báez, 2011). There are others models, such as the egocentric (self-to-object) and allocentric (object-to-object) frameworks (Latzky, 1998). This paper focuses on the absolute component of the framework and discusses the system of bearings used traditionally by Māori.

The following section explores some of the spatial frameworks that gave rise to the major direction terms and bearings, drawing on primarily data from interviews with four elders, Mona and Sonny Riini, Tuteira Pohatu and Hohepa Delamare, in 1999 by Tony, one of the authors (see Trinick, 1999). While somewhat dated, this particular data is relevant because this group of elders were all born in rural areas, in small villages where the traditional Māori spatial frameworks were still used and understood. Second, they were all fluent speakers of the Māori language who at some point in their careers were teacher/educators and thus could relate to the issue of reintroducing traditional knowledge into public schooling- a process not always supported by elders. These data form the background to the development of diagnostic and teaching activities discussed in the second part of this paper. The next sections provide a summary of the participants discussions supported by published literature.

Reintroducing Māori spatial language and frameworks

Without the aid of magnetic compasses, Māori traditionally used a variety of spatial frameworks abstracted from geomorphic or landmark-based systems to orientate

themselves to the general direction of—east, west, north and south—and intermediary directions (Trinick, 1999). These references were derived from a mixture of physical phenomena, including the actions of the sun and wind, and geographical landforms. The elders suggest that the close similarity of the Māori systems to those of Tahiti and the Marquesas suggests that these systems may have been imported from Eastern Polynesia (Trinick, 1999).

1. East–west axis: using the sun (*Tama-nui-te-rā*) as a spatial framework

The sun is a natural compass because it rises every day in the east (or close to it) and sets in the west, with its exact position being related to the time of year. Māori had terms for the ecliptic (*Mārua roa*), the path the sun moved during the course of a year. *Tama-nui-te-rā* (sun) is of considerable cultural importance to Māori and features in a number of traditional stories, *karakia* (prayers) and *waiata* (songs) (Trinick, 1999). According to the elders (Trinick, 1999), a number of directional terms are derived from the sun's pathway across the sky from east to west and include:

Rāwhiti (East)—where the sun rises. The east had religious significance for Māori for centuries, a custom probably derived from East Polynesia. For example, many ancient burials are orientated to the east, with the heads facing the rising sun (Duff, 1997).

Raki (North): *rā*—sun, *kī*—full (the sun at its highest point is close to north).

Uru (West)—relates to *Tama-nui-te-rā*, when setting [sun] enters the night (*ka uru atu ki te pō*).

Te rā tō (setting sun) refers to the west in a number of tribal areas (such as Te Arawa, where Te Koutu is situated). Diagrammatically, the spatial reference points could look like those in Figure 1.

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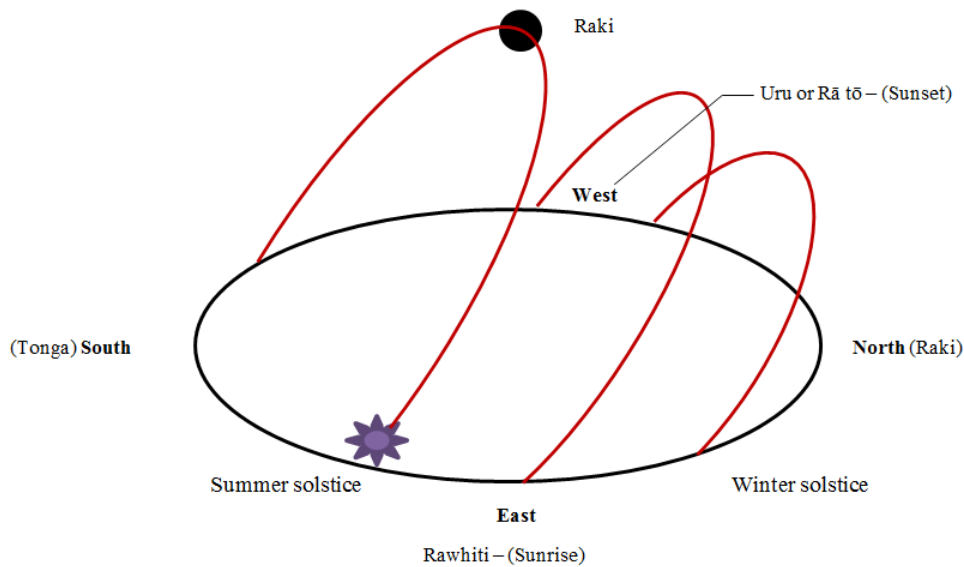


Figure 1. Tama-nui-te rā as a spatial framework

Various forms of “*raki*” meaning north are found throughout Eastern Polynesia, supporting the view that the directions originated in East Polynesia but underwent some change in orientation to fit the conditions in Aotearoa/New Zealand (Trinick, 1999). For example, in Samoa, the equivalent of *raki*, north, is *Ja'i*, west wind. Interestingly, in Tahiti, *raki* is *rai*, which refers to the sky.

2. South–north axis: using geographical form of *Te Ika-ā-Māui* (North Island) as spatial framework

The geography of Aotearoa/New Zealand encompasses two main islands (the North and South Islands), and a number of smaller islands (see Figure 2). Throughout Polynesia, one of the many great feats of Māui, a legendary hero, was to pull up a great fish from the depths of the ocean. In Aotearoa/New Zealand, as described by the elders, this fish became *Te Ika-ā-Māui* (the fish of Māui—the North Island) (see Figure 2). *Te Upoko-o-te-Ika* (the head of the fish) is in the south at Wellington, and *Te Hiku-o-te-Ika* (tail of the fish) refers to Northland (also referred to as *Murihiku*) (Auckland Museum, 2001).

Therefore, the head of the fish is *runga*—up and the tail of the fish is *raro*—down. This can be confusing for those steeped in Western spatial conventions because “up” and “down” as spatial references are reversed. For example, in Māori traditions, *Te Upoko o te Ika*

(Wellington), the capital city located at the bottom of the North Island, is considered “up”, and *Te Hiku o te Ika* (Northland) at the top of the North Island is “down” (see Figure 2).

The South Island is known as *Te Waka-a-Māui* (the canoe of Māui). Stewart Island, which lies at the very bottom of Aotearoa/New Zealand, is known as *Te Punga-a-Māui* (Maui’s anchor), because it was the anchor holding Maui’s *waka* (canoe) still as he pulled in the giant fish. Therefore, Māori in the South Island had a different idea of what was up (north) and down (south). In this case it is in alignment with that of Western culture.

The seaward side of the fish, irrespective of which coastline you lived on, was referred to as “*waho*–outside” by some tribes. This importance of making a distinction between the seaward or inland position is evident throughout island Polynesia and provides the main axis of orientation for a *marae* (traditional meeting house). As well, this distinction was heard in many *karakia* (prayer) and *waiata* (song) in Aotearoa/New Zealand, demonstrating the persistence of a widespread ancestral Polynesian distinction between the directions of *tai* (seaward) and *uta* (landward) (Amoamo, Tupene, & Neich, 1984).

Māori knowledge about *Te Ika-ā-Māui* was acquired before the advent of European maps. The North Island and South Island were represented as mental images and thus orientated to the shape of the fish and the canoe respectively. Knowledge derived from direct experience is often different from knowledge derived from maps. For example, maps show the spatial relationships between all the places represented on the map, but when an area is learnt over time from direct experience, knowledge is created gradually and may require the development of a cognitive map [such as a fish] to organise this information (Kitchen & Mark, 2002).

Although, traditionally, visualisations of the relationship between the North and South Islands were not orientated to cardinal points, now *Te Ika-ā-Māui* is presented in maps as having a north-up orientation, showing how it has been incorporated into Western map orientation understandings. The image in Figure 2 of the North island (*Te Ika-ā-Māui*) has an image of a stingray overlaid to show the concept of up (head of the fish) and down (tail of the fish).

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Figure 2. Te Ika-ā-Māui (North Island) as a spatial framework

3. The wind as a spatial framework

Many directional terms are derived from winds, particularly the prevailing winds (Trinick, 1999). In Aotearoa/New Zealand, the prevailing winds are from the west but in certain months easterlies may predominate (New Zealand MetService, 2014). Over time, the terms for the winds have become directional terms, orientated to a consistent direction in particular locations. One of the most commonly used terms for west, heard throughout much of Aotearoa/New Zealand, is *Te Hau-ā-uru* (west wind) and *marangai* (variously, east wind, north-east wind). Nevertheless, the functional use of wind names to orientate was generally localised knowledge (Trinick, 1999). There was a shared understanding of wind terms amongst the *hapū* (subtribe) or *iwi* (tribe), enabling them to be ideal local direction markers. Outside their local area, the same term could refer to a different direction. For example, while Māori is much the same language throughout the country, the elders indicated that the term *marangai* orientates to east wind, east, northeast, north and north wind, depending on the direction of the prevailing winds in a certain locality and thus *hapū* and *iwi* (Trinick, 1999).

Wind names were culturally significant to Māori (see Figure 4). Not only were they

direction indicators, but they also indicated fishing and planting times. When a particular wind blew, it was an indicator of good fishing conditions for a particular species of fish. Knowledge of the land and sea breezes was important when fishing some distance from the shore (Trinick, 1999). For example, on the east coast, a south-east breeze (*māwake*) blew fishermen offshore for several miles to desired fishing grounds and, in the evening, another sea breeze brought them back in (Trinick, 1999). *Māwake* is also derived from spatial frameworks, a wind term that occurs in the *karakia* used by *Māui* (Anderson, 1969) to assist him in catching his fish (*Te Ika-ā-Māui*—see Figure 2). Figure 3 shows various wind names known to the elders. This is only a small sample of wind names known and used throughout Aotearoa/New Zealand.

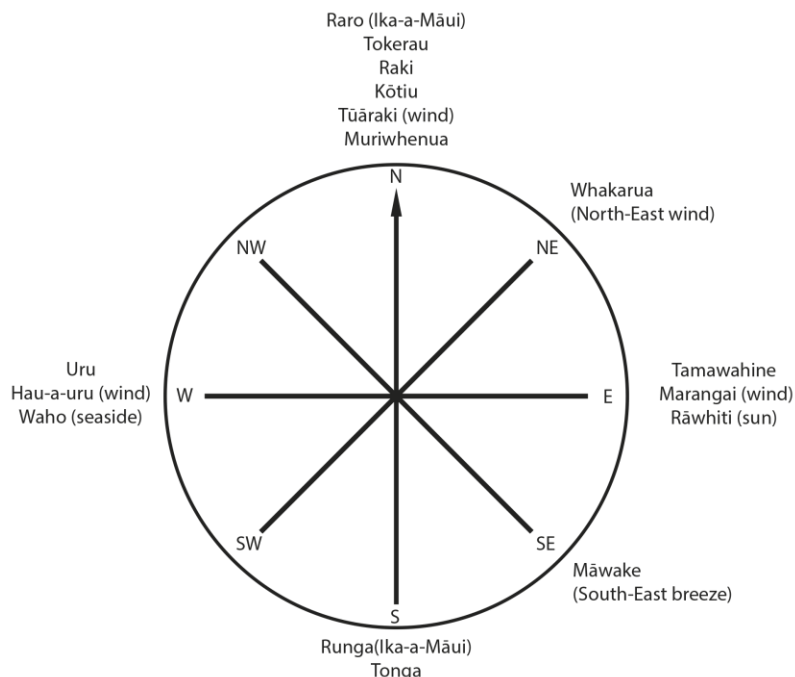


Figure 3. Wind as a spatial framework

Table 1 connects directional terms and spatial frameworks.

Direction/Ahunga	Spatial Framework
East	<i>Tamawahine (Ika-a-Māui), marangai (wind), rāwhiti (sun)</i>
North	<i>Raro (Ika-a-Māui), tokerau (wind), raki, kōtiu/tiu (wind), tūāraki (wind), muriwhenua (Ika-a-Māui)</i>
North-east	<i>Whakarua (wind), raranga-te-muri (wind), marangai-mā-raro</i>

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North-west	<i>uru mā raki</i> (wind), <i>mā-uru</i> , <i>tapatapa-atiu</i>
West	<i>Uru</i> , <i>hau-ā-uru</i> (wind), <i>waho</i> (seaward side), <i>rā-to</i> (sun)
South-east	<i>Māwake</i> (south-east breeze), <i>Paeroa</i> (wind)
South-west	<i>Tonga-mā-uru</i> (wind), <i>tuauru-mā-tonga</i>
South	<i>Runga</i> (<i>Ika-a-Māui</i>), <i>tonga</i>

Table 1. Summary of directional terms derived from spatial frameworks

Data from the interviews with elders highlighted that there were other spatial frameworks used by Māori to orientate, such as the position of stars and environmental signs like moss growing on the southern side of trees (Trinick, 1999). Linguistically, unlike the English language, Māori uses terms derived from intrinsic spatial relationships (i.e., local nouns *muri*–back, *runga*–up, *waho*–outside, *raro*–down) as absolute directional terms (see Table 1). The difference as to whether it refers to the intrinsic (back, front, up down, etc.) or absolute meaning (cardinal points) is determined by the syntactic structure of the utterance. The *te* particle is used to differentiate between local nouns (intrinsic) and directional nouns (absolute). For example, *kei muri* (location) refers to the rear, behind, at the back of, and *te muri* refers to north. Thus, according to the elders *te muri* variously means the north direction and a wind that blows from the north (Trinick, 1999).

In the next sections, we outline some activities that were trialled by Uenuku (one of the authors of this paper) with learners in Years 7–10 at Te Koutu that were based on the Māori spatial frameworks discussed previously. In the present Aotearoa/New Zealand curricula (Ministry of Education, 1991) and Te Tāhuhu o te Mātauranga (1996) at Level 4 (Years 8–9), spatial orientation knowledge is related to a bearings coordinate system, that is, a vertical reference line to north (based on magnetic compass). No mention is made of using traditional Māori spatial frameworks in either version.

The activities were developed by the authors in response to diagnostic interviews that indicated that many students at Te Koutu were unable to orientate themselves outside using traditional spatial orientation practices discussed by the elders in 1999 (see also Trinick, Meaney & Fairhall, 2015). The development and trialling of these activities is in the initial stages and has provided us with reflection points for considering revisions so

that a more extensive evaluation process can be implemented. We anticipate being able to expand these activities to all year levels and to consider other spatial frameworks such as the passage of stars across the sky.

ACTIVITIES FOR STUDENTS

Activity One: *Kei te anga atu ki hea? Which direction am I facing?*

As discussed earlier, according to the elders, Māori used a variety of objects in the environment to locate themselves —such as the sun and wind (e.g., north, east, west or south of). Therefore the key teaching idea in this first activity was to introduce students to this range of possibilities for helping them to orientate themselves based on the information provided in 1999 by the elders.

In order to do this, the students went outside with the teacher to a place where they could see the horizon in all directions. They were asked to draw on the ground where they thought the directions were (i.e., *rāwhiti*—east, *raki*—north, etc.) and intermediary points if they knew them. They were asked what clues they could use to orientate themselves. Then, they came back inside and constructed a circle with themselves at the centre, supplying the names of the various directions dotted around the horizon and the clues they used for orientation.

Teacher: We found that the students had great difficulty orientating themselves to the major directions. When I tried this activity, students who relied on the road that led to Auckland to orientate themselves [to the north] and did not use natural phenomena, were the least accurate in terms of directions. (June, 2014)

Students were then introduced in their mathematics lesson to the traditional Māori spatial frameworks (Figure 1–3 above) by the teacher, who had used the interview material from the elders to become knowledgeable in this area. While a long-term advocate of language revitalisation, most of his focus had been on introducing his students to the senior mathematics in the New Zealand curriculum. He had assumed students were learning traditional knowledge about spatial orientation at home. However, information from the diagnostic assessments indicated that this was not the case.

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Activity Two: *Nga anga whaitua—he rangahau* Spatial constructs—an investigation

Based on the information provided by the elders, the key teaching idea in this activity was to introduce the students to the idea that, Māori geomorphic or landmark-based systems of bearings were often very localised such as the winds, or fairly generic such as the rising and setting of the sun, *Tama-nui-te-rā*.

To become familiar with these differences in orientation, in this activity students were required to make contact with the elders of their own *iwi* and *hapū* in order to find out from them the origins of the spatial orientation terms, used in their traditional tribal areas. The findings were presented to the class, followed by a discussion of the similarities and differences. This discussion supported an understanding of the differences between different kinds of spatial frameworks.

Activity Three: *Kei hea koe e noho ana?* Where do you live?

In the present Aotearoa/New Zealand curricula, the position of objects on a map are determined by Cartesian coordinate geometry, that is, determined by two measurements: the first is the distance along the horizontal line, and the second is the distance along the vertical one.

In order to indicate that there were other ways to form understandings of the position of objects in the environment, the key teaching idea in this activity was to show that a map is a representation of the spatial knowledge of the environment held by a community. As it is developed over time, respecting the knowledge of elders of that community becomes particularly important. Thus, land maps can be defined and structured by social relationships by showing the territory and history of a community such as an *iwi* or *hapū*. Consequently, students were asked to create a map of their area from memory, adding significant cultural sites, place names, places of significance and a scale. They were asked not to add roads, railways, and so on, but to add other references that provided a sense of direction, that is, winds that they might have collected in the previous activity. When the map creation was completed, students compared the differences and similarities between their maps with a topographical or a satellite map of the region.

Teacher: What students drew was highly influenced by cultural considerations. The most important things on their maps were the tribal landmarks which is not surprising because geographic features such as mountains and rivers are one of the key means Māori from different tribes identify themselves. (June, 2014)

SUMMARY

According to the information provided by the elders, Māori traditionally used a mixture of spatial frameworks, often simultaneously, to orientate themselves (Trinick, 1999). Some seemed to be generic, such as orientating to *Te Ika-a-Māui*, the fish outline of Aoteroa/New Zealand whereas others were very localised, such as winds. The directional terms that arise from the various frameworks are still part of the everyday Māori language but have become orientated to Western spatial frameworks such as the compass. Traditional Māori spatial frameworks also act as metaphors for important Māori cultural stories and traditions (Trinick, 1999).

Unfortunately, the pool of Māori elders with the relevant cultural knowledge has significantly decreased over the past 30 years. Thus, Māori-medium schools in many communities do not have access to the traditional cultural knowledge. While much cultural knowledge in the form of songs, dance, stories etc has been captured in print, film and so on, the same cannot be said of the mathematical practices. As a result, busy teachers default to the material which is readily accessible. In general, this is the corpus of mathematics material based on Western perspectives, which is incorporated into curricula.

The learning outcomes in the Aoteroa/New Zealand curricula make assumptions about spatial learning drawn primarily from Western mathematical perspectives with minimal encouragement to consider Māori, even though one curriculum is written specifically for Māori-medium schools. This illustrates the power of national curricula whereby even in the school which trialed the activities, a school noted for its language revitalisation efforts, mathematics was still dominated by Western mathematical perspectives. This paper does not suggest that teachers in Māori-medium should replace Western mathematics knowledge expressed in the curriculum with Māori cultural knowledge. Mathematical

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experiences such as the activities suggested here can be used to help students' to understand how mathematical ideas are constructed and applied, depending on the needs and circumstances of a particular community. Introducing activities which support the acquisition of traditional cultural and Western mathematics is compatible with the goals of the school in this study—that is for students to grow up as Māori with the skills to participate in a global environment.

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