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Ethnomathematics and indigenous teacher education: Waka migrations

Ngā Hekenga: Te Tātai me Nga Kura Akoranga-Taketake

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Abstract: In order to assist Indigenous peoples to revive their language and culture, teachers need strategies to enhance both cultural and mathematical knowledge for students. This paper presents findings from a project in which pre-service teachers investigated ethnomathematical practices using the context of ancestral ocean voyages by canoes. This context was chosen because a primary identification marker for Māori are their ancestral canoes. The results indicated that these pre-service teachers did not generally associate these ancestral voyages with mathematical practices, indicating that more work is needed to increase their understandings of ethnomathematics. Their understandings about the knowledge and practices connected to traditional methods of navigation were disrupted by myths perpetuated by European colonists. Despite this, a renaissance in canoe building and interest in traditional navigation practices provided the pre-service teachers with valuable information.

Keywords: Traditional navigation. Ethnomathematics. Preservice teacher education. Cultural symmetry.

Etnomatemáticas y formación de professores indígenas: migraciones de canoas Waka

Resumen: Para ayudar a los pueblos indígenas a revivir su idioma y su cultura, los maestros necesitan estrategias para mejorar el conocimiento cultural y matemático de los estudiantes. Este artículo presenta los hallazgos de un proyecto en el cual los maestros de pre-servicio investigaron las prácticas etnomatemáticas utilizando el contexto de viajes oceánicos ancestrales en canoas. Este contexto fue elegido porque un marcador de identificación principal para los Māori son sus canoas ancestrales. Los resultados indicaron que estos maestros de pre-servicio generalmente no asociaron estos viajes ancestrales con las prácticas matemáticas, lo que indica que se necesita más trabajo para aumentar su comprensión de las etnomatemáticas. Su comprensión sobre el conocimiento y las prácticas relacionadas con los métodos tradicionales de navegación fueron interrumpidos por los mitos perpetuados por los colonos europeos. A pesar de esto, un renacimiento en la construcción de canoas y el interés en las prácticas tradicionales de navegación proporcionaron a los maestros de pre-servicio informaciones valiosas.

Palabras clave: Navegaciones tradicionales. Etnomatemáticas. Formación de profesores. Simetría cultural.

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Etnomatemática e formação de professores indígenas: migrações de canoas Waka

Resumo: Buscando auxiliar os povos indígenas a reavivar a sua língua e cultura, os professores precisam utilizar estratégias para aprimorar os conhecimentos culturais e matemáticos dos alunos. Esse trabalho apresenta os resultados de um projeto em que os professores em formação docente investigaram as práticas etnomatemáticas utilizando o contexto de viagens oceânicas ancestrais por canoas. Essa conjuntura foi escolhida porque uma das principais marcas identitárias dos Māori são as suas canoas

ancestrais. Os resultados indicaram que, geralmente, esses professores não associaram essas jornadas ancestrais com as práticas matemáticas, sinalizando ser necessário um maior treinamento para aumentar o seu entendimento da etnomatemática. A compreensão sobre os conhecimentos e as práticas ligadas aos métodos tradicionais de navegação foram prejudicados por mitos perpetuados pelos colonizadores europeus. Contudo, um ressurgimento da construção de canoas e do interesse pelas práticas tradicionais de navegação propiciou valiosas informações para os professores em formação docente.

Palavras-chave: Navegações tradicionais. Etnomatemática. Formação de professores. Simetria cultural.

1 Introduction

In this article we examine how pre-service teachers in a teacher education programme designed to serve Māori-immersion schools identified and described interrelated cultural and mathematical practices using traditions surrounding the canoe (*waka*) migrations to New Zealand, known in Māori as *Aotearoa*. The aim of this was to improve our understandings of how teacher education can better prepare teachers to support schools in the revitalisation of Māori knowledge and language through mathematics education.

There has been considerable loss of language and cultural practices in Indigenous communities, and teachers and schools frequently play a critical role in the revitalisation. Ó Laoire & Harris (2006) contended that the school has become one of the most critical sites for language and cultural revitalisation. Ferguson (2006) went further to state that the school often bears the entire burden of language and cultural revival. One of the reasons for this is that education is most often controlled by the State.

Previously, in many colonial contexts, States have used schooling systems to assimilate Indigenous people into valuing the knowledge and the language of the colonisers (D'AMBROSIO, 1990; TRINICK, MEANEY & FAIRHALL, 2016). Ironically, in more recent times, schooling systems have become State agencies of language planning for positive language and cultural outcomes. Schools are also where the socio-political and ideological values of the language community, needed for supporting cultural and language revival, can be transmitted and reflected. Therefore, mathematics education as part of the schooling system has the potential to support such changes (TRINICK, 2015).

As Trinick (2015) noted, mathematics education has played a pivotal role in first supporting the loss of the Māori language (*te reo Māori*), and then in the modern era, revitalising the Māori language due to the high status of mathematics in the school curriculum in Aotearoa. In order for Māori-medium schooling to provide learning opportunities that support the revitalisation of Māori language and cultural practices, there is a need for a continuous supply of teachers with the necessary competencies, skills and dispositions (HŌHEPA *et al*., 2014).

However, teacher education institutions in New Zealand were slow to respond to the explosive growth in Māori-medium schooling in the 1980s and 1990s (TRINICK, 2015, 2018). Eventually, bilingual education pathways were developed in the early 1990s to address the need for competent Māori-medium teachers. While based on good intentions whereby Māori culture was acknowledged and given some emphasis, the teaching of learning areas such as mathematics in the medium of Māori was not a focus. Most of the curriculum areas including mathematics were taught in English.

There was an assumption that the knowledge and skills learned in English by graduates were transferable to Māori-medium schooling contexts (TRINICK, 2018). This is not an unusual practice in many other Indigenous language contexts throughout the world (see for example JORGENSEN *et al*., 2010; MUNROE *et al.*, 2013). We argue that there are major pedagogical, language and cultural revitalisation implications within such an assumption for Māori-medium education — primarily concerned with the continued privileging of Western mathematics, the need to develop academic language proficiency in Māori-medium mathematics, and the status of the language itself.

At the Auckland College of Education, later merged with the University of Auckland, several attempts were made to adapt this model of bilingual education to include more *te reo Māori* and cultural knowledge. Finally, in 1996 a three year Bachelor of Education (Teaching) programme called *Te Huarahi Māori* (The Māori Pathway) was established. This programme is delivered in the medium of *te reo Māori* and had an entry criteria requiring students to have a modicum of language proficiency — basic conversational level.

From its inception, the programme sought to address the complex challenges of language and knowledge revitalisation of the Indigenous people of Aotearoa (DALE, McCAFFERY & MCMURCHY-PILKINGTON, 1997). The programme's aim is to produce teachers who can actively engage at an academic level in *te Ao Māori* (The Māori World), in terms of language, knowledge, commitment, pedagogy, understandings of *tikanga* (cultural customs), and how *tikanga* plays out in a range of contexts.

However, producing graduates with the necessary competencies, skills and dispositions to use mathematics education to revive the language and cultural knowledge remains a challenge. Many pre-service teachers have acquired negative attitudes to the learning of mathematics from their schooling experiences. Although they are passionate about Māori language and knowledge revitalisation, they are often second language learners of the Māori language and have themselves only had limited possibilities for learning about Māori cultural practices (TRINICK & MEANEY,

2017).

This is because many graduates were raised in Auckland a large city, an outcome of significant urban migration in the 1950s and 1960s, resulting in them becoming disconnected from their tribal roots in rural areas. These language and cultural loss factors led to focussing on the language of mathematics as a discipline necessary for teaching children, and as academic language for discussing how to teach mathematics. The consequence is that the programme has had some success at revitalising and elaborating the language for teaching subjects such as mathematics education at the tertiary level (TRINICK, MEANEY & FAIRHALL, 2014).

However, the programme has not succeeded as much in the revitalisation of less accessible cultural knowledge. This is the more specialised knowledge that is not necessarily practiced in the everyday activities of the students and their families, and particularly families who live in urban cities. This is also reflected in the schooling sector where graduates of this programme and others have struggled to revive Indigenous mathematics ideas or to locate mathematics in contexts that can be considered authentically Māori (see TRINICK, MEANEY & FAIRHALL, 2016).

Consequently, we examined the results from a Māori-medium teacher education programme in Aotearoa in which pre-service teachers investigated the ethnomathematical practices connected to the ocean migrations of their ancestors. By identifying how the pre-service teachers made sense of their investigation and their thoughts about how to transfer this to their future mathematics teaching, we provide insights into how this teacher education programme and other similar programmes worldwide can be developed.

2 Ethnomathematics and Canoe Migrations

From 2017-2019, pre-service teachers in *Te Huarahi Māori* (Bachelor of Education (Teaching)) programme had an assignment in which they had to investigate mathematical practices connected with early Māori migratory voyages using an ethnomathematical approach. This approach was chosen because ethnomathematics is considered as one way to support Indigenous students in understanding how their traditional cultural heritage is devalued by Western schooling (D'AMBROSIO, 1990).

During the 1980s and 1990s, a growing resistance to a deficit interpretation of Indigenous students emerged among teachers, mathematics educators and researchers (POWELL & FRANKENSTEIN, 1997), and (neo)colonial prejudices (BISHOP, 1990). Gerdes (1985) provided a critique of situations, where mathematical elements existing in the daily lives of Indigenous

populations during colonial occupation were not recognised as mathematics. To raise the status of Indigenous peoples' mathematics, Gerdes (1986) endeavoured to reconstruct or "unfreeze" Indigenous mathematical thinking that was "hidden" or "frozen" in practices such as basket making, which might stimulate cultural awareness in Indigenous learners of mathematics.

However, unfreezing cultural mathematics in Indigenous practices can be criticised as merely providing a pathway into participating in Western mathematics. Thus, guided by the arguments of D'Ambrosio & D'Ambrosio (2013) that ethnomathematics is a human right, we have developed a three-step cultural symmetry model for incorporating cultural practices into mathematics education. As Trinick, Meaney & Fairhall (2017) noted, "In this way, we anticipate that the valuing of the mathematical meanings will not colonise or distract from other understandings connected to cultural processes and artefacts" (p. 250). The three steps were:

(1) To discuss the cultural knowledge connected to processes and artefacts using appropriate Indigenous language

(2) To identify the designs used to create the different artefacts and discuss them from a range of perspectives in order to see how those design elements are used in other cultural artefacts

(3) To discuss the design elements in relationship to mathematical principles in order to show how mathematics can add value to understandings about the artefacts without detracting from the cultural understandings.

The cultural symmetry model situates mathematics as one of many ways to discuss a cultural artefact, and allows for discussions of how Western mathematical understandings dominate such discussions and can act as a colonising force. Thus, it opens up for socio-political discussions about whose knowledge is valued in what contexts, and is an important component to consider when students are striving to de-colonise their education.

Early *waka* migrations were considered an appropriate context for a teacher education assignment, as we considered it had potential to support pre-service teachers' development of cultural knowledge through the cultural symmetry model. While the *waka* migrations took place several hundreds of years ago, the stories about them remain critical components of identity of Māori in Aotearoa in contemporary times (ORBELL, 1975).

Waka traditions describe the arrival in New Zealand of Māori ancestors from a distant place, most often called *Hawaiki*. The exact location of *Hawaiki* has been lost in the midst of time. With the advent of technology such as DNA mapping, it has been established that most Māori migratory *waka* came from different points in East Polynesia, more specifically, Raiatea, Taha'a,

Porapora (Bora Bora), Tahiti and some of the islands of the Cook Group (UNDERHILL *et al*., 2001).

The migration stories tell of the construction of waka, conflicts before departure, voyaging at sea, landing, inland and coastal exploration, and the establishment of settlements in new regions. Genealogical links (*whakapapa*), back to the crew of founding *waka* have served to establish the origins of many tribes and defined relationships with other tribes. For example, a number of tribes trace their origin to the *Tainui waka*, while others such as *Te Arawa* take their name from their migratory canoe. When identifying themselves on a *marae* (meeting house) outside their tribal area, people reference their *waka* first and foremost. Along with the tribal dialects, *waka* traditionally are one of the significant identity markers for Māori.

Waka traditions continue to express authority and identity and define tribal boundaries and relationships. In doing so, they merge poetry and politics, history and myth, fact and legend, and as such, contain both symbolic and historical elements critical to Māori identity such as land ownership and tribal knowledge. Thus, the *waka* traditions provide rich data for steps 1 and 2 of the cultural symmetry model. These traditions could also support step 3 of the cultural symmetry model, because in order for *waka* to successfully navigate to *Aotearoa*, considerable skills in mathematical activities such as spatial orientation were needed, thus providing opportunities for discussing the mathematical aspects of these journeys (TRINICK & MEANEY, 2017).

Spatial orientation is knowing where you are and how to get around in the world with respect to your own position and your movement through it (TRINICK, MEANEY & FAIRHALL, 2015). While the precise date of the *waka* migrations is a matter of debate, there is a corpus of material, both traditional (oral stories and artefacts) and contemporary (modern recreated voyages using traditional methods, DNA testing) that provide an understanding of these earlier voyages. As spatial language is still very much evident in contemporary communicative day-to-day language, including *te reo Māori*, we considered that it would provide entry into discussions of these concepts.

Therefore, we anticipated that the pre-service teachers would be able to see how mathematical understandings could add value to their knowledge about *waka* migrations, while at the same time providing opportunities to critique how specific forms of knowledge come to be highly valued in societies. Thus, having the pre-service teachers engage in an assignment about *waka* migration based on the cultural symmetry model would serve two goals: 1) reintroducing of traditional ethnomathematical activities into Māori-medium schooling (BARTON, 2008); and 2) supporting language learning goals.

3 Data Collection and Analysis

Data were collected from two sources — the assignments from three cohorts of final year Māori pre-service teachers from 2017-2019, and a survey conducted with the 2019 cohort about the assignment and course in general. The assignment consisted of two parts — students were required to carry out a statistical investigation into their ancestral *waka* and suggest the various mathematical practices that were required to enable the voyage to occur. The statistical investigation included the following guiding questions:

- Name your ancestral *waka* and where do you think it came from and why?
- How many people were on board?
- What do you think was the gender and age group mix?
- What sort of foods did they bring?
- How long did they take to get to *Aotearoa*?
- If any of the above information is unavailable you will need to predict the answers using the variables (information) that are known.

The outcomes of the statistical investigation and the challenges that the pre-service teachers from the 2017 cohort encountered are reported elsewhere (TRINICK & MEANEY, 2017). In this article, we focus on the ethnomathematical practices discussed by the pre-service teachers in answering the above questions in the second part of the assignment and the survey. The survey asked the following questions:

- While doing the investigation, what were some of the mathematical related ideas you learnt about the ancestral voyages?
- Why do you think it is important to link culture and mathematics?
- Did you find anything challenging to do with *tikanga* (cultural practice)?
- What did you learn about cultural contexts for the learning of mathematics?
- What else would you like to learn about the inter-relationships between mathematical practices and culture?

The responses from the pre-service teachers were analysed against the three steps in the cultural symmetry model. Although the responses often showed links to more than one step, for reporting, they are categorised by one specific step. For responses to be connected to step 1, we

considered that the responses had to refer to the cultural aspects of *waka* migration, including the *te reo Māori* needed to discuss *waka* traditions. An example of this was a response about what was challenging to with *tikanga*, "The only thing I found challenging to *tikanga* was the fact that each *iwi* (tribal group) have different ideas about *nga Hekenga waka*" (*waka* migrations).

In regard to step 2, the responses needed to connect to design elements of the cultural practices and how they could be discussed in a range of ways. The following response was considered to belong to step 2 because it identified the different elements that were part of considerations to do with *waka* migrations: "Our ancestors were awesome navigators-using currents, winds speed to calculate direction and speed".

Responses that were categorised as belonging to step 3 connected mathematics to the design elements. An example from the assignment from the 2017 cohort was:

> I estimated the time for the voyage of my ancestral *waka* at 36.7 days from Raiatea to *Aotearoa*. This was based on contemporary *waka* voyagers by Hekenukumai Busby which took him 30 days to travel 3233.73 km from *Aotearoa* to Rarotonga, travelling around 146.98 km per day.

This response identified the relevant elements connected with canoe migrations and then provided a description of how they were calculated.

As well as identifying the three individual steps, we also categorised the pre-service teachers' responses in regard to how they discussed socio-political understandings about how knowledge was valued in different societies, and how this could contribute to critiquing colonial understandings about Western mathematics. One response, again from the 2017 cohort, which was classified as being about socio-political understandings about the valuing of knowledge was:

> Each tribe or *hapu* (sub tribe) have their own *pūrakau* (stories), *hitori* (history) and *kōrero* (talk) pertaining to *Māhuhu-ki-te-rangi*. Who am I to question it? I can't tell the people of *Te Roroa* that Rongomai is the captain because he is most likely according to the data, therefore their history is *koretake* (useless).

In this response, there is a questioning of how appropriate it is to use an enquiring gaze on knowledge that is considered *taonga tuku iho* (sensitive information handed down from the ancestors), and thus not always open to interrogation (TRINICK & MEANEY, 2017).

Although this is an issue that has sometimes impinged upon the revitalisation of *mātauranga Māori* (Māori knowledge) in schooling, we anticipated that completing this assignment would allow for a discussion of these aspects and thus broaden the pre-service teachers' understandings about these issues. The source and authenticity of the data created a tension

throughout the process for most pre-service teachers and also reflected tensions in the migration stories that contained both fact (they did occur) and legend (the prowess of the captain of the *waka*) (ORBELL, 1975).

4 Findings and Discussion

In this section, we discuss the responses that are connected to each of the three steps and then discuss those that raise issues regarding socio-political contexts about how knowledge is valued in different societies.

4.1 Step 1: Cultural Aspects of Waka Migrations

The pre-service teachers responses to the assignment suggest that they learnt a lot about the *waka* migrations. This provided them with a sense of pride in regard to what their ancestors had achieved. Thus, cultural aspects provided the pre-service teachers with a solid background for their investigations which was not overwhelmed by the mathematical aspects.

Initially, a number of these pre-service teachers believed that their *waka* migrations were fortuitous, a European orthodoxy that argued that the various *waka* migrations were accidental rather than planned (ANDERSON, 2017; HANSON, 1989). This orthodoxy gained traction from the European belief that Indigenous people such as Māori did not have the required navigation skills and material technology to successfully traverse the vast oceans in a planned way and then return to their island origins (FINNEY, 1991 traced this story back to SHARP, 1956, 1963).

However, it was not until the 1960s and 70s that scholars began to document and study South Pacific wayfinding traditions and realised they were still practiced in places such as the Marshall and Caroline Islands (see FINNEY 1991; LEWIS,1972). Subsequently, modern sailings using ancient techniques, investigations of changing wind patterns and DNA variations have shown planned and return journeys between New Zealand and the Pacific were highly probable (ANDERSON, 2017; HANSON, 1989). Some comments from the pre-service teachers about this aspect were:

> I learnt that our people had the navigation sophistication to travel all over the Pacific.
>
> The journey to Aotearoa was planned and not by chance — I feel proud about our ancestors ability to do so.

Some pre-service teachers also noted how learning about migration *waka* first and

foremost contributed to their language awareness and learning, “being able to talk about things more effectively in *te reo Māori*”.

It also made them aware of other information that they could learn about, “I would love to learn about the navigation artefacts they used” and that there were good sources of information related to their own tribal history, “I learnt that there is information out there on our *tupuna* (ancestors)”.

In circumstances where language and culture revitalisation are important goals for the schooling system, it is essential that teachers know how to search for and find relevant information that they themselves do not have. As noted previously, many of the pre-service teachers grew up in cities often knowing little about their ancestral roots. This project gave them the opportunity to identify important cultural knowledge that they did not have and find ways to fill these gaps.

4.2 Step 2: Design Elements of Waka Migrations

In this step, it is important to identify individual elements related to the cultural artefact of process and discuss these from a range of different perspectives. In regard to *waka* migrations, these elements were related to navigation, speed and distance covered by the canoes.

All of the pre-service teachers identified the use of traditional navigation as being important, with many indicating that they had a number of friends or relatives who had been involved in the contemporary sailings of *waka* (see http://www.navigatortours.co.nz/Te_Aurere.html).

Looking for information about these elements involved searching for different sources of information. These included consulting with elders, books, and online sites such as *Te Ara – The Encyclopedia of New Zealand* which resulted in the identification of *pūrākau* (traditional Māori stories), star maps, and finding examples of the canoe itself as an artefact (TAONUI, 2005).

Pūrākau of the early migrations contain references to stars and other celestial phenomenon as navigational aids. For example, in the story of the *Te Arawa waka* to Aotearoa, amongst many references to celestial phenomena is the following statement made by the navigator *Ngatoroirangi*:

> Kia whakatau koutou ki a Atutahi ma Rehua
>
> Ko Atutahi e whakatata nei ki Te Mangaroa
>
> Direct your course to Canopus by Antares
>
> Canopus that is by the side of the Milky Way

The pre-service teachers had to understand the meaning of the *pūrākau* and their structure as well as what the *pūrākau* had to say about the location of stars and how they were used to. For example, it is important to know that Canopus rises and falls in the south.

This navigating story also involved understanding the rhetorical techniques used in *pūrākau*. In the *pūrākau* above the speaker is appealing directly to the listener, even though the story is several hundred years old. *Pūrākau* are a traditional form of Māori narrative, containing philosophical thought, epistemological constructs, cultural codes and world views (TRINICK, 2015).

A number of pre-service teachers noted that many sources, particularly books and manuscripts, highlighted that one of the greatest skills of traditional navigators was their ability to read the night sky, the currents and the winds and the relationship between them. For example, the rising and setting points of the brightest and most distinctive stars and planets were gauged with the help of sophisticated star compasses, and then memorised. This required the pre-service teachers to discuss the environmental aspects connected to navigation and led to a wider appreciation of the skills their forebears had:

> "Navigating without Western tools. The huge understanding/knowledge of our environment".
>
> "Our ancestors were awesome navigators—using currents, winds speed to calculate direction and speed".
>
> "Our *tipuna* (ancestors) were experts in estimating time, distance etc which determined how much food and water was required".

The students were also asked what else they like to learn about. The students' answers varied, with some responses including "the use of star maps", "to be a better researcher" and "if I had done my assignment properly I would have found out more than I did". This suggests that revitalising cultural practices and understandings requires pre-service teachers to learn how they themselves and their future students can identify not only what they do not know about the cultural practice, but also how to identify reliable sources.

Engagement with a range of sources required the pre-service teachers to make connections between different kinds of information and be able to interpret the information through how it was presented. These interpretation skills provided possibilities for interpreting information about other cultural aspects. This investigation also provided understandings about how mathematical understandings, such as estimating time and distance to determine the amount of food and water required, were linked to the cultural aspects of *waka* migrations.

4.3 Step 3: Mathematical Aspects of Waka Migrations

In the cultural symmetry model, the third stage provides opportunities for the mathematics to provide extra value to what is known about a mathematical practice. Thus, by discussing elements of the cultural practice using mathematics, extra understanding about the practice is provided. Mathematics, therefore, does not colonise what is valued in the cultural practice, but becomes just another way, albeit an important way, of describing that practice.

Most pre-service teachers identified measurement concepts as being an important consideration in the construction of the *waka*. One pre-service teacher illustrated this by discussing the use of the ethnomathematical practice of body measurements:

> *"Heoi, mā te kaihanga, me ōna whatu, me ōna wheako e whakaioro i ia o ngā kōko o te waka."* (It was the principal builder, who used his own body as the measuring tool to determine the dimensions of the *waka*).

The pre-service teachers all considered, "the relationship between the shape and size of the *waka* determined how many people could go on board". However, there was considerable variation in the data sources as to the numbers on each waka, with anywhere from 20 to 140 people being recorded. As noted by Trinick & Meaney (2017), there was some need to work with pre-service teachers about what might be likely sizes given information such as the height of the trees that their ancestors would have used to build the *waka*.

It seemed that some pre-service teachers were influenced in their mathematical calculations by observations of contemporary single-hull *waka*, which would have been paddled, as they discussed the number of people who would be paddlers on the canoes. For example, one pre-service teacher in discussing the results of a survey they had done with their relatives about the gender distribution of those on board stated:

> "It was very clear to see that the majority (21) participants of this survey believed that there were more men on board than women, and 2 participants believed there were equal number of men and women aboard the … *waka* for the following reasons:
>
> Men were stronger at paddling.
>
> Women were there to help look after men who were paddling.
>
> Men needed women to reproduce offspring".

However, traditional ocean-going *waka* were double-hulled and used a sail, although there is some discussion about what this sail might have looked like (see ANDERSON, 2017). One pre-service student who discussed double-hulled canoes noted that to ensure consistency between the hulls some transformational geometry skill would be required by its principal maker.

Measurement skills were also noted as being used for wayfinding, where the *waka* themselves were used as navigation artefacts. For example, parts of the canoe were used to measure the height of *Te Taki o Autahi* (Southern Cross) above the horizon. This helped determine the latitude and how far south the *waka* was, for example, in relationship to *Aotearoa*. Some navigators also lined up their *waka* with wind direction, using pennants tied to both mast and rigging as a guide.

It was clear that, particularly with the first cohort from 2017, that pre-service teachers needed more support in linking cultural aspects to mathematics, if the mathematics were to add value to cultural understandings about *waka* migrations. However, as is discussed in the next section, having to consider how mathematics was connected to *waka* migrations did make them think about what knowledge is valued in what circumstances and for what reasons.

4.4 Socio-Cultural Aspects About Knowledge Valuation

Ethnomathematics has been discussed as a human right (D'AMBROSIO & D'AMBROSIO, 2013) and as a way to decolonise how Indigenous knowledge is perceived (MEANEY, TRINICK & FAIRHALL, 2017), because it is much harder to argue against a human right rather than a cultural right. Thus, it was important to understand whether and how these pre-service teachers used this project to raise issue about knowledge validation.

The responses from the pre-service teachers suggested that while they queried differences between tribes, the differences were of a political nature rather than a mathematical one. For example, all *waka* navigators used a mixture of wind, waves, current and celestial phenomena for wayfinding. Differences were often related to the demographics of who was on board, where they landed first and the final resting place of the canoe.

Tribal differences came up several times as something that the pre-service teachers had to consider when assessing the reliability of sources, with one pre-service teacher stating, "The only thing I found challenging to *tikanga* was the fact that each *iwi* (tribe) have different ideas about *nga Hekenga waka*" (*waka* migrations)". As previously stated, these differences were often related to whether or not it was culturally acceptable for pre-service teachers to query elders about traditional knowledge. This led them to consider the value of doing ethnomathematical investigations with their potential students with students from different tribes.

The view that mathematical practices were only of value when it was from the dominant group or the group who did well in mathematics was challenged as a consequence of this

investigation, with one pre-service teacher stating, “I learnt that mathematics is not just for *Pākehā* (Europeans)and Chinese”.

Thus, as has been suggested by Powell & Frankenstein (1997), ethnomathematics can have a role in overcoming deficit views about who can do mathematics and help Indigenous students challenge hegemonic discourses from mainstream society. Working with *waka* migrations provided pre-service teachers with an opportunity to see that mathematics could be related to culture, “Mathematics is relatable no matter what culture — for example our *tipuna* had their own mathematics”.

The pre-service teachers were then able to make links from their own investigations towards their future work with students. This produced several responses that highlighted that mathematics and culture were linked and not separate, “It’s important for students to understand culture and mathematics because there is potential for them in all fields — mathematics straddles all cultures”. This was seen as providing more appropriate learning opportunities to students as “It makes for more authentic learning — they are able to make connections”.

However, as could be expected, one investigation was unlikely to change pre-service teachers’ ingrained dislike of mathematics that they had gained from their own schooling, “It’s easier to relate to culture rather than just numbers”. Thus if critiquing the way that knowledge comes to be valued is to be an outcome for *Te Huarahi Māori* (DALE, McCAFFERY & MCMURCHY-PILKINGTON, 1997) then more discussions focused on ethnomathematics are needed, otherwise the raising of issues around the valuation of knowledge will be reduced to simplistic statements such as “mathematics is everywhere”, stated by one of the pre-service teachers.

5 Conclusion

Despite tensions and the issues highlighted in this paper, much has clearly been accomplished over the past 20 years or so in the development of the field of Māori-medium mathematics education at the pre-service teacher education level. These developments include: a reliable supply of very good Māori-medium graduates entering the profession; a standardised corpus of terms developed to support the teaching of mathematics education at tertiary levels where previously none existed; the validation of *te reo Māori* as the medium of instruction; and opportunities becoming available for teachers to participate in professional learning opportunities in dialogic communities with fellow teacher practitioners and academics locally and internationally in areas such as ethnomathematics.

However, it also remains clear that determined effort and time is needed to revitalise the traditional cultural knowledge and/or make it available to teachers so that it is useful to them and meaningful to their students. While Māori language revitalisation began in earnest in the early 1980s, the revitalisation of cultural knowledge has proved to be more challenging. Part of the problem was the requirement to develop a national curriculum for all Māori-medium. Māori were then and still are resistant to having their knowledge decontextualised and generalised as is the practice in Western mathematics curriculum development.

Thus, teachers in Māori-medium schooling have several competing demands that are rarely heard in English-medium — the need to resurrect the traditional cultural knowledge being one of them. Therefore, in the absence of readily available resources, teachers need strategies to support them. This is where pre-service teacher education and academic research should play a key role, not just in Aotearoa but also elsewhere in the world where Indigenous mathematical practices have been marginalised or introduced as tokens within Western education systems.

Our research aim for this paper was to examine how pre-service teachers identified and described the interrelated cultural and mathematical practices in *waka* traditions and how these related to the cultural symmetry model. In particular, we wanted to see if an ethnomathematics investigation could support the pre-service teachers in considering how knowledge becomes valued, notwithstanding the distorted views of traditional Indigenous practices held by colonisers and perpetuated for decades in the school curriculum.

The cultural symmetry model provides a framework for supporting teachers and learners to ensure that working with ethnomathematics supports the decolonising of Western knowledge rather than a colonising of Indigenous knowledge by putting the cultural focus first and foremost. The first step was about seeing that the artefacts or practices within the cultural context. One of the reasons for choosing *waka* to investigate is that the questions constructed for the study were unlikely to be as contentious as some other topics as there is no doubt that they occurred.

While knowledge about the *waka* voyages can be considered localised, *waka* migrations are a phenomenon that all of the pre-service teachers could relate to. Most of the pre-service teachers began with some knowledge of their ancestral *waka*, but this project affirmed their cultural identity and made them feel proud of the endeavours of their ancestors. Many had grown up in the era when traditional voyages and navigation were initially considered to be accidental rather than planned according to European researchers, because they lacked the material technologies of the West. Ethnomathematics has provided a critical perspective and framework to challenge ways in which Eurocentrism permeates mathematics and mathematics education in general.

While the pre-service teachers believed their ancestors practiced mathematics in ocean voyaging, they did not initially see any connection between the cultural aspects and mathematics. The second step of the cultural symmetry model supported them to see different elements that contributed to the waka journey which in the third step they could explicitly link to mathematics. The preservice teachers were familiar with one or more example of the stories, but it was something of a surprise to them to think about these traditions having a mathematical aspect. For all, it was the first time that mathematics had been introduced to them in this way — the connecting and valuing of the cultural knowledge.

As pre-service teachers, they were familiar with the pedagogical rationales behind the need to connect school students' mathematical learning to a context, e.g., to make mathematics meaningful, but this was the first time they had been introduced to the idea of using mathematics to revitalise the cultural knowledge and that cultural knowledge was important knowledge in its own right. This highlights the need to introduce the concept of ethnomathematics earlier in this teacher education programme and in their schooling. The cultural symmetry model supported the pre-service teachers to not just identify mathematical aspects of the migration journeys but also to see how the mathematical focus added value to their understandings about the cultural practices.

Analysing the pre-service teachers' comments using the cultural symmetry model also allowed us to see how they made sense of how knowledge was valued by different groups. Although the points that they made were not always clear in regard to how they resolved issues to do with valuing of knowledge in different situations, it did make them query some of their assumptions. For the process of using cultural practices as a basis for mathematics lessons to make a difference in decolonising school knowledge, then it is hoped that the querying of how knowledge is valued is raised also in these pre-service teachers' future teaching. But that will be another study…

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