Use of a Cultural Metaphor in Pre-service Mathematics Teacher Education

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This paper describes a pilot study into the use of a traditional Māori cultural activity as a metaphor and overarching theme for both content and pedagogical knowledge development within a pre-service mathematics education course. Students' feedback on their own learning and their future use of such activities is presented. Findings include that pre-service teachers view the inclusion of cultural activities positively and can identify mathematics in such activities, however they are less confident in describing links to Treaty principles.

Ahakoa he iti, he pounamu.
Although it is small, it is precious.

Ānō me he whare pūngāwerewere.
As though it were a spider web.

This paper reports on one aspect of ongoing investigations which explore ways of addressing the implications of the principles of the Treaty of Waitangi in mathematics education in Aotearoa New Zealand. This research builds on studies previously reported at MERGA (Averill & Te Maro, 2003; Averill, Anderson, Easton & Hynds, 2004) and seeks to evaluate the effectiveness of the use of a cultural metaphor as an encompassing theme in a mathematics education pre-service course. Such use is a new aspect of our practice which attempts to model pedagogy that addresses the implications of the principles of the Treaty of Waitangi (subsequently referred to as the Treaty).

Use of a metaphor to underpin the mathematics education pre-service course originated from a metaphor initially proposed to represent the qualification within which the course sits. The Bachelor of Teaching (BTeach) was developed from 2001 with the first cohort of students beginning in January 2002. Te Kura Māori[1] staff and the coordinator of the BTeach together developed the use of the wharenui[2] as the metaphor of the BTeach qualification. In the proposed model the teaching practice papers were to be the backbone and ribs of the wharenui with curriculum papers taking on other aspects of the meetinghouse.

The BTeach model led us to explore the use of metaphors and themes in a mathematics course in another qualification. These informal trials and subsequent discussion regarding

[1] Te Kura Māori o Ako Pai, (No official translation exists. School of Māori Studies is offered as a translation for the purposes of this paper.)
[2] traditional Māori meeting house, central building of a Māori community complex (marae)

an appropriate metaphor for the second year BTeach mathematics education course led to the selection of tukutuku[1] as the course metaphor and theme. Tukutuku has the place of enhancing the aesthetic beauty of the wharenui. Thus our use of tukutuku as a metaphor can be interpreted as showing how the students' learning in mathematics education could enhance their general understanding of teaching and learning. The image of learning in mathematics education helping to enhance such understandings is continued in the third year BTeach mathematics education course that uses kōwhaiwhai[2] as the metaphor and theme.

In each case as new courses were prepared and taught for the first time, the theme, metaphor and course content were developed together. The research described in this paper was undertaken to evaluate the effectiveness of the use of tukutuku as a cultural metaphor, theme and associated practical activity in the second year mathematics education course.

The research questions of this study were:

- Was there a shift in students' intentions and attitudes concerning the use of cultural activities in their mathematics teaching as a result of the course?
- How confident were the students completing this course in their ability to address the implications of the Treaty of Waitangi in their mathematics and wider teaching programmes?
- How effective was the use of a cultural metaphor and associated practical activity in advancing students' confidence in their ability to address the implications of the Treaty of Waitangi in their mathematics teaching programmes?
- What specific mathematical links did students find in the practical activity?

Theoretical Perspective and Background

Wilson's interpretation (2002) of the Treaty principles of partnership, protection and participation, which originated in Bishop and Graham's work (1997) underpins our understanding of the implications of the Treaty of Waitangi and consequently the way we approached the inclusion of tukutuku.

We had several aims in choosing the tukutuku as a metaphor, theme and practical activity. Most importantly we wanted to better prepare students to be able to meet the beginning teachers' professional standard requiring them to demonstrate that they "understand the implications of the Treaty of Waitangi and te reo me ōna tikanga[3]" (Ministry of Education, 1998), a need indicated by Averill, Anderson, Easton, and Hynds (2004). In building our course around an aspect of Māori culture in this way we hoped to address the Treaty in our own practice as well as provide a model for the students. We wanted to use a theme that would bind together the course content (in particular Problem Solving, Algebra, Number, and Measurement) and connect with the overall metaphor of the wharenui for the qualification. It would also provide ways that students could meet the learning outcomes for the course which included that students would be able 'to incorporate bicultural and multicultural perspectives in teaching and learning decisions'.

[1] framework of ornamental woven panels decorating the inner walls of a wharenui

[2] painted designs on rafters inside a wharenui

[3] Te reo me ona tikanga as used in the Professional Standard and this paper can be roughly translated as (Māori) language and custom.

Finally we wanted the students to engage in depth with the complexity and range of mathematical skill involved in a Māori cultural activity.

Use of metaphor, modelling and practical activities are all consistent with traditional Māori teaching pedagogies (Hemara, 2000). Bishop and Glynn (1999) also refer to Heshusius' idea of metaphor as not simply providing an organising principle but actually shaping the content of our thinking. This was the intention of our use of metaphor.

Issues of inequity across ethnicities in what is seen as mathematical success encourage educators to continue the search for ways that may reduce disparity (Young-Loveridge, 2004). Portraying mathematics as a culture-free or mono-cultural activity is unlikely to bring about positive change (Walls, 2004). Glynn, Atvers and O'Brien (1999) found very low numbers of Māori topics and themes in their study of mainstream schools and concluded that Māori students would not see much that upheld the status of their culture in their everyday school life. Alton-Lee (2003) describes the development of inclusive learning communities and making effective links between school and students' other cultural contexts as characteristics of quality teaching. In modelling inclusion of mathematically rich Māori cultural activities for pre-service teachers we hoped to begin to address these issues.

We believed that identifying the mathematics involved in such a cultural activity would help our predominantly European pre-service teachers to "understand that mathematics is not the preserve of Western or Asian cultures" (Young-Loveridge, 2004, p. 35) and that Māori culture is "knowledgeable and skilled in many forms of mathematics" (Clark, 1999, p. 36).

Knight (1994) discusses the importance of giving the prestige to Māori culture rather than to the mathematics. At the beginning of the course students examined a traditional tukutuku panel and discussed the mathematics that was evident. A lecturer from Te Kura Māori presented an overview of its Māori origins and descriptions to the class. The reasons for using tukutuku as a theme and metaphor were described and information was given about the place and role of tukutuku. As a course component students were required to plan and make their own raffia and wood models of tukutuku panels that would show their growth as teachers of mathematics as well as reflect course content. In order to encourage them to problem solve and find their own methods students were given no prescribed instructions for making their designs but were shown several wood and raffia examples. Emphasis was placed throughout the course on the students working on their panels within class sessions and discussing the mathematics within them, thus using tukutuku as a cultural image to build mathematical ideas. In addition different traditional tukutuku designs were used as starting points for each mathematical strand of the course: Problem Solving, Algebra, Number, and Measurement.

Tukutuku panels hold stories and meanings and can be seen to provide clear links for mathematics concepts (Barton, 1989; Hughes, 1989; Hughes, 1990). McKinley, Stewart, and Richards (2004) discuss that the wide and often superficial use of a small number of "Māori contexts" in New Zealand junior secondary mathematics school programmes can lead to these cultural activities being seen as "Māori caricatures". They express concern that teaching superficially linked to a traditional Māori cultural activity can be seen to be unrealistically representing the wider complexities of Māori culture. We hoped to avoid a tokenistic, superficial, and 'caricature'-style approach by using tukutuku as an underlying theme which was integrated throughout the course in a range of ways, and by developing this theme in partnership with a mathematics lecturer from Te Kura Māori. Further, many

other methods of addressing the implications of the Treaty were also modelled through course teaching. Our approach was that inclusion of such aspects would provide a window through which students could glimpse sights of Te Ao Māori (the Maori world) and recognize these as being glimpses rather than the totality of Māori culture.

Method

The study data (two questionnaires, course evaluations, and transcripts of focussed group discussions) were collected from a class of twelve pre-service teachers in the third year of their degree. The class is the entire first cohort of those undertaking the BTeach degree. Eleven students were of European descent: Nine were New Zealand European, one Australian European, and one English. There was also one New Zealander of Indian ethnicity.

Students individually completed the first questionnaire at the conclusion of the course. They responded to questions regarding the mathematical content links they made to their tukutuku panels, the mathematical content they would aim to develop if they were to use tukutuku panel making in their own mathematics teaching, their intention to use a cultural activity in their own future teaching, and their confidence in addressing the Treaty in their mathematics teaching. Many questionnaire responses did not provide the detail researchers were seeking and it was decided to ask the students to expand on responses in a focussed discussion group setting. The class was split into two discussion groups both of which were asked to give written group responses to clarify the original questionnaire data. In order to eliminate possible bias a lecturer not involved with the research, the teaching of the course, or the students' previous courses led the discussion groups. The discussions were recorded, transcribed, and written group responses collected. Further data regarding students' confidence in understanding the implications of the Treaty was collected from individuals by way of a second questionnaire at the conclusion of the group discussions. Curriculum documents were available at all times.

The data was analysed collectively by the researchers by examining responses and determining the main themes. The researchers then individually checked that the collective analysis fairly represented the data.

Limitations of this study include that only eight of the twelve students completed the questionnaires, and data on the students' perceptions of the changes in their intended practice was gathered retrospectively. Examining students' planning would have allowed greater confidence that students' practice matched their reported intentions. Collection of such planning did not fall within the timeframe of this study as there was no teaching practicum directly following the course.

Results and Analysis

Intentions About Using Cultural Activities in their Mathematics Teaching

All of the students who responded to the questionnaires agreed or strongly agreed that as a result of the use of tukutuku they were more aware of opportunities to use cultural activities in their maths programmes. Statements indicated they might not have thought to use this type of activity in mathematics.

> "It showed me a different way of incorporating cultural activities into maths. I would have been more inclined to use tukutuku for art before this."

All students agreed or strongly agreed that they would use a cultural activity such as making tukutuku panels in their own teaching. Reasons given by students for planning to use cultural activities such as tukutuku panel making in their own teaching included cultural, pedagogical and motivational aspects. They felt such activities would assist them to address the cultural needs of the class, ([I feel it is] "very important to include tikanga and te reo Māori into my classroom", "it integrates Māori culture in an appropriate manner"), to establish links to further cultures, and to draw on community support and involvement. Pedagogical reasons included identifying such activities as a 'hook in' to new learning, a practical hands-on approach, showing mathematics is not just a text-book based subject, and as a way to integrate teaching across several curriculum areas (art, social studies, science, and technology).

> "How about integrating it with your social studies unit so when children are doing social studies and they've actually got a cultural understanding, then when you come to do this stuff in maths it's not so tokenistic, it actually has meaning for them…"

> "…say if the kapa haka[1] group needed new headbands, they could do little like cross stitch things for them."

Also expressed was that such activities would generate high interest and be motivating and fun. One student had used tukutuku with her practicum class following the first four weeks of the mathematics education course, and reported, "The children adored it."

Three students indicated that they would have been unlikely or very unlikely to include such an activity in their future mathematics programmes if they had not done the activity in the course.

> "I had thought maths was one of the hardest subjects to incorporate Māori culture into without being tokenistic as in counting or using Māori names."

Five students indicated that they were likely or very likely to have included such activities previous to undertaking this course. Two students indicated this was because of their strongly held beliefs about cultural inclusion and addressing diversity, and three because the BTeach courses strongly model such inclusion.

Transcripts showed that students could consider how best to make use of tukutuku in their own teaching.

> " I would aim, I would mostly aim to develop patterns, I mean that's why I'd mostly use this." "I'd go patterns, algebra." "Yeah, because I mean you can pick all of that out, but there are probably better activities to teach skip counting and multiplication and things." "Yeah agreed."

Students identified cultural activities other than making tukutuku panels that they may use in their future teaching of mathematics. These included tapa cloth/Polynesian bark cloth (patterns and transformations), waiata/songs and music (measurement and number), tititōrea/stick games (counting, repeating and sequential patterns, shapes), piupiu/garment made of flax (measurement, number, patterns, and problem solving), dance and kapa haka (rotation, symmetry, repetitive patterns, and number), saris and clothing, cooking and hangi/earth oven (time measurement, weight, volume), and visiting a marae.

[1] a term often used to describe a group who perform traditional and contemporary Māori songs and dances

Confidence in Addressing the Implications of the Treaty

There were varied responses to the first questionnaire regarding personal confidence in incorporating ways of addressing the Treaty in mathematics programmes. Three students expressed confidence to some degree, one was ambivalent, and four expressed lack of confidence. When these issues were probed further in the second questionnaire, all but one student stated that they felt confident in their understanding of the Treaty (4 of 8 were confident, 3 moderately confident, and 1 not confident), but they were less confident in their understanding of the implications of the Treaty for their mathematics programmes (3 of 8 confident about addressing the Treaty in their mathematics programmes, 3 not confident, and 2 not sure what it meant to address the Treaty in this way). These levels of confidence were the same as their levels for addressing the Treaty in their teaching in general for all students except one. This student was more confident about addressing the Treaty in mathematics than in general stating that the course "as a whole addressed this and greatly increased my confidence."

Students expressed some difficulty in linking the making of tukutuku with addressing the implications of the Treaty. Five students stated that they did not find the tukutuku activity valuable in developing their understanding of ways of addressing the Treaty in their mathematics teaching, two stated strongly that they did find it valuable, and one was ambivalent. Comments from three students indicated that while the activity was useful in introducing aspects of Māori culture, they were not sure that doing so actually addressed the Treaty. Three expressed concerns about tokenism and two students did not see any links between doing the activity and addressing the Treaty, wanting the links to be discussed further and made more explicit.

Challenges students foresaw in trying to address the Treaty in their mathematics teaching included having children who did not want to participate, lack of access to appropriate resources, difficulties in making such teaching meaningful and valid, and lack of children's background knowledge.

Mathematical Links Identified in the Practical Cultural Activity

All but one of the students agreed or strongly agreed that designing and making their own tukutuku panels had helped them identify the mathematical skills and understandings involved in such an activity. Opportunities for exploring mathematical ideas within their tukutuku panels were found and explained by all students although often these ideas were broadly rather than specifically expressed, for example 'shapes', 'symmetry', 'problem solving'. More specificity was achieved in the discussion groups as shown in Table 1. Students did not make use of the curriculum documents.

In course evaluations students were asked to list three things they liked about the course. Eight students included making tukutuku in their list and two students also included the whakatauāki (Māori proverb) of the spider web as well as other whakatauāki used in lectures. Students' comments from discussion transcripts about the use of tukutuku also indicate an appreciation of the holistic cultural approach and included:

> "It's a lot deeper way of addressing [the Treaty] than just counting in Māori."

> "…it's putting it all together, eh, like you know, the rotation and the symmetry, and sort of meshing it all in together, yeah."

> "It's fantastic that we look at Māori and Pacific Island cultures and stuff."

Table 1
Mathematical Content Identified in Making Tukutuku Panels

Strand	Mathematical Content in Making Their Own Panels and/or that Students Plan to Develop when Using Tukutuku Panels in Their Own Teaching
Algebra: Te Taurangi	Repeating and sequential patterns, algebraic equations and relationships
Number: Te Tau	Skip counting forward and back in 2s, 4s…, multiplication, subtraction, fractions
Geometry: Te Āhuahanga	Symmetry, lines of symmetry, transformations, enlargement, reflection, rotation, translation, names and properties of shapes
Measurement: Te Ine	Estimating the length of raffia needed to make each desired part of the panel, area, estimation
Mathematical Processes: Ngā Tukanga Pāngarau	Problem Solving e.g., using half stitches, fitting required patterns into the panel

Discussion and Conclusion

These findings show that pre-service teachers view the inclusion of cultural activities positively and can identify mathematics in such activities. However they are less confident in describing mathematical links to Treaty principles. The results of the case study encourage us to continue to develop the use of this metaphor, theme, and activity for this course. It is planned to retain the overall metaphor, the practical tukutuku making activity and links to associated traditional tukutuku and whakatauāki. Specific mathematics content identified by the students will be more explicitly incorporated into course teaching. Course documentation will include information explicitly linking course aspects to the principles of the Treaty.

Students' lack of confidence in identifying ways of addressing the implications of the principles of the Treaty was evident and of concern, since this was part of the rationale for inclusion of Māori cultural themes and activities. It seems students did not equate using cultural activities as contexts for learning with addressing the implications of the Treaty. There are many factors that may affect how well students are able to make connections between course aspects and the Treaty. These include students' understandings and personal philosophies regarding the Treaty, their lack of experience in describing links to the Treaty, and how explicitly such links were made within this and other pre-service courses. This raises the dilemma as to the optimum placement of learning in this area within degree courses. We feel that better preparation for students in this regard would lead to fewer superficial responses and concerns about tokenism. Our preference is that students are able to recognise aspects of their courses that are consistent with the principles of the Treaty thus readily transferring such knowledge to their mathematics course work.

On reflection we feel that we addressed the Treaty with integrity, and in so doing presented mathematics in a way consistent with views of Knight (1994) and Clark (1999). We recommend that mathematics educators consider use of a holistic multifaceted theme

as an approach to issues of diversity. We feel that this is best achieved in partnership with colleagues. In our case partnership and oversight from the mathematics lecturer based within Te Kura Māori was essential as this person brought with him not only vast cultural knowledge and expertise, but also an authority in this respect. Such partnership is consistent with Alton-Lee's (2003) characteristics of inclusive learning communities. Absence of such investigations into culture-rich mathematics programmes is likely to hinder students seeing the status of the cultures of both Treaty partners within their study and is unlikely to address concerns expressed by Walls (2004) and Glynn, Atvers, and O'Brien (1999).

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