Some Strategies Used in Mathematics by Māori-medium Students

Ngārewa Hāwera
The University of Waikato
<ngarewa@waikato.ac.nz>

Merilyn Taylor
The University of Waikato
<meta@waikato.ac.nz>

Ko te manu kai i te miro, nōna te ngahere.
Ko te manu kai i te mātauranga, nōna te ao!

This study set out to explore the perspectives of students attending Māori-medium schools. Sixty-one year 5–8 students in four schools were interviewed individually to identify their mathematics strategies for subtraction. The 44 year 7–8 students were also asked to solve a multiplication problem. The findings show that there was a range of mental strategies displayed by the students.

Background

Best & Hongi (2002) state that pre-European Māori had a "very good system of numeration and doubtless quite elaborate enough for their purposes" (p. 1). Such a system enabled them to count items singly, in pairs, in twenties, and in hundreds.

With the advent of European-style schooling, Māori students were assimiliated into a Western system of education in which little was done to explore connections with a Māori education paradigm. This contributed to low achievement generally for Māori in the European school system, and mathematics was no exception. This situation remained constant for a long period of time (Knight, 1994; Forbes, 2002).

In recent times, this negative trend has begun to reverse for Māori students in mainstream schools (Caygill & Kirkham, 2008). There have been significant increases in the mean mathematics achievement of these Māori students as measured by international benchmarks (Ministry of Education, 2006). For example, the National Education Monitoring Project, report 38, (Crooks & Flockton, 2006) states that students in Māori-medium schools performed well in tasks that involved recall of basic facts and geometric reasoning.

These gains may be a reflection of curricular changes in the 1992 *Mathematics in the New Zealand Curriculum* document, which explicitly stated that many Māori students' mathematics needs had not been catered for. A greater emphasis was therefore placed on schools to provide more appropriate mathematics teaching and assessment tools, taking cognisance of the background and experiences of Māori students (Ministry of Education, 1992, 1996; Christensen, 2002). Encouraging the confidence and greater participation of Māori students when they were learning mathematics became a key obligation for schools (Garden, 1997; Ministry of Education, 1992; 1996).

Māori initiatives such as kōhanga reo and Māori-medium schools have placed emphasis on improving Māori achievement in education (Smith, 1991). These developments contributed to a demand for appropriate resources for use in Māori-medium settings. A later emphasis on numeracy in New Zealand resulted in Te Poutama Tau, a professional development project based on the Numeracy Development Projects (NDP) (Christensen, 2002). Te Poutama Tau focuses on teacher development to enhance students' learning of numeracy in Māori-medium schools.

In an effort to support the improvement of mathematics learning, there has been an increasing expectation that mathematics education needs to shift from learning and remembering procedures

involving number to solving problems within a range of meaningful contexts (Ministry of Education, 1992, 1996). The mathematics learning area in *Te Marautanga o Aotearoa* emphasises that students should be making connections within and across different mathematics ideas (Ministry of Education, 2008). The ability to make such connections is perceived to be critical for the development of number sense (Anghileri, 2006).

Students who have developed a rich sense of number display flexibility of thinking and an awareness of the links and relationships between number ideas. These students are able to make generalisations about number and choose the most efficient and appropriate operations to solve problems in ways that make sense to them. Such processes can aid problem solving in alternative situations (Angliheri, 2006; Dowker, 2005).

Part of number sense involves being able to utilise mental computation strategies in a variety of situations. In order to develop such strategies, students need to learn and readily access a wide base of number facts. Knowledge of number facts can provide a platform for helping students to develop further thinking about number. The more known facts students can access mentally, the greater their potential for constructing strategies to solve mathematics problems (Dowker, 2005; Thompson, 1999a).

In recent years, the development of robust methods of mental computation has become a focus generally in mathematics education in the western world. In Britain, for example, the National Numeracy Strategy advocates exposing students to a variety of mental strategies. From such a range of strategies, students are encouraged to explore and choose the most appropriate for the situation or problem they are engaged in. This process assists them to develop confidence in their ability to problem solve (Suggate, Davis, & Goulding, 2006). These precepts are also embedded in *Te Marautanga o Aotearoa* (Ministry of Education, 2008).

Being able to articulate a mental computation strategy is deemed beneficial for students' learning in mathematics (Zevenbergen, Dole, & Wright, 2004; Ittigson, 2002). The ability to do so must be learned (Anthony & Walshaw, 2007). All recent curriculum documents and Te Poutama Tau reflect the importance of learners developing proficiency in the articulation of their mathematics thinking. Furthermore, Moschkovich (2002) reminds us that mathematics discourse is more than learning mathematics terminology. Students also have to learn to participate in valued mathematics discourse practices.

Māori-medium settings support learners to articulate their mathematics thinking in Māori. These settings have necessitated the development of appropriate vocabulary in Māori for learning mathematics. Mathematics discourse that is interwoven with the conceptual development of mathematics ideas continues to be a challenge for learners, including Māori (Barton, 2008; Christensen, 2004).

It is helpful for students to become familiar with written ways of recording their mathematics thinking. This enables them to record their mathematics thinking systematically and then to communicate those ideas. Written methods should closely align with their mental processes of calculation (Anghileri, 2006; Beishuizen & Anghileri, 1998; Suggate et al., 2006). Traditional western algorithmic procedures for calculating implemented in schools have seldom mirrored mental computation processes and have contributed instead to "cognitive passivity"(Thompson, 1999a, p. 173). It is argued that mathematics instruction should therefore include ways of helping all students to integrate their mathematics thinking and recording so that they are not using procedures by rote in meaningless ways (Gilmore & Bryant, 2008).

In order to align students' mental and written computation strategies, close examination of their mathematics thinking for solving mathematics problems is necessary. For example, when subtracting, students can exhibit a range of mental computation strategies. The recording of these strategies should reflect their mathematics thinking. This is important when students have to deal with more complex calculations (Anghileri, 2006).

Several subtraction strategies used by students have been identified. One example is the counting-back strategy (CB) that can be employed when subtracting one, two, or three items. However, this strategy is deemed to be inefficient and problematic when larger amounts need to be taken away (Zevenbergen et al., 2004). Another subtraction strategy is one where students count up (CUP) from the lower number to the higher one and thereby find the difference (Jordan, Hanich, & Uberti, 2003). A bridging-through-ten strategy (BTT) is noted by Thompson (1999b). This process involves partitioning the subtrahend (the amount subtracted) into two chunks. Subtracting one chunk from the minuend (the starting amount) takes the total to a decade number from which the remaining chunk is subtracted. For example, 37 – 9 becomes (37 – 7) – 2 = 30 – 2 = 28. Subtraction by compensation (COM) involves working from known facts. The subtrahend may be changed to a more convenient number that is then subtracted from the minuend. The change made to the original subtrahend must then be compensated for (Anghileri, 2006). For example, 37 – 9 becomes 37 – (9 + 1) = 37 – 10 = 27. So 37 – 9 = 27 + 1 (the extra 1 that was subtracted with the 9) = 27 + 1 = 28.

For students to develop efficient subtraction strategies, they need to be presented with numerous opportunities to practise the automatic retrieval of number bonds such as complements of or to ten. Immediate retrieval of this type of number knowledge will aid the development of mental flexibility with number (Beishuizen & Angliheri, 1998).

Being aware of how numbers can be manipulated is also important for the development of multiplication strategies. Siemon (2005) suggests that multiplicative thinking demonstrates an individual's "capacity to work flexibly with the concepts, strategies and representations of multiplication (and division) as they occur in various contexts" (p. 1). The simplest form of a multiplicative situation that students will meet is one where there is a one-to-many correspondence between two sets, for example, 1 car, 4 wheels. The most basic strategy students use to solve this type of problem is when they add the multiplier the number of times indicated by the multiplicand. So for 17 cars each with 4 wheels, 17 x 4 becomes 4 + 4 = 8 + 4 = 12 + 4 ... (Nunes & Bryant, 1996).

Another strategy that students might use is to double numbers to create "clumps" that are added together to find a total. These can include a double-double strategy (DD), where 17 x 4 becomes (17 + 17) + (17 + 17) = 34 + 34 = 68, or a times-doubling strategy (TD), in which 17 x 4 becomes (17 x 2) x 2 = 34 x 2 = 68. The doubling strategy may be seen as less efficient when larger numbers are involved. A standard place value partitioning strategy (SPVP), in which the multiplicand is partitioned and then each part multiplied by the multiplier and both results combined to find the solution, is deemed to be more efficient (Ambrose, Baek, and Carpenter, 2003; Baek, 2006). 17 x 4 becomes 17 partitioned into 10 and 7, 10 x 4 = 40, and 7 x 4 = 28, 40 + 28 = 68. Baek (2006) argues that compensating is a very sophisticated strategy that requires flexible thinking and a fluent understanding of both the numbers and the process of multiplication. For example, 17 x 4 becomes (17 + 3) x 4 = 80; 17 x 4 = 80 – 3 x 4 (the extra amount added on to the 17 at the beginning] = 80 – 12 = 68.

When multiplying, some students use traditionally-taught written procedures (ALG). Difficulties arise if they do not have a clear understanding of place value and try to perform calculations by following poorly understood rules (Lawton, 2005).

Method

Participants

This study focuses on the responses of 61 year 5–8 Māori students in four schools. Two schools were kura kaupapa Māori catering for students from years 0–8. Another kura catered for students from years 1–15, and the wharekura catered for students from years 0–13. Three of the kura had participated in Te Poutama Tau, the Māori-medium equivalent of the NDP, for some years prior to this study. Twenty of the students were from a decile 1 kura, 21 from decile 2 kura, and 20 from a decile 5 kura. Thirty-eight students were female, and 23 were male.

Table 1
Composition of the Students by Kura and Year Level

Kura	Year 5	Year 6	Year 7	Year 8	Total
1*	2	2	0	6	10
2*	2	3	3	2	10
3*	4	4	8	4	20
4	0	0	12	9	21
Number of students	8	9	23	21	61

* Te Poutama Tau participants

Procedure

Schools were asked to nominate year 5–8 students from across a range of mathematics levels. These students were interviewed individually for about 30 minutes in te reo Māori or English (their choice) in a quiet place away from the classroom. They were told that the interviewer was interested in finding out about their thoughts regarding their learning of pāngarau/mathematics.

The questions this paper focuses on are part of a larger collection of questions that the students were asked to respond to. Other questions have been previously analysed and discussed elsewhere (Hāwera & Taylor, 2008; Hāwera, Taylor, Young-Loveridge, & Sharma, 2007). The subtraction and multiplication questions were selected on the basis that the mathematics involved should be accessible to the students. The questions were designed to elicit the use of important and relevant strategies and knowledge that this age group could be expected to employ. The questions analysed here are:

1. E $37 i roto i te pēke o Te Āwhina. I pau i a ia te $9 ki te toa. E hia ana moni kei te toe?

   Te Āwhina had $37 in her bag. She spent $9 at the shop. How much money did she have left?

2. E hanga motokā ana te kamupene o Hera. E 4 ngā wīra mō ia motokā. E hia katoa ngā wīra mō te 17 motokā?

   Hera has a car manufacturing company. She needs 4 wheels for each car. How many wheels does she need for 17 cars?

Audiotapes of the interviews were transcribed by a person fluent in te reo Māori. Transcripts were subjected to a content analysis to identify common strategies in the students' responses. The students' responses have been coded[1] to maintain confidentiality and to be consistent with the reporting of other data from the larger study.

[1] See explanation of code on page 70.

Results

Subtraction Strategies

All 61 students in the study were asked the subtraction question, and all provided a solution. Fifty-three solved the subtraction problem correctly, and all of these students could articulate the strategy they used. As might be expected, there was a range of responses to this question. The responses have been grouped according to the following strategies:

BTT: bridging through ten, for example, 37 – 9 = (37 – 7) – 2 = 30 – 2 = 28

COM: compensating, for example, 37 – 9 = 37 – (9 + 1) + 1 = 37 – 10 + 1 = 27 + 1 = 28

CB: counting back by one, in this case, from 37

CUP: counting up by one, in this case, from 9 to 37

ALG: using a traditionally-taught written procedure

Nexp: no explanation of the strategy used.

Table 2
Strategies used for the Subtraction Task

Kura	Number of Students in Study	BTT	COM	CB	CUP	ALG	Nexp
1*	10	5	1	4 (2W)	0	0	0
2*	10	5 (1W)	3	1	0	0	1 (1W)
3*	20	7	9	2 (1W)	0	0	2 (1W)
4	21	7	2	3 (1W)	2 (1W)	2	5
Total	61	24	15	10	2	2	8

*Te Poutama Tau participants
(*n*W) indicates the number of incorrect solutions

The two most commonly used strategies were bridging through ten and compensation. These strategies require efficient and flexible mathematics thinking (Beishuizen & Anghileri, 1998). Of the 61 students interviewed, 24 used the bridging-through-ten strategy for solving this problem. The compensating strategy was used by 15 of the students. It is noted that a significant proportion of students from each of the schools demonstrated the use of these strategies.

The less efficient counting-back strategy was used by 10 of the students. These students came from each of the kura. Four of them gave an incorrect solution: two used the counting-up-by-one strategy, and the other two used an algorithm. Of the 12 students who used a counting-up-by-one strategy, almost half reached an incorrect solution. Eight of the students did not divulge their strategy for this problem, although most of these students calculated a correct solution. Of the group who did not disclose their strategy, most were from kura 4.

Six of the students were able to offer a second strategy for finding a correct solution (see Table 3). (Four of these students were from kura 3 and two from kura 4.) This indicates a desired flexibility of thinking and an ability to employ number sense in a pressured situation.

Table 3
Subtraction: Two Strategies (as stated by the students)

Names	Kura	Strategy 1	Strategy 2
K37f7[2]	3	30 – 9 = 21 + 7 = 28	9 – 7 = 2, 30 – 2 = 28
K39m6	3	37 – 10 = 27 + 1 = 28	40 – 9 = 31 – 3 = 28
K46m7	3	39 – 11 = 28	37 + 2 = 39 – 9 = 30 – 2 = 28
K38f7	3	37 – 10 = 27 + 1 = 28	37 – 9 = 28
K61m7	4	37 – 7 = 30 – 2 = 28	* 37 on the top and then you take 9 away from 7 but you cannot do that so you slash the 3 and put 1 on the 7, [that] makes it 17, and then you take 9 away from 17, which is 8, and then you write a 2, and then it's 28.
K51m7	4	40 – 10 = 30 – 3 = 27 + 1 = 28	37 – 7 = 30 – 2 = 28

* asked for paper to record on.

One such example of this is articulated by K37f7.

Her first strategy was:

> I tango au te iwa mai ..., mai i te toru tekau ... āe, arā ko tērā te rua tekau mā tahi.
>
> Tāpiri ki te whitu.
>
> (I took the 9 from 30 and got 21. I added that to the 7.)

Her second strategy was:

> ... ka tango te whitu mai i te iwa, ā, ko te toru tekau, ka tango te rua mai i te toru tekau.
>
> (I took 7 from 9, made 30, took 2 from 30.)

Multiplication Strategies

Only the 44 year 7–8 students in the study were asked to complete the following multiplication task:

> E hanga motokā ana te kamupene o Hera. E 4 ngā wīra mō ia motokā. E hia katoa ngā wīra mō te 17 motokā?
>
> Hera has a car manufacturing company. She needs 4 wheels for each car. How many wheels does she need for 17 cars?

Thirty-six out of 44 students attempted to solve the multiplication problem. Of these, 29 were able to do so correctly. As with the subtraction problem, the students used a range of strategies to solve this problem. These responses have been categorised into the following strategies:

SPVP: standard place value partitioning, for example, 4 x 17 = (4 x 10) + (4 x 7) = 40 + 28 = 68

DF: derived fact, for example, 4 x 17 = (4 x 10) + (4 x 5) + (4 x 2) = 40 + 20 + 8 = 68.

TT: times twice, for example, 4 x 17 = (2 x 17) x 2 = 34 x 2 = 68

[2] K = kura, 37 = the 3rd group out of the 61 students and the 7th student in that group, f = female, and 7 = year level

DD: double double, for example, 4 x 17 = (17 + 17) + (17 + 17) = 34 + 34 = 68

TD: times doubling, for example, 4 x 17 = (2 x 17) + (2 x 17) = 34 + 34 = 68

C4: counting up in fours, for example, (4, 8, 12, 16 ... 68)

ALG: a traditionally taught written procedure

NA: no attempt made or no strategy offered.

Table 4
Strategies Used for the Multiplication Task

Kura	Number of Year 7–8 Students	SPVP	DF	TT	DD	TD	C4	ALG	NA
1*	6	0	0	0	0	1	0	1 (1W)	4
2*	5	1	1	1	1	1	0	0	0
3*	12	6	0	0	0	1	0	2	3
4	21	4 (1W)	4 (1W)	0	0	1	5 (1W)	6 (3W)	1
Total	44	11	5	1	1	4	5	9	8

* Te Poutama Tau participants
(*n*W) indicates the number of incorrect solutions

11 of the students used the standard place value partitioning strategy. An example of this is:

> I took the 7 away, and I just did 10 times 4 equals 40, then I done 4 times 7, which equals 28. Then I added those 2 answers together and got 68. (K68m8)

The derived-fact strategy was used by five of the students to reach a solution. Further analysis indicates that this group of students was able to make use of known facts that they were instantly able to recall. For example:

> Whā whakarau tekau ka puta whā tekau, ā, whā whakarau rima ka puta rua tekau, ā, whā whakarau rua, ka puta waru, ā, ka tāpiri ērā mea kia ono tekau mā waru. (K25f7)
>
> (4 times 10 makes 40, and 4 times 5 makes 20, and 4 times 2 makes 8, and you add those to make 68.)

Another student, who worked from a fact that she knew, said:

> ...um, I went 4 times 12 which is 48, and then I just went 4 times 5 is 20 and then added the 20 to the 48. (K65f7)

Variations of the doubling strategy (TT, DD, TD) were used by six of the students. For example:

> I rounded the 17 down to um 15. I times'd the 15 times 4, times'd 15 times 4, which equals 60.
>
> [How'd you know that equals 60?]
>
> Two 15s equals 30, then two 30s equal 60.
>
> [60 and the 2 that you took off?]
>
> You times it by 4, which equals 8, and 60 plus 8 equals 68. (K51m7)

Counting up in fours was used by five of the students, all of whom came from kura 4. The traditionally-taught written procedure was used by nine of the 44 students, most of whom came from kura 4. Just over half of the students who used the algorithmic strategy were able provide the correct solution.

Eight of the students indicated that they did not know how to do the multiplication task and made no attempt to do so. Of the 36 students who did attempt the problem, seven of these provided an incorrect solution.

For the multiplication task, nine of the students shared more than one strategy for finding the solution. All of these solutions were correct. This group included three of the students who had also offered a second strategy for the subtraction problem.

Table 5
Multiplication: Two Strategies (as stated by the students)

Names	Kura	Strategy 1	Strategy 2
K27f8	2	2 x 17 = 34 + 34 = 68	4 x 10 = 40, 4 x 7 = 28, 40 + 28 = 68
K25f7	2	4 x 10 = 40, 4 x 5 = 20, 4 x 2 = 8, 40 + 20 + 8 = 68	4 x 20 = 80, 4 x 3 = 12, 80 –12 = 68
K36m7	3	17 x 2 = 34 + 34 = 68	4 + 1 = 5, 5 + 5 = 10, 10 x 17 = 170 ÷ 2 = 85 – 17 = 68
K37f7	3	10 x 4 = 40, 7 x 4 = 28, 40 + 28 = 68	17 x 2 = 34 x 2 = 68
K46m7	3	10 x 4 = 40, 7 x 4 = 28, 40 + 28 = 68	* 4 x 7 = 28, 4 x 1 = 4 + 2 = 68
K38f7	3	4 x 10 = 40, 4 x 7 = 28, 40 + 28 = 68	17 + 17 + 17 + 17 = 68
K610f7	4	4, 8, 12, 13, 14, 15, ... 68	* 4 times 7 is 28, and then you stick the 2 there, and then … 4 times 1 is 4, plus the 2 is 6.
K64f8	4	4 x 7 = 28, 4 x 10 = 40 28 + 40 = 68	17 x 2 = 34 x 2 = 68
K57f7	4	4, 8, 12 ... 68	* 4 times 7 is 28. Put the 8 down here and the 2 up there. 2 and 4 is 6.

* asked for paper to record on

For example, K36m7's first strategy was:

> Um, tekau mā whitu whakarau rua, ka toru tekau mā whā, toru tekau mā whā tāpiri toru tekau mā whā, ka ono tekau mā waru.
>
> (17 times 2 equals 34. 34 plus 34 equals 68)

His second strategy was:

> Ka taea ki te tāpiri te kotahi i runga i te whā ka rima, kātahi huri te rima ki te tekau; tekau whakarau tekau mā whitu ka tahi rau whitu tekau, kātahi me hāwhe te tahi rau whitu tekau ka waru tekau mā rima, kātahi tango tekau mā whitu ka ono tekau mā waru.
>
> (You can add 1 to the 4 to make 5, then change the 5 to 10; 10 times 17 makes 170, then half the 170 makes 85, then take away 17 equals 68.)

Discussion

It is heartening to see that many of these students seemed to readily make sense of these two word problems, given that they had only just met the interviewer, whose Māori language usage they may not have been accustomed to. The students were also isolated from their normal classroom and were expected to adjust quickly to an unfamiliar situation.

Of the students interviewed, most were able to successfully complete the problems. For the subtraction task, almost two-thirds of the students used the bridging-through-ten (Thompson, 1999b) and compensation strategies (Anghileri, 2006). The strategies were used by some students from each of the kura. Many students were able to demonstrate the ability to reason from what they knew and understood about basic facts and the ways that numbers can be manipulated. This flexibility with number is an important aspect of developing rich number sense and thereby increases the facility to utilise number in different contexts (Anghileri, 2006; Dowker, 2005).

While most of the students could solve the problems presented, some used less efficient strategies that proved to be cumbersome and time consuming for them. For example, some students from kura 4 displayed the use of the less efficient counting-up-in-fours strategy when multiplying, while others were able to draw on the more efficient standard place value partitioning and derived-fact strategies (Dowker, 2005; Baek, 2006). More consideration of and emphasis on pedagogical practices to help some students become more efficient thinkers and manipulators of number may be required. For example, when appropriate, students should be encouraged to multiply rather than to continue with repeated addition. Such connections need to be made more explicit for some learners (Anghileri, 2006). This ability to think multiplicatively has implications for developing and appreciating algebraic relationships and should therefore not be underestimated (Lamon, 2007; Watson, 2008).

It is interesting to note that some students were able to share more than one strategy to solve the subtraction and multiplication problems. This indicates the flexibility of being able to use number knowledge in different ways and awareness that there can be more than one pathway to a solution (Young-Loveridge, 2006). Zevenbergen et al. (2004) maintain that expecting students to explain, listen to, and reflect on a range of strategies helps them make better sense of the mathematics they engage with. Such thinking is illustrative of current expectations of students' learning in mathematics education (Ministry of Education, 2007, 2008).

Of the 12 students who used a counting-up-in-one or a counting-back-in-one strategy for subtraction, almost one-half calculated an incorrect solution. This indicates that the cognitive demand of these strategies predisposes students to make errors as they try to keep track of their calculations. More students made errors when subtracting using this process than those who used alternative methods. This confirms Zevenbergen et al.'s (2004) view that when subtracting more than three items, a more efficient and effective strategy should be employed.

An emphasis on communication is reflected in recent curriculum documents and support resources in New Zealand (Ministry of Education, 1992, 1996, 2007, 2008; Christensen, 2002). It is noteworthy that 41 of the 61 students chose to be interviewed in te reo Māori and were able to express their mathematics reasoning clearly and succinctly in that language. This indicates a confidence in their knowledge and use of appropriate mathematics vocabulary and discourse. Barton (2008) argues that mathematics development is affected by language development and vice versa. Parallel advancement in both of these aspects has implications for students' ability to learn about and share mathematics ideas. Students who did not share their strategies in this study may not have been able to make the necessary connections between their mathematics thinking and the language required to express it.

Analysis of the multiplication results from this study indicates that 15 of the 44 year 7–8 students were not able to either access the problem or solve it correctly. Of the seven students who provided an incorrect solution, four used an algorithmic strategy. These students did not appear to fully understand the process of manipulating numbers when using the algorithmic procedure (Gilmore & Bryant, 2008; Thompson, 1999a).

Eight of these year 7 and 8 students did not seem to have a strategy to solve or even begin the multiplication problem. Given that these students are likely to have been exposed to the process of multiplication for at least three years (Ministry of Education, 1992), it is a concern that they appeared unable to access and use a mathematics strategy to solve the problem. Learning about multiplication is a complex process, and research indicates that the development of multiplicative thinking has proved to be a challenge for many students (Lamon, 2007).

Although data has been collected from four Māori-medium schools, a limitation of this paper could be that these findings pertain to just 61 students in total, only 44 of whom were asked to respond to the multiplication problem. This makes it difficult to generalise, but it does give some insights about students learning mathematics in Māori-medium settings.

There seemed to be no significant trends emerging from any one school because students from all the schools shared a range of mathematics strategies. As expected, those students involved in Te Poutama Tau were more inclined to use strategies promoted in that project. It should be noted though, that use of those strategies was also apparent in the kura not involved in Te Poutama Tau. This illustrates that students may well be able to generate a variety of mathematics strategies without formal instruction. However, overt teaching that promotes efficient strategy development and number knowledge appears to be beneficial for increasing students' facility with number.

Conclusion

This study indicates that the majority of students interviewed in Māori-medium settings were able to solve the two problems offered to them and articulate their mathematics thinking. They displayed a diverse range of strategies for mental computation for subtraction and multiplication, some of which were more efficient than others. The process of multiplication appeared to be a challenge for about 15 of the year 7–8 students. This is a concern and warrants further investigation.

Many of these students in Māori-medium settings demonstrated that they are developing mathematics competency. Most were able to communicate clearly their ideas in te reo Māori. Further facilitation of their mathematics learning is required to support the use of more efficient strategies so that they can continue to develop more sophisticated ideas in the realm of numeracy. This is essential if we are serious about Māori gaining more equitable access to all the opportunities that the New Zealand societal landscape has to offer.

Concluding Comments

It has been a privilege to listen to the mathematics ideas presented by these Māori students. These results indicate that the majority of these students have experienced success in demonstrating a way to solve these problems and articulate their thinking. What are the challenges for those who have not been able to do this? Further research into identifying the barriers preventing the development of multiplicative thinking in Māori-medium settings should be explored and acted upon to ensure success for all students.

Furthermore, because we expected students to be able to access and complete these problems, it would be enlightening to explore the ways in which year 7–8 students approach more complex mathematics problems that encompass a broader range of ideas. This can only provide further insights into students' thinking and learning of mathematics in Māori medium and contribute to the paucity of the knowledge base in this area.

Hei Mihi

Hei kapi ake, ka haere tonu ngā mihi ki te iti me te rahi me ā rātou tautoko, mō tā rātou ūtanga mai ki te kaupapa. Mei kore rātou, e kore e pēnei rawa te puta o ngā māramatanga me ngā momo kōrero hei tautoko i te kaupapa nei. Mauri ora ki a tātou!

References

Ambrose, R., Baek, J., & Carpenter, T. (2003). Children's invention of multidigit multiplication and division algorithms. In A. Baroody and A. Dowker (Eds), *The development of arithmetic concepts and skills* (pp. 305–336). Mahwah, NJ: Lawrence Erlbaum.

Anghileri, J. (2006). *Teaching number sense.* London: Continuum.

Anthony, G., & Walshaw, M. (2007). *Effective pedagogy in mathematics/pāngarau: Best evidence synthesis iteration [BES].* Wellington: Ministry of Education.

Baek, J. (2006). Children's mathematical understanding and invented strategies for multidigit multiplication. *Teaching Children Mathematics, 12*(5), 242–247.

Barton, B. (2008). *The language of mathematics: Telling mathematical tales.* New York: Springer.

Beishuizen, M., & Anghileri, J. (1998). Which mental strategies in the early number curriculum? A comparison of British ideas and Dutch views. *British Educational Research Journal, 24*(5), 519–538.

Best, E., & Hongi, H. (2002). *Māori numeration.* Christchurch: Kiwi.

Caygill, R., & Kirkham, S. (2008). *Mathematics: Trends in year 5 mathematics achievement 1994 to 2006.* Ministry of Education. Retrieved on 21 January 2009 from: www.educationcounts.govt.nz/publications/series/2571/timss_200607/34160/34161/10

Christensen, I. (2002). *An evaluation of Te Poutama Tau 2002:* Exploring issues in mathematics education. Wellington: Ministry of Education.

Christensen, I. (2004). *An evaluation of Te Poutama Tau 2003:* Exploring issues in mathematics education. Wellington: Ministry of Education.

Crooks, T., & Flockton, L. (2006). *Assessment results for students in Māori-medium schools 2005.* National Education Monitoring Project, Report 38. Dunedin: University of Otago: Ministry of Education.

Dowker, A. (2005). *Individual differences in arithmetic: Implications for psychology, neuroscience and education.* Great Britain: Psychology Press.

Forbes, S. (2002). Measuring the equity of mathematics education outcomes. *The New Zealand Mathematics Magazine, 39*(1), 3–18.

Garden, R. (Ed.) (1997). *Mathematics and science in middle primary school: Results from New Zealand's participation in the Third International Mathematics and Science Study.* Wellington: Ministry of Education

Gilmore, C. K., & Bryant, P. (2008). Can students construct inverse relations in arithmetic? Evidence for individual differences in the development of conceptual understanding and computational skill. *British Journal of Developmental Psychology, 26*(3), 301–316.

Hāwera, N., & Taylor, M. (2008). Māori and mathematics: "Nā te mea he pai mō tō roro! (Because it's good for your brain!)." *Te Poutama Tau Evaluation Report 2007* (pp. 36–48). Wellington: Learning Media.

Hāwera, N., Taylor, M., Young-Loveridge, J., & Sharma, S. (2007). Who helps me learn mathematics, and how? Māori students' perspectives. In *Findings from the New Zealand Numeracy Development Projects 2006* (pp. 54–66). Wellington: Learning Media.

Ittigson, R. (2002). Helping students to become mathematically powerful. *Teaching Children Mathematics, 9*(2), 91–95.

Jordan, N. C., Hanich, L. B., & Uberti, H. Z. (2003). Mathematical thinking and learning difficulties. In A. Baroody and A. Dowker (Eds), *The development of arithmetic concepts and skills* (pp. 359–384). Mahwah, NJ: Lawrence Erlbaum.

Knight, G. (1994). Mathematics and Māori students : An example of cultural alienation? In J. Neyland (Ed.), *Mathematics education: A handbook for teachers: Volume 1* (pp. 284–290). Wellington: Wellington College of Education.

Lamon, S. J. (2007). Rational numbers and proportional reasoning: Towards a theoretical framework for research. In F. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 629–668). Charlotte, NC: Information Age.

Lawton, F. (2005). Number. In A. Hansen (Ed.), *Children's errors in mathematics: Understanding common misconceptions in primary schools* (pp. 22–75). Exeter: Learning Matters.

Ministry of Education (1992). *Mathematics in the New Zealand Curriculum.* Wellington: Ministry of Education.

Ministry of Education (1996). *Pāngarau i roto i Te Marautanga o Aotearoa.* Wellington: Ministry of Education.

Ministry of Education, (2006). *An overview of some key national year 5 and year 9 students' achievement results: Findings from the Trends in International Mathematics and Science Study (TIMMS) 2002–2003.* Wellington: Ministry of Education.

Ministry of Education, (2007). *The New Zealand Curriculum.* Wellington: Ministry of Education.

Ministry of Education, (2008). *Te Marautanga o Aotearoa.* Wellington: Ministry of Education.

Moschkovich, J. N. (2002). A situated and sociocultural perspective on bilingual mathematics learners. *Mathematical Thinking and Learning* [Special issue on diversity, equity, and mathematical learning]. *4*(2/3), 189–212.

Nunes, T., & Bryant, P. (1996). *Children doing mathematics.* Oxford: Blackwell.

Siemon, D. (2005). *Multiplicative thinking.* Retrieved on 30 March 2009 from: www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/ppmultithinking.pdf

Smith, G. H. (1991). *Reform and Māori educational crisis: A grand illusion.* Monograph 3, Research Unit for Māori Education. Auckland: University of Auckland.

Suggate, J., Davis, A., & Goulding, M. (2006). *Mathematical knowledge for primary teachers.* Abingdon, UK: David Fulton.

Thompson, I. (1999a). Getting your head around mental calculation. In I. Thompson (Ed.), *Issues in teaching numeracy in primary school* (pp. 145–156). Buckingham: Open University Press.

Thompson, I. (1999b). Mental calculation strategies for addition and subtraction: Part 1. *Mathematics in School,* 29(1), 24–26.

Watson, A. (2008). School mathematics as a special kind of mathematics. *For the Learning of Mathematics, 28*(3), 3–7.

Young-Loveridge, J. (2006). Patterns of performance and progress on the Numeracy Development Project: looking back from 2005. In *Findings from the New Zealand Numeracy Development Projects 2005* (pp. 6–21). Wellington: Learning Media.

Zevenbergen, R., Dole, S., & Wright, R. J. (2004). *Teaching Mathematics in Primary Schools.* Crows Nest, NSW: Allen & Unwin.