TEACHING & LEARNING
RESEARCH INITIATIVE
NĀU I WHATU TE KĀKAHU, HE TĀNIKO TAKU

PO Box 3237
Wellington, New Zealand
e-mail: tlri@nzcer.org.nz

Mathematics:
She'll be write!

Tamsin Meaney, Tony Trinick and Uenuku Fairhall

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Teaching & Learning Research Initiative
P O Box 3237
Wellington
New Zealand
www.tlri.org.nz

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1. Ways to improve mathematical writing

The second focus for this project was to explore the ways that students were supported to produce appropriate mathematical genres. This was an essential part of the project because:

> the teacher plays an important role in selecting writing tasks for students and in framing them in ways that attend to audience, purpose, and genre. The teacher also plays a role in responding to students' work, especially that of students who are struggling with written expression, in ways that support students in achieving greater clarity and more coherence. (Doerr & Chandler-Olcott, in press)

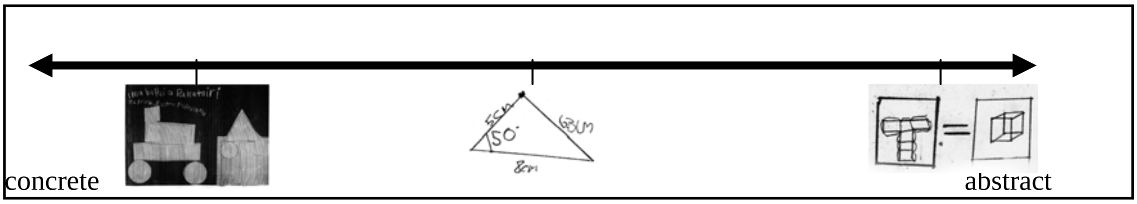
In considering research on writing in general, Ivanic (2004) suggested that "[t]he ways in which people talk about writing and learning to write, and the actions they take as learners, teachers and assessors, are instantiations of discourses of writing and learning to write" (p. 220). She went on to state that these discourses revolved around beliefs about language, writing, learning to write, approaches to the teaching of writing and approaches to the assessment of writing. Given this complexity in approaches to writing, it is not surprising that it is not always clear to teachers what they themselves do to support writing and what other ways could be utilised that could be more effective.

In investigating students' writing about mathematics, Morgan (1998) felt that there was a general lack of knowledge about language and language teaching. Consequently, she was unsure that students could adequately express themselves mathematically. This is supported by research by Bicknell (1999) in which New Zealand secondary teachers voiced their belief that the process of writing explanations and justifications should be explicitly taught to students.

In mathematical learning experiences, manipulating objects has been seen as a valuable way for students to gain understanding of mathematical concepts. This can also be related to research in art education. Pelland (1982) found that students who were able to handle an object (half an artichoke) were deemed by professional artists to produce better drawings than those students who were only able to look at an object.

Writing is often introduced to record experiences about the manipulation of ideas (see Burns, 2005) and in so doing supports the development of the ideas from the concrete to the abstract. Figure 26 suggests a development of the ideas about shapes that move from illustrating where shapes can be found in the environment to using diagrams to show the relationship between a net and its solid. The drawing of the triangle with its measurements may have been copied from using a concrete triangle, but was more likely to be constructed using written instructions. At every stage, the markings on the paper form an iconic representation that has some semblance of the actual object they are representing (Roth, 2001). However, as the ideas about shapes develop, the immediate relationship to a concrete item in front of a student becomes less important. This movement can be considered as another way of moving children from everyday language to official mathematics language (Herbel-Eisenmann, 2002).

Figure 1 **Representations of shapes where the relationship to concrete materials becomes less obvious**



As the forms of writing progress, the marks on the paper become more abstract and the relationship to actual manipulation of concrete objects less transparent. The final form in these progressions means that students are able to manipulate abstract concepts without the need for concrete materials at all.

One of the activities used in the kura that supported the movement from concrete to abstract symbolism was *kanikani pāngarau* (mathematical dancing) (Figure 27). This activity was taken from the New Zealand television programme, Toro Pikopiko E!, and initiated by T4. In this activity students learnt a series of movements for each of the numbers from 0 to 10. They also learn symbols for the four operations (+, –, x and ÷). Students were given problems through movement by the teacher or a student and asked to provided an answer also using movements. As students became better at this, they were asked to write the problem and solution before giving their physical response.

Figure 2 **Kanikani pāngarau**

We identified a number of teaching strategies that were used by teachers to increase the quantity and quality of students' mathematical writing. This was done through analysing videos of teachers' lessons as well as discussing with teachers what they had done. The data, therefore, included videos, interviews, meeting notes, students' writing samples and photos from classrooms. Our results are not only useful to the teachers at this kura but could also be valuable to teachers at other kura as well as in mainstream schools anywhere in the world.

Our analysis has shown that it is impossible to separate writing from speaking, reading and listening. In our last project, the teachers had been most supportive of strategies that "encourage students to move between modes of expression such as speaking to writing" (Fairhall, Trinick, & Meaney, 2007, **page ref**). More often than not, the teachers used and expected the students to use all four language skills. Sometimes writing was used to support speaking, while at other times speaking and listening were used to support writing. At the meeting in August 2006, this relationship was described in this way:

1. you [the teacher] are talking, thinking, and writing
2. children are talking and thinking and you are writing
3. children use written language to present information.

The students were engaged in a mathematical activity while they were learning to use all four forms of communication fluently. Depending on the context and the amount of support that is provided to the students, the language activity could fit into any of the four stages of the mathematics register acquisition model (MRA). The following sections discuss the strategies according to the MRA model as well as "acts of writing". Whereas the MRA model describes the strategies teachers use to support students acquiring mathematical writing, *acts of writing* refers to different types of writing processes that students had to integrate.

The mathematics register acquisition model

We analysed the teaching strategies by considering them in regard to the MRA model (Meaney, 2006b). This model was used in the previous TLRI project to identify the strategies that teachers were using to support mathematical register acquisition (Fairhall et al., 2007). It divides the acquisition of mathematical language, including written genres, into four stages, from Noticing to Output. These stages are shown in Table 6.

Table 1 **Mathematics acquisition model**

TAUMATA	WHAKAMĀRAMATANGA	
KITENGA NOTICING	Ka kitekite i ngā kupu me ngā kīanga hōu me ako. Ka kitekite i ngā wā e kōrerotia ai. Taka huirangi ai te kōrero i ngā kupu me ngā kīanga hōu.	Students have to notice that there is new language to be learnt and when it is used by others. With prompting by others, students will use the new terms and expressions.
AKORANGA INTAKE	Ka kōrero i ngā kupu me ngā kīanga hōu i ngā āhuatanga rerekē kia akoako pai ai i ngā momo wā me kōrero.	Students start using the terms in a variety of situations. Feedback, both positive and negative, helps them to refine their understanding of when and how to use the terms and expressions.
TAUNGA INTEGRATION	Ka rite te kōrero i ngā kupu me ngā kīanga hōu.	Students will use these terms consistently except when the situation is challenging and they may revert back to simpler terms.
PUTANGA OUTPUT	He wāhanga pūmau ngā kupu me ngā kīanga o te reo tātaitai o te ākonga, ā, ka kōrerotia i ngā wā e tika ana.	Students are using the terms fluently even in the most demanding situations.

The four stages of the MRA model involve the teacher in gradually loosening control of the "what" and "how" in students' use of mathematical language. In the initial stages, the teachers very much restrict students' options in regard to terms and grammatical expressions as well the situations in which they are used. On the other hand, the final two stages provide students with increasing control over when and how they discuss their mathematical ideas. These stages have similarities with the three stages of the model for gradual release of responsibility that Doerr and Chandler-Olcott (in press) described for supporting students to become mathematical writers.

The 2005–6 TLRI project found that teaching strategies from each of the MRA stages were present in most lessons, although there did seem to be a relationship to the teaching of the mathematical concept. When a new topic was being introduced, teachers were more likely to use strategies related to the earlier stages of the model. At the end of a unit of work, teachers were more likely to use strategies from the last two stages of the model. Teachers used a range of strategies at each of these stages. Although all seemed to be useful to some degree in supporting students' acquisition of the mathematics register, the teachers valued those that moved students towards being more reflective about their learning.

Acts of writing

In describing the strategies from the four stages, there is also a need to consider the acts of writing that the teachers engage students in. These are the processes that make up writing. We have labelled these acts of writing as physical, superficial and deep.

Walshe, March, and Jenson (1986) describe four parts to the physical act of writing that they felt supported the writing process. These were:

> Handling—the physical manipulation of pen or pencil on a page; the computer keyboard and use of the mouse
>
> Depicting—handwriting, spelling, punctuation
>
> Scrutinising—the constant reading back before writing on
>
> Restating—the so-called 'shaping at the point of utterance', which is really our earliest form of editing, the editing of inner speech. (p. 165)

Apart from these physical acts, Winch et al. (2004) also identified part of the writing process that was to do with revision, as a consequence of reflecting on a draft and then refining it. They stated that:

> A sensitive teacher can lift the quality of thinking to higher levels during a writing activity through emphasising quality preparation and, once a draft is achieved, the limitless potential for pondering, cutting, extending, putting aside, returning, revising again, and so on until it is right. (p. 172)

However, our separation of the acts of writing was different. The actual physical control of writing implements and learning of the conventional mathematical terms and expressions were considered to be different from the editing and revision stages. The initial editing stage of checking the equivalent of spelling and punctuation in mathematics, such as learning more efficient ways of setting out working, was labelled as superficial acts of writing. This was not to suggest that they were unimportant, but rather to suggest that they did not lead to a revision of the thinking process that deeper acts of writing were able to do. Our final acts of writing were these deeper revision processes that contributed not just to improving students' pieces of writing but actually to their thinking mathematically. For this to happen, Winch et al. (2004) stated that "time and opportunity are given to write without undue constraint" (p.171).

Physical acts of writing

These are the acts that reproduce conventional mathematical diagrams, symbols and so on. In the database there are countless examples of students who reversed numbers so that 3 was written backwards and 18 became 81. There were also other instances of students struggling to replicate conventional mathematical writing. For example, Figure 28 shows a student's drawing of a square pyramid shape that accompanied a given diagram of a net.

Figure 3 **Student drawing of a square pyramid**

The diagram is not drawn conventionally as the middle edge is not lower than the two side edges. In looking at different ways a cube can be represented, Kress and van Leeuwen (2006) showed how different representations are all equally valid. However, they provide different information about both the object and how the drawer perceives the object. The conventional drawing of 3D shapes rarely shows what the drawer sees but rather shows what the drawer knows about the shape. The lack of perspective in Figure 28 has meant that it is difficult to know whether the diagram is supposed to be that of square pyramid or that of a tetrahedron, thus making the meaning the diagram is trying to convey difficult to interpret. Therefore, in mathematics, the ability to reproduce conventional mathematics is necessary if it is important that others are able to gain a specific intended meaning.

For students to be able to use writing in mathematics to support their thinking, then, it is valuable for them to have automated as far as possible the physical acts of mathematical writing. Cognitive approaches to writing have suggested that:

> If young writers have to devote large amounts of working memory to the control of lower-level processes such as handwriting, they may have little working memory capacity left for higher-level processes such as the generation of ideas, vocabulary selection, monitoring the progress of mental plans and revising text against these plans. (Medwell & Wray, 2007, p. 12)

Learning how to replicate the conventional mathematical writing modes would come into the whakaahua genre lessons. Teachers did spend time providing students with activities that helped them recognise the essential features of the mathematical writing they were reproducing. For example, in the September staff meeting, T8 related how she and T1 and T3 had taught the students a series of sentence structures for mathematics. They all concentrated on these sentence structures for three weeks and the children were still using them in class. T1 shared resources with T8 and T8’s students were “blown away” that someone else in the kura was doing the same topic. T8 believed that the students often thought they were the only ones having to learn a particular mathematical topic.

Superficial acts of writing

Another act of writing that teachers provided lessons on was how to clarify meaning through editing. Sometimes students could reproduce the conventional mathematical writing but its meaning was not always easily interpretable because they failed to structure their writing clearly. For example, T2 in the November staff meeting stated:

T2: The rest of Year 8/9, actually I don't know if you've noticed it too . . . when kids think they have the right tau mahi (level of work) that's what they do for [their lessons in] te reo writing, [but in their mathematical] writing they've omitted all grammatical things like full stops and capital letters and everything is just a word drrrrrrrrrr like this to explain what they mean . . . To put it on paper, everything, you might as well kiss all te reo grammar out of it because that is what they will show. Very erratic. And yet, there was something in there that was meaningful so I suppose what I'm saying is, is . . .

T9: Is it our job to fix it up?

T2: Is it our job to fix it up when it comes to something that uses common sense, you know.

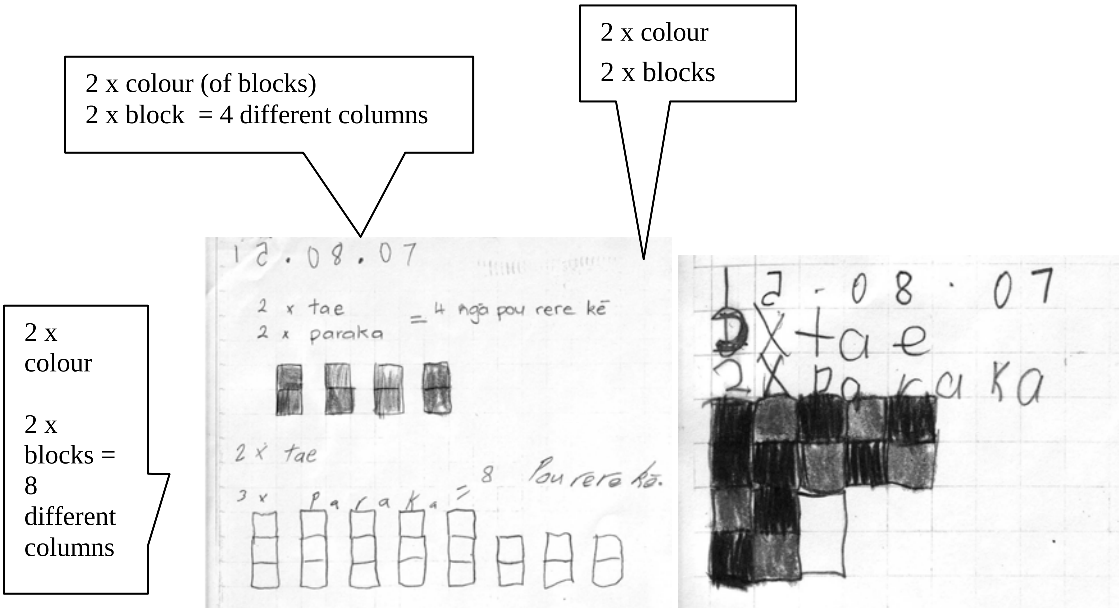
T9: Definitely, we have no choice, we are a language school. We have no choice. If you are a language school you have got to expect that language is the vehicle, or the barrier, even stronger than it would be in a first-language school.

This had meant that the teachers not only had to teach the basic conventional mathematical writing but must also help the students improve the clarity of what they had written. This can be seen from Tau 2's session on the problem of how many combinations of blocks of different colours could be made. Figure 29 shows different children working on this problem.

Figure 4 **Children using blocks to find combinations**

A systematic recording of their results was necessary for working out the answer. Figure 30 shows two examples of the recording of the different combinations. In the first one, the initial part of the recording is in the teacher's handwriting indicating that they showed the student how to set out their results. The second example is in the child's handwriting but follows the teacher's example.

Figure 5 **DPIAtL3a and DPIPaL3a**



Although the children had the skills already to draw the blocks and to use the words and symbols to describe the combinations, the teacher's intervention was needed to help them structure their recordings systematically. Students needed explicit instruction on how to reorder what they had previously produced.

Teacher support for these acts of writing occurred in regard to the teaching of all three genres. Superficial acts of writing are important as they focus on how to organise information in conventional ways that can lead towards deeper thinking processes.

Deep acts of writing

These acts of writing concentrate on improving writing by focusing on the planning, drafting, revising and polishing stages of the composing process (Ivanic, 2004). One of the approaches that had begun to be used in the kura during the project was an adaptation of an idea used in Helen Doerr's project in the United States. At the New Zealand Mathematics Teachers Association (NZMTA) conference in September 2007, Helen had been one of the keynote speakers whom many of the teachers had heard. She mentioned the RAVE strategy that one of the teachers in her study had picked up during a language arts course and that the other teachers in the project had found valuable. RAVE was a mnemonic that stood for: Rewrite the question; Answer the question; use mathematics Vocabulary; and provide Examples. The teachers did not ever talk about using this mnemonic with their students but about developing their own one which reflected their needs and the language used at the kura. Many of the teachers at the kura felt that this was an approach to try. The following extract comes from the November staff meeting:

T7: I have been trying that RAVE.

TM: How did it go?

T7: It’s been going fine. I found . . . finally getting them to restate the question in a different way was a couple of lessons at least. To answer it as well, rather than just saying yes or no. And then to justify their answer and to attach an example onto that as well of what they actually did, if they were going to do some mihi hanga whatever. Getting them to answer the question, what they exactly did and why did they believe that the answer, to the question, they have given is right. Then they draw their tauira for me as well within the answer . . . And now they all have to stand up and give their answer.

TM: So they are orally presenting it? And then do they write?

T7: No, they are orally presenting their writing because if there are questionable answers that are produced and they’ve obviously heard everyone else’s, then they go maybe, maybe I have to redo mine. Plus I don’t mind telling them that’s not quite right, start again . . . I didn’t actually go to the hui, it was just a chance meeting with [T10].

. . .

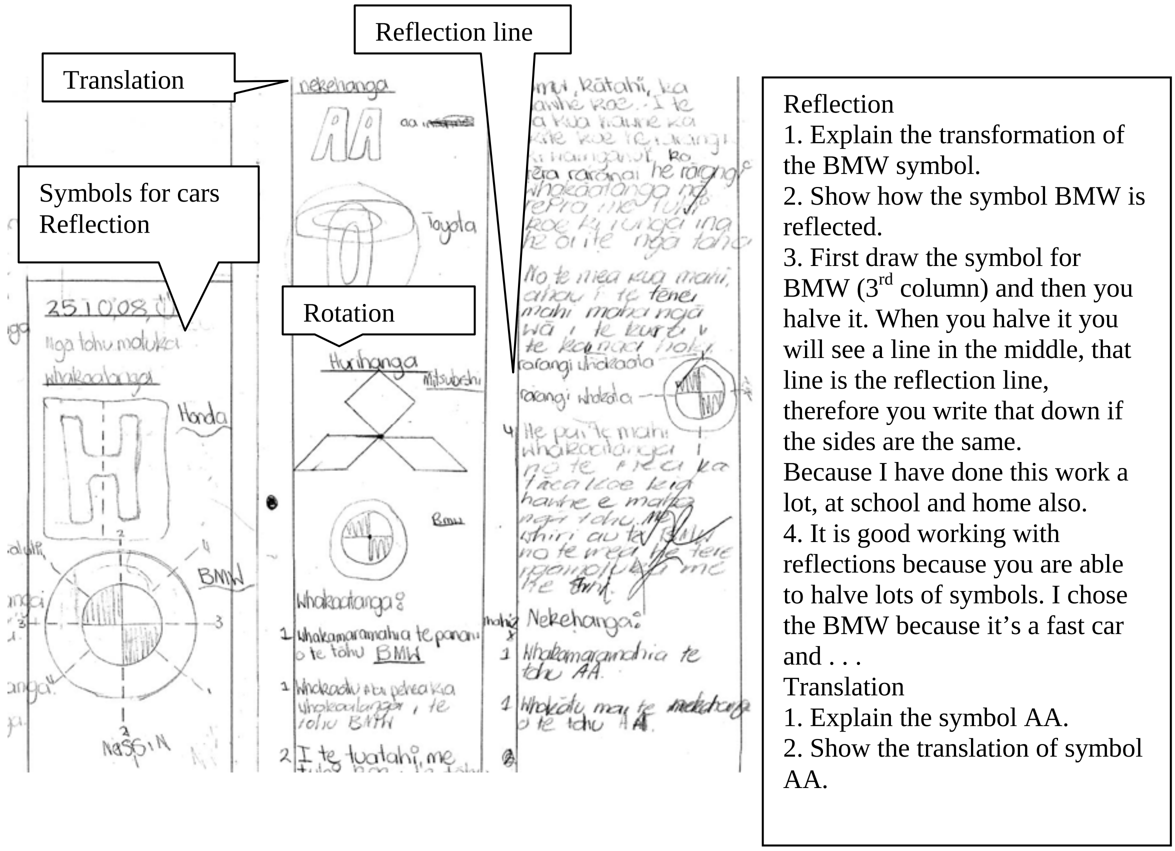
T7: What I found interesting was that I had tried to tell the kids that mathematics is not just a series of numbers, it involves writing. We are fortunate enough that we are doing āhuahanga at the moment. I would like to try a times-table equation and see if they can give me that same sort of format answer to explain how they got their answer. We try to say to them that as they get further up towards where T9 is, you’ll notice that you do more explaining, more and more writing, so you need to justify your answer even if it is wrong, but you don’t know that. You justify as far as you can then the teacher will tell you what parts are wrong, once you’ve justified it pretty well. How you got to where you are, explaining what actual process they took. Because we looked at car logos in the car park, so they looked at the Mitsubishi and when they looked at it, straight away they thought the whole star series was what they were transforming but when they had to re-look at it again and it was only one diamond that had been rotated three times, in a third of a circle so the writing about it they realised oh, yeah, you’re right. I’m not turning the whole star I am turning just one diamond around.

TM: So it was the process of writing that forced their thinking?

T7: Some of them got it wrong but they justified their answer. How come they ended up with it. Then at the end we added another bit where they look at it and say what they thought of it. I thought why not have a go and see how it ends up. Have a dive in and have a look. I was noticing if I asked them how they got their answer, the answer had been I just know, I just did it and it came out like this. Now they justify everything they’ve done, explain to me where they put the rawini tamariki (?)

Using the RAVE approach was seen by the teachers as something that could help students elaborate on their responses so that it got them thinking about the components that contributed to a quality response. There is more discussion about RAVE in Chapter 8. Figure 31 provides one student's response to writing about the transformations that could be seen in the car logos.

Figure 6 **JCUn**



Integrating writing with genres and MRA model stages

The acts of writing are about the process of actually putting something on a page, while the MRA model considers the strategies the teachers used to support students acquiring mathematical writing. The next sections on the four stages of the MRA model explain these strategies more explicitly. However, Table 7 presents how acts of writing, genres and the MRA model can be integrated.

Table 2 **Integration of acts of writing, genres and the stages of the MRA model**

Genres	Whakaahua	Whakaahua, Whakamārama, Parahau	Whakamārama, Parahau
Acts of writing / MRA stage	Physical	Superficial	Deep
Kitenga	↓	↓	↓
Akoranga	↓	↓	↓
Taunga	↓	↓	↓
Putanga	↓	↓	↓

The relationship to genre is that learning how to physically produce mathematical writing conventions only occurs when learning to write whakaahua. Learning about the superficial aspects of writing occurs when learning about any of the three genres, while the deeper aspects of writing are learnt when learning to write whakamārama and parahau. The following sections outline the strategies teachers used to support students acquiring mathematical writing.

Kitenga

The kitenga stage is when the teachers introduce new terms or expressions or add extra meanings to ones that students are already familiar with. The function of this stage is to make students aware of new aspects of the mathematics register, whether these are new layers of meaning for already known terms or previously unheard terms or expressions. This stage is characterised by the teacher doing almost all of the cognitive work. They engineer the activity so that the new terms are needed. They ensure that the words are used frequently, mostly by themselves, but also by the students. At this level, students themselves rarely do any writing. If they do write, it is of a very limited kind that reinforces the physical aspects of the writing.

Modelling

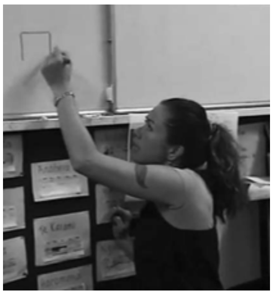
At the kitenga stage, teachers model writing. As was the case in Doerr and Chandler-Olcott's (in press) research, "students needed to have models of good writing before they could be expected to write such responses independently". Our research showed that there were several different types of modelling done by teachers. These were: the writing of words, symbols or diagrams as a part of a focused discussion; the modelling by the teacher of the mode of writing that students would do as part of participating in an activity; and the modelling of an extended piece of writing that students would be then expected to copy into their books.

The first kind of modelling can be seen in Figure 32. As part of a teacher-controlled discussion, the teacher would emphasise words, symbols or diagrams by writing them on the board. The following is an extract from the video where the square is drawn on the board.

Figure 7 **Writing as part of the discussion in the lesson**

I kī koe i mua he tapawhā rite. He aha te tikanga o tērā? He pai nga ingoa Māori no te mea ka whakamārama i te āhua i roto i te ingoa, nē? He tapawhā rite. He aha te tikanga o te rite (draws shape on board)? He ōrite te aha? He rite nga taha. Mehemea ka whakamahia au taku ruri . . . he rite ia taha? Na reira he tapawhā . . . . He tapawhā . . . he tapawhā ōrite, na te mea he ōrite nga taha.

Before you said it was a square. What does that mean? Māori names are good because the shape is explained in the name, isn't it? A square. What is the meaning of equal (the same) (draws shape on board)? What is the same? The sides are the same. If I use my ruler are the sides the same? Therefore it's a four side . . . four side . . . It's a square, because the sides are the same.

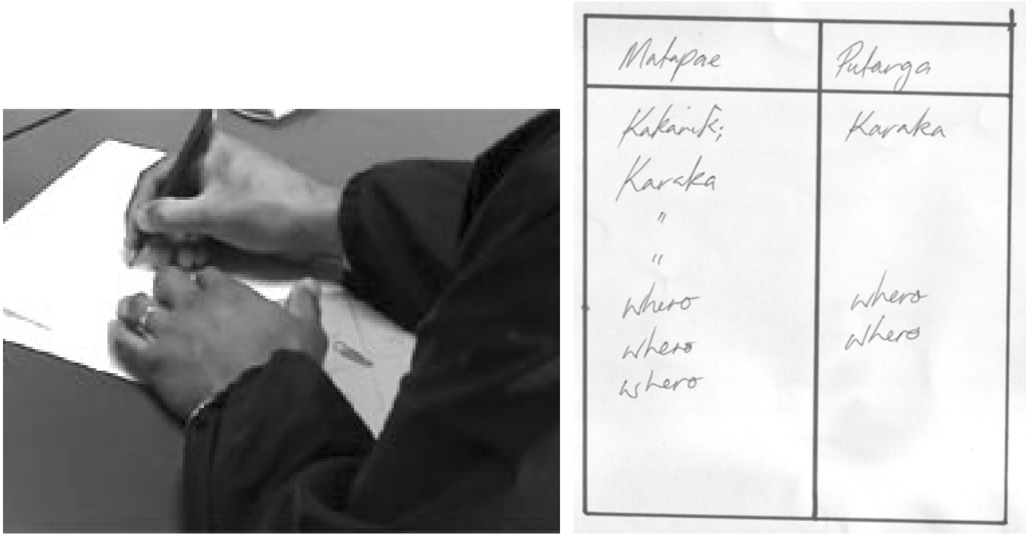


In this example, the teacher draws the shape on the board as part of a discussion about the features of a *tapawhā rite* (square). The students were sitting with the teacher in front of the board and had a worksheet on which they are colouring in different shapes. In order to do this, they needed to identify the different features of each shape. This worksheet can be seen in Figure 33. By drawing the square on the board, the teacher was able to channel the students into being able to describe and recognise the features of the square.

Figure 8 **Student worksheet to accompany T1's lesson**

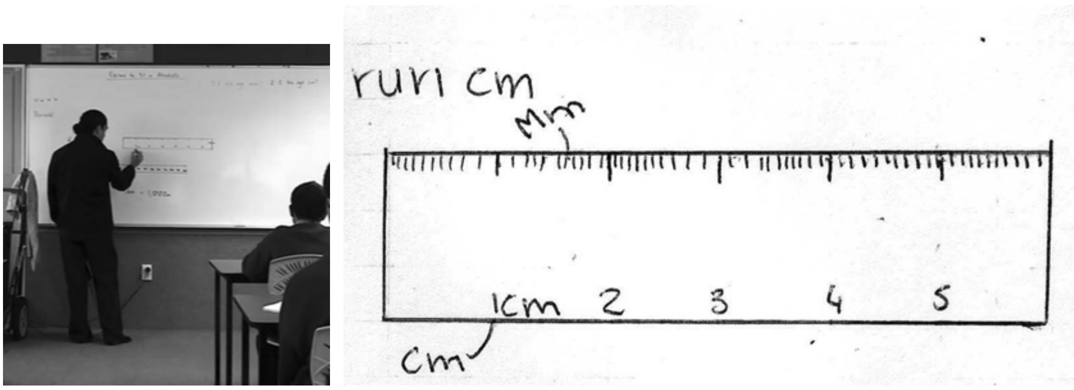
Teachers also modelled how they expected students to record information while doing an activity. Figure 34 shows a teacher setting out how to show the results from using a spinner. Students were not expected to copy these but were expected to produce their own tables. This part of the lesson belonged to the kitenga stage because it highlighted for students the features of a table. When the students use the tables themselves, in the next part of the lesson, they most likely would be operating at the integration stage. The teacher's example would be there to remind them of how they should set out the information. However, the fluency students showed in producing their own table and the amount of intervention provided by the teacher would determine the stage the student was actually working at.

Figure 9 **Teacher doing and recording**



Another example of modelling is when the teacher writes something on the board that is then copied by students into their workbooks. Often these were extended pieces of writing. Figure 35 provides an example of a short piece of writing. These pieces of writing then become examples for students to use if they need to draw a similar example themselves. They also provide a model for explicitness in mathematical writing if the teacher expected students to refer to these pieces of writing later on.

Figure 10 **Teacher writing on the board which is then copied into students' books**



In the November staff meeting, the teacher from Tau 2 described students' modelling books. In these books, students, or the teacher, would write the learning intention for the day. The learning intention set out what it was that students were expected to learn. When they had completed the day's worksheet, students would paste it under the learning intention. Students would then be able to refer back to this at a later stage. The focus for why students were doing the writing, then, is linked explicitly to the examples of the writing.

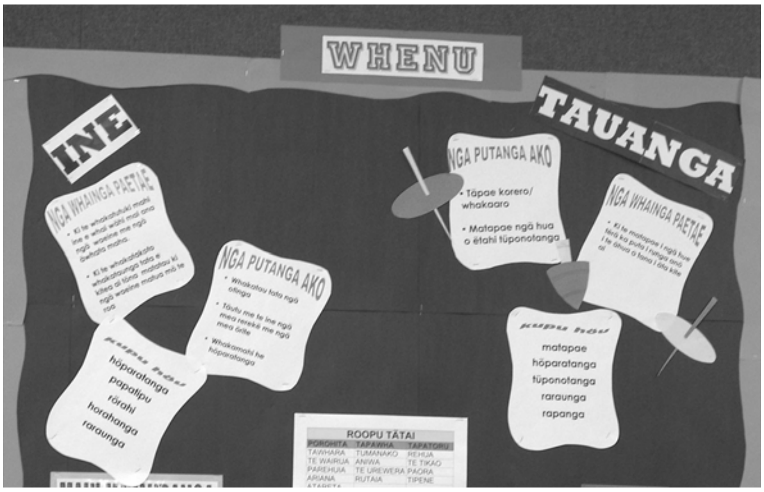
Providing examples of new writing

As well as modelling pieces of writing that students would be expected to master themselves in due course, teachers also started lessons by highlighting new material. In the following extract, T3 has *āhuahanga* (geometry) written on cardboard. She then had the children in her Tau 1 class read it with her. She finished by drawing different shapes that fitted into the category of āhuahanga and having the children name them.

T3:	Na reira Kua mutu kë tënä mahi inäianei. Ko tö matou mahi i tënei rä, kua timata he kaupapa hou—ko te ähuahanga. Koutou katoa . . .	T3: Now, this is finished now. Our work this day is something new—it is geometry. All of you . . .
Katoa:	Ähuahanga	All students: Geometry
T3:	Ähuahanga	T3: Geometry
Katoa:	Ähuahanga	All students: Geometry
T3:	Äe. Anei te kupu. Korero mai.	T3: Yes, here is the word, say it.
Katoa:	Ähuahanga	All students: Geometry
T3:	Ähuahanga. Anei ngä Ähuahanga. Titiro. Ko te kupu ähuahanga e pä ana ki enei mea (kei te tuhi i runga i te papatuhituhi)	T3: Geometry, here is some geometry. Look. The word "geometry" that relates to these things (draws on board)
Katoa:	Tapatoru—tapaono	All students: 3 sided—six sided
T3:	Ko enei ngä aha?	T3: What are these?
Tamariki:	Porohita—taimana	Students: Circles—diamonds

Teachers also highlighted new words that students were expected to use in their own writing by displaying them on the walls. Figure 36 shows an example of one of these walls. The words and expressions were referred to during the lessons.

Figure 11 **Wall showing *ine* (measurement) and *tauanga* (probability) words**



Kinaesthetic activities

As an introduction to the diagrams or symbols needed for writing, some teachers involved the students in physical activities to highlight features. Kanikani pāngarau described in the first section of this chapter was one example of this. Figure 37 shows a teacher with her students engaged in another activity around drawing shapes.

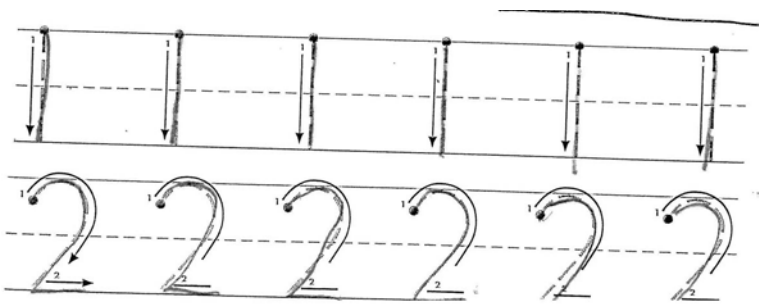
Figure 12 **Making shapes with the body**

In this lesson the teacher had previously had students manipulate concrete examples of the different shapes. Physical activities of making the shapes is one stage away from this manipulation, but students are not yet drawing anything on paper. This would be the next stage.

Restricted writing activities

At the kitenga stage, the only independent writing that students are engaged in is of a very restricted kind. Figure 38 provides an example of a student tracing numerals so that they are formed correctly. The tracing with arrows to show direction means that students will be able to draw the numerals conventionally. This activity is done up to Tau 2 because many students may still be reversing some numerals at this year level.

Figure 13 **DSWNKaL1a**



The activities in this stage of the MRA model were often concerned with the physical acts of writing as they were about ensuring that students are able to physically manipulate the writing objects as well as correctly produce conventional mathematical objects. However, modelling activities could also be about modelling both superficial and deeper acts of writing.

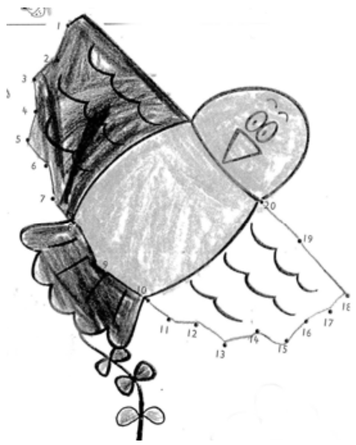
Akoranga

By this stage, some of the cognitive load has shifted to the students. They now need to give definitions and examples, rather than just being expected to notice and interpret those provided by the teacher. Nevertheless, the teacher is still very much in control and students' contributions are usually short, thus providing them with little opportunity to provide inappropriate responses. The function of the akoranga stage is for students to form understandings of when and how new aspects of te reo tātaitai are to be used.

Worksheets

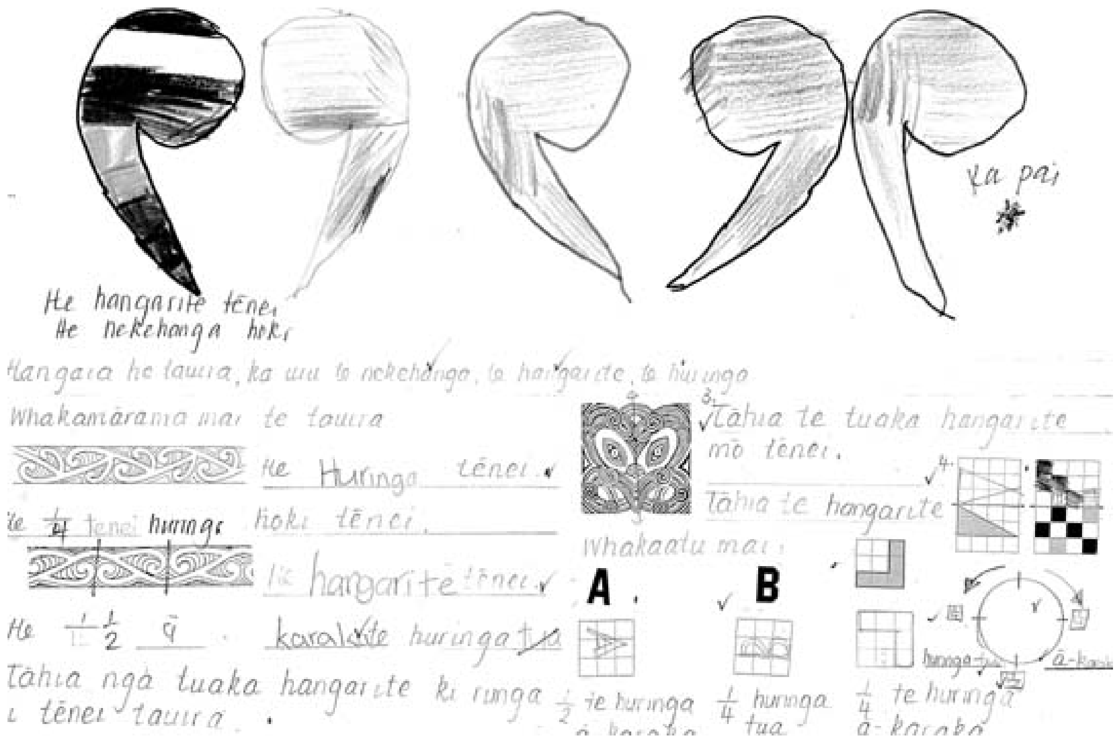
One way of ensuring that students were channelled into using correct mathematical writing structures was by providing them with worksheets where they had only limited ways to respond. These worksheets provided students with more opportunities to make mistakes than those in the kitenga stage. Figure 39 shows an example of a worksheet where a student could get the pattern incorrect but it is unlikely that this would occur. It may be that such a worksheet belongs to the kitenga stage. It is unclear whether such an activity would actually support students to learn about the sequential order of numbers.

Figure 14 **DWNTaL3a**



On the other hand, Figure 40 shows a worksheet that is mostly the teacher’s writing, but with spaces for the students to add in words or diagrams. The teacher has also written comments after the sheet was completed. In contrast to Figure 39, this worksheet provides opportunities for the students to show their understanding.

Figure 15 **DGTrCArL3**

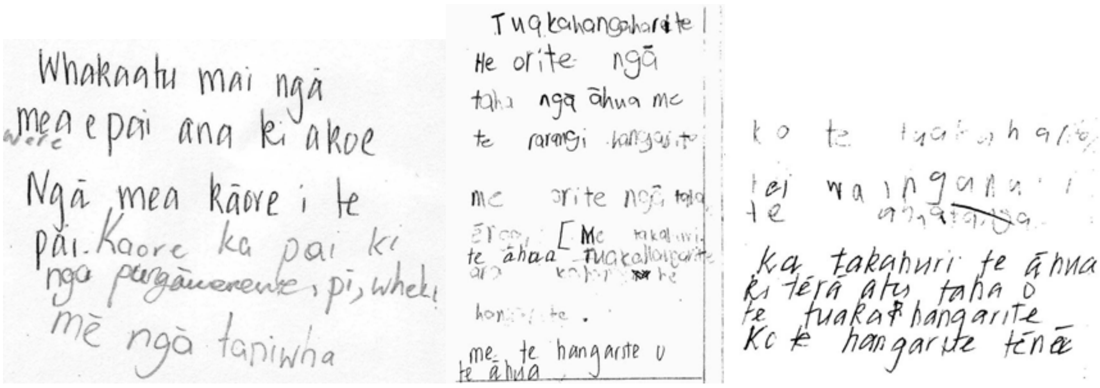


Using students' own words as a starting point for writing

Students contributed to the writing process by providing words either orally or by writing them. At the September staff meeting, T8 related how she transcribed some students' contributions because they were too slow to write their ideas down and this impeded what else had to be done during that lesson. At the beginning of the next lesson, T8 asked them about their ideas from the previous lesson, whether they still agreed with them, and if they wanted to add anything to them. She found that doing the writing for these students meant that their ideas were valued. If they had to write it down they rarely got anything else done in the lesson. Having something written down meant that it was not just those students who could write whose ideas were appreciated.

T1 used various strategies around using the students' own writing. In the first example in Figure 41, she began the student's writing and then had them complete it with a sentence. In the second example, T1 had corrected the student's narrative, and in the third example she had the student interpret what he had wanted to write and then rewrote it for him. The range of strategies employed that used the student's own writing suggests that the teacher was actively monitoring students' work while they were doing this writing.

Figure 16 **DNAkL4 (left), DNHiL4 (middle) and DNTiL4 (right)**



Show the things that you like, the things you do not like. Spiders are not nice, bees, octopus and monsters.	Mirror line The sides, the shape and the mirror line are the same. Let the sides be the same but turn the shape. The shape is symmetrical.	The mirror line is between the shape. If you turn the shape to the other side of the mirror line that is symmetrical.

The akoranga stage mostly had students involved in superficial acts of writing. However, the strategies, such as the one of working with students to improve their writing, could also support students by being used to move students into doing deeper acts of writing.

Taunga

By the taunga stage, students have a good understanding of the new aspects of te reo tātaitai. The function of this stage is to have students use these new aspects but in a situation where the teacher is able to step in and provide support if necessary. Consequently, the teacher’s role has become one of reminding students of what they know and can do. The students are the ones who have the major responsibility for making use of the new language. If the student seems unable to operate at this level, the teacher is quickly able to supply more support, thus recognising that the student is still at the akoranga stage. If students do not need the teacher’s help then they would be operating at the putanga stage.

Correcting students’ writing

A very common strategy at this level is for teachers to collect in students’ work and check it for accuracy. Figure 42 shows an example of a piece of writing that has been checked by the teacher.

Figure 17 **Students’ work that has been checked for correctness by the teacher**

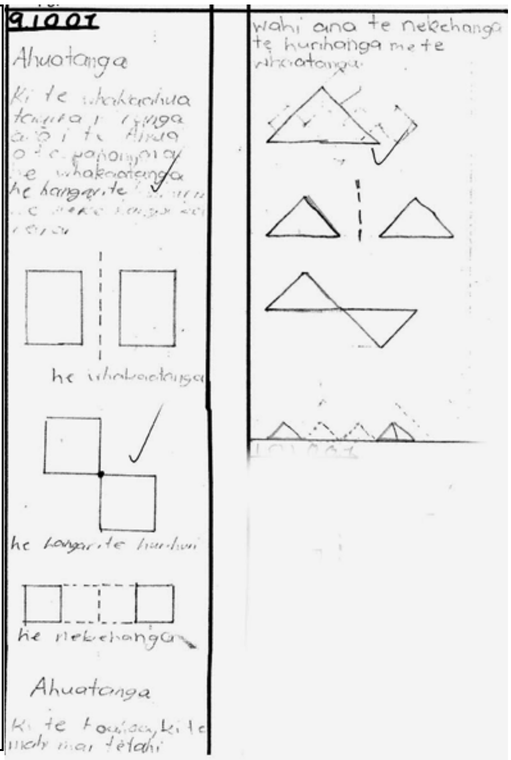
9.10.07
Geometry
To describe patterns according to transformations, it’s a reflection, its symmetrical

A reflection

Rotational symmetry

Translation

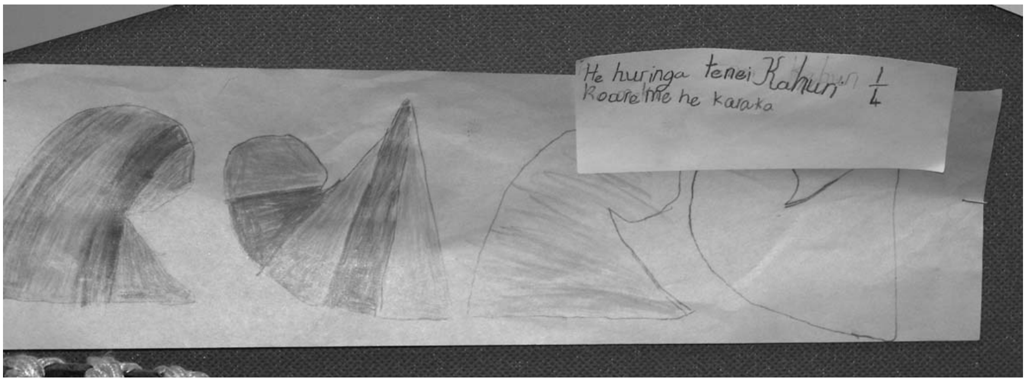
Geometry



A place again the translation, rotation and reflection.

Sometimes, the students would write an initial draft and then check it, often by asking the teacher. In the junior grades this tended to be at a superficial rather than a deep act of writing. Once this had been done then a final version would be produced. Figure 43 shows an example of a sentence about rotation that has been written to accompany a set of diagrams. In Doerr and Chandler-Olcott’s (in press) research, the middle school teachers they had worked with had found that “the editing of student work began to yield improvements in the quality of students’ written responses”. This editing was done in a number of ways. Sometimes it was done in a whole-class situation where a sample piece of work was used. At other times students did the editing by themselves or occasionally with peers.

Figure 18 **DGTrUnL5**



In Figure 43, an earlier version of the sentence can be seen faintly underneath the final sentence. This is most obvious in the writing of *kahuri*. Writing that is displayed, such as this piece, often shows students’ growing fluency with new aspects of te reo tātaitai and, therefore, will come from the taunga stage. The teacher will closely supervise the work to ensure that students do produce an appropriate response for public display. However, the amount of support the teacher provides will depend on the students’ levels of fluency.

Public displays were not just flat posters, as Figure 44 shows.

Figure 19 **Classroom display of 3D-shape posters**

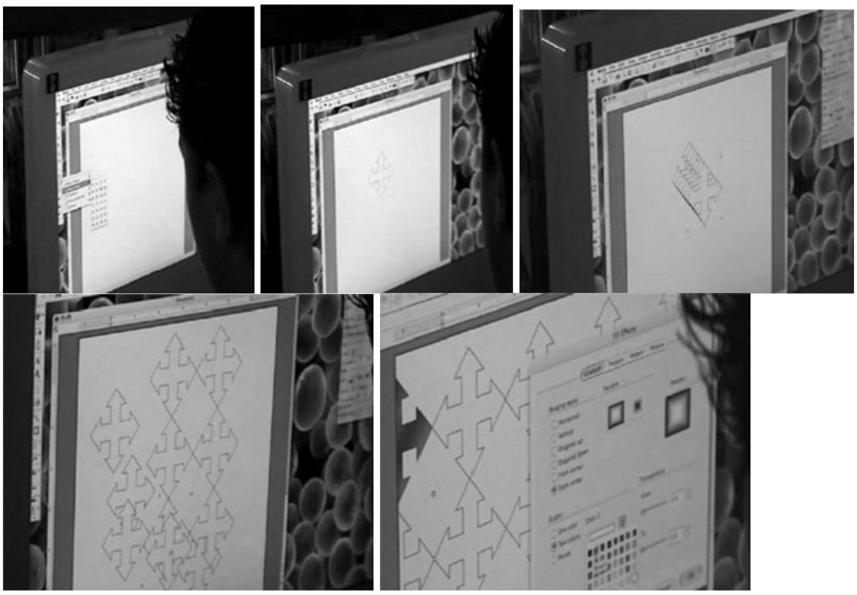
The problem with fragile displays such as those shown in Figure 44 is that they become damaged very easily. However, the folding of the 3D shapes would have given students immediate feedback about the appropriateness of the shapes. This takes the pressure off the teacher as always being the arbitrator of what is appropriate or correct. This, therefore, supports the students as having the responsibility for determining the accuracy or appropriateness of their own work.

Writing using computers

Another strategy one teacher used that provided students with immediate feedback was having students use MSWord drawing functions to produce tessellating patterns. Halliday (2007) described literacy as “a technological construct; it means using the current technology of writing to participate in social processes, including the new social processes that it brings into being” (p. 113). The use of computer technology to alleviate some of the demands of writing has been available in mathematics classrooms for some time. Winch et al. (2004) suggested that students find revision of narrative pieces of writing much easier if they can use word processing programs. It may be that students find being able to use computers to replace the tediousness of some parts of mathematics, such as tessellating patterns and drawing graphs, an incentive to engage with these topics. Brown, Jones, Taylor, and Hirst (2004) found that students were more able to engage with a problem about the diagonal properties of quadrilaterals using Geometers Sketch Pad whereas some had not been able to do so using a pencil and paper technique. However, the videoed lessons only showed one example of technology being used in this way and this was from a series of T2’s lessons.

Figure 45 shows the development of a pattern using a translated shape. Others in the class rotated their shapes to form their patterns. The software allows a very quick development of a complicated pattern that would have taken many hours to have drawn by hand.

Figure 20 **Stages in developing a tessellating pattern using translation**



The first picture shows the student choosing a shape. The next activity is to draw the original shape, copy it and then paste several examples onto the screen. The student slides (translates) the copies around the page to form a pattern. The final picture shows the student choosing colours to shade the shapes in the pattern.

Writing in public places

When students did mathematical writing on playgrounds or on whiteboards they were also displaying their fluency, but not in the same way as the static posters put up around the room, of which Figures 43 and 44 are examples. Public writing was done quickly and was only available for immediate scrutiny and discussion. If students had produced something that was not correct, then there were opportunities to discuss why this was the case. There were also opportunities to discuss well-presented pieces of work. The discussion had to be immediate as the work would be removed at the end of the lesson, if not earlier. These activities were part of the taunga stage because they allowed for instant feedback.

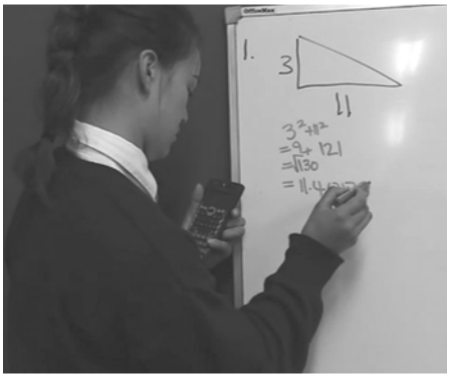
One of the junior classes used large pieces of chalk to draw 2D shapes on the concrete. This can be seen in Figure 46. There was a strong link to oral language in these activities where the students' recording was just part of developing the students' understanding of shapes. The teacher gave a description of the shape, and students had to draw it and jump into it when they had finished. This was followed by some students taking on the task of describing the shapes.

Figure 21 **Drawing shapes on concrete**

This activity had students concentrating on the features of shapes. It resembles those suggested by Juraschek (1990) for supporting students to move from van Hiele's visualisation level where students are only aware of global features to analysis level where students are aware of specific features.

At the other end of the kura, students were regularly expected to present their ideas on the whiteboard. This was seen in all of T9's lessons recorded since 2005. An example of this writing can be seen in Figure 47.

Figure 22 **Presenting explanation of the length of the hypotenuse of a triangle**



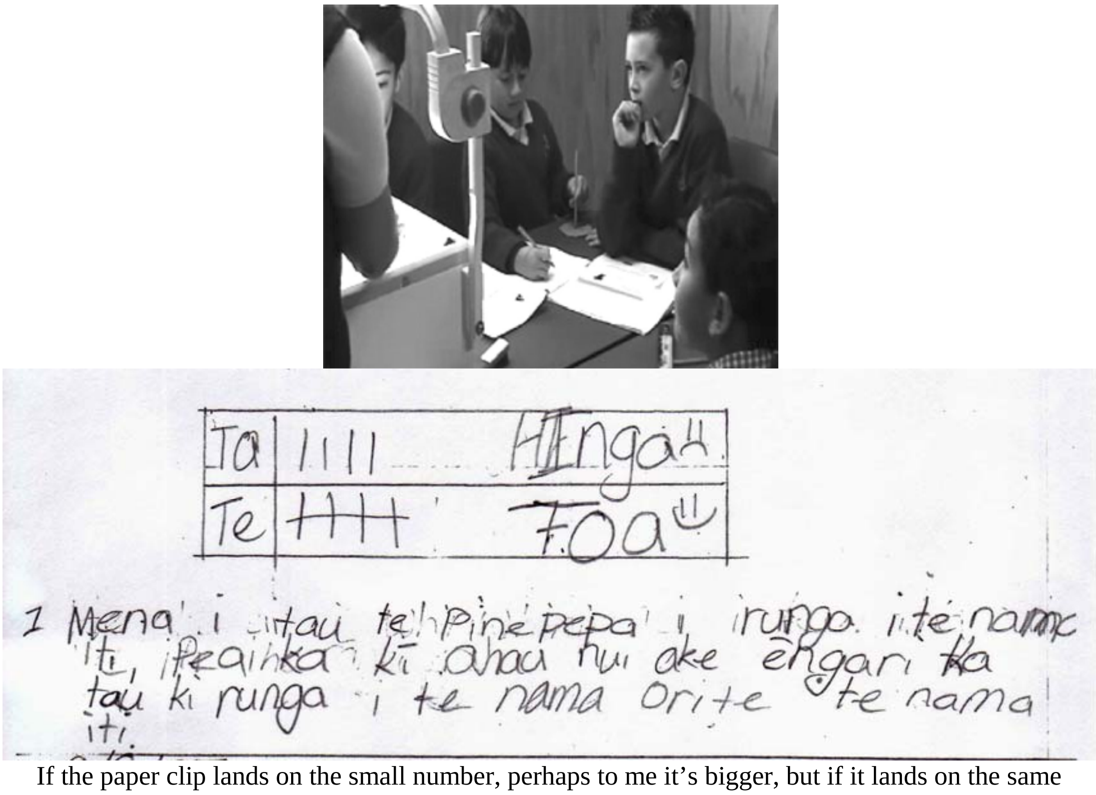
The scrutiny that accompanied these public writings meant that it was very easy for teachers or other students to highlight difficulties in understanding the meaning that the writer was trying to display. Consequently, the students themselves would clarify the meaning that they were trying to give. In asking students to display their knowledge, it is assumed that they have the skills to do so and that the classroom environment was supportive of them if they struggled in writing up a response. This supportive environment is used to remind the students of what they do already know and if they cannot resolve it themselves then the teacher can intervene by using strategies from the akoranga stage.

Putanga

The final stage of the MRA model allows students to show their fluency in using te reo tātaitai. Its function is to enable students to use their knowledge and skills without any support from the teacher. At this stage, there is not a series of strategies that teachers choose from. The teacher's role is simply to provide opportunities for students to make use of the fluency they had acquired. Sometimes students who were engaged in learning a new topic would use other aspects of te reo tātaitai that they were fluent in. Often the work produced at this stage was for formal assessments.

Figure 48 shows a student completing a tally to record their results from using a spinner as part of a beginning activity on probability. This student had no difficulty with this part of the task. However, their fluency in being able to describe what they had done clearly was not so high.

Figure 23 **Recording the results of a spinner using a tally**



If the paper clip lands on the small number, perhaps to me it's bigger, but if it lands on the same (equal) number, smaller number.

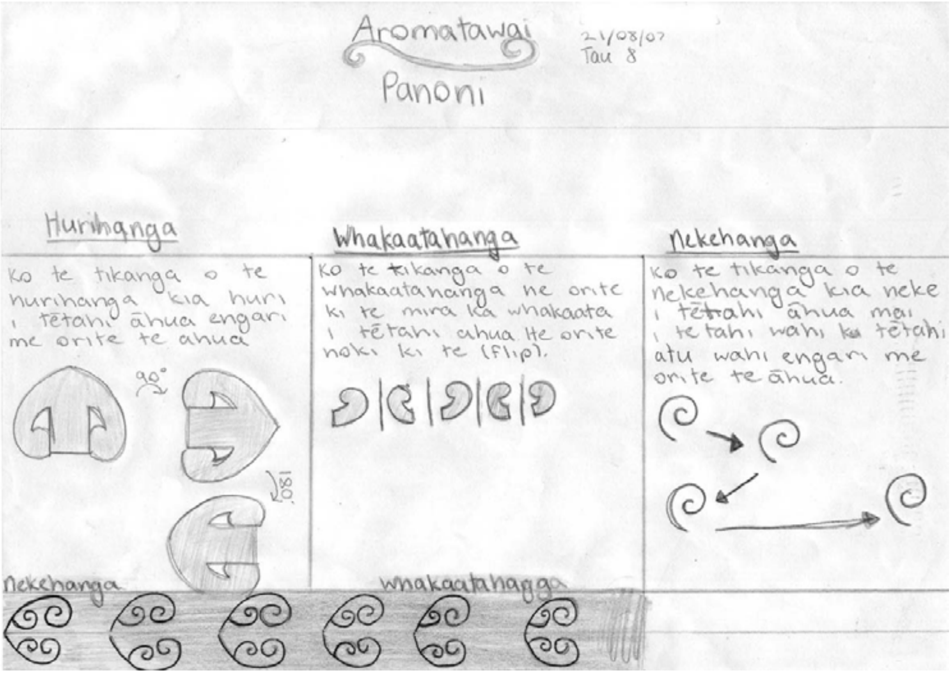
Assessment tasks also tested students' fluency in being able to provide appropriate mathematical writing. Two teachers, T1 and T2, asked students to write about a topic both at the beginning and at the end of a unit of work. This enabled not only the teacher but also the student to be able to see what had been learnt and what improvements had been made in their writing. A teacher in Doerr and Chandler-Olcott's (in press) research had used a similar approach in that she had given students the same writing prompt at the beginning, middle and end of a unit. This had provided her with insights into how students' understanding had grown while completing the unit. In the second year of the project, the teacher had got the students themselves to look at the work and consider how to make it better.

In the September staff meeting, T2 described why she had students produce two examples of writing about transformations:

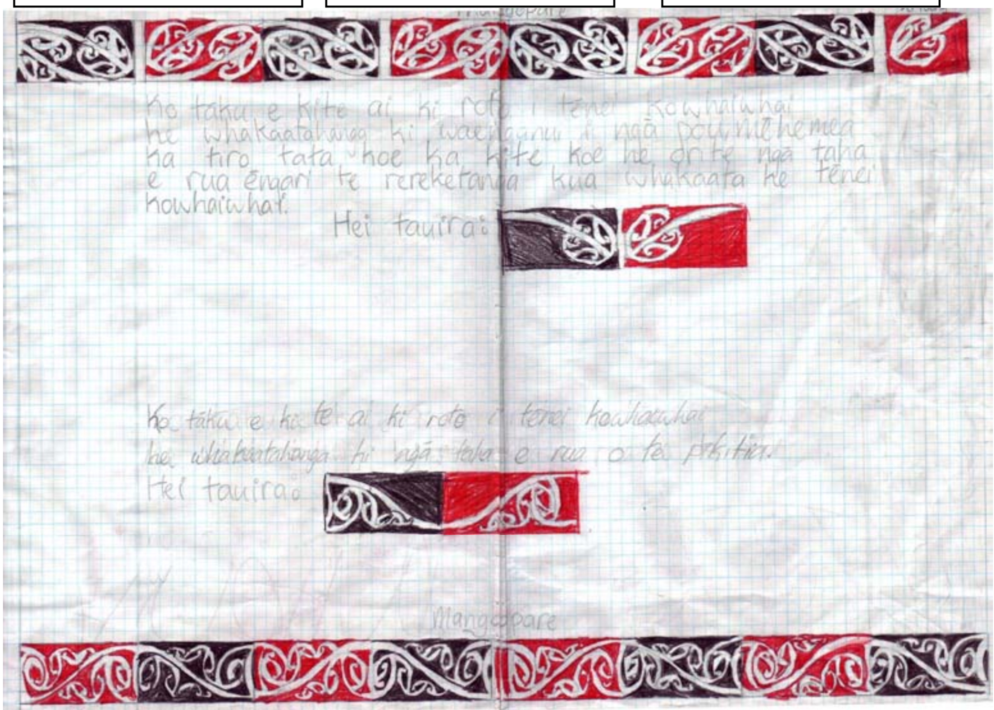
> T2 mentioned that in her group she has some students who struggle with writing generally. She saw in the examples of writing about transformations (reflection, rotation and translation) that some students appeared to have played safe. For example, to show reflection a student chose the letter 'T'. Although this was reflected, it does not actually change which would have been the case if she had chosen something like the letter 'K'. A good piece of writing on this topic gave the explanation generally through diagrams. However, some students could have done better by providing a longer written text. Students need strong te reo Māori if they are to produce good narrative texts. Even with good mathematical vocabulary they also need good general writing skills.
>
> Having students present their understanding of a topic means that they have to make some independent choices about what they are going to do. This shows you where they are at.
>
> T2 had students complete a second piece of writing on this topic by having students choose a kōwhaiwhai pattern and then describe the transformations within it. In this case T2 felt that she provided more explanation about what she was wanting than she had with the earlier piece. The first piece was in some ways a diagnostic test to see what students knew about the topic.

Figure 49 provides the two pieces of writing from one student. It is possible to see a significant change in the type of transformation that is being discussed.

Figure 24 **Transformation assignments by a Tau 8 student**



Rotation	Reflection	Translation
The meaning of rotation is to rotate a shape but it remains the same shape.	The meaning of reflection is when the same shape is in the mirror. It is the same when you flip it.	The meaning of translation is to move a shape from one place to another but the shape is the same.



What I see in this kōwhaiwhai is a reflection between the columns. If you look closely you will see that both sides are the same. The difference is that this kōwhaiwhai is reflected.
An example
What I can see in this kōwhaiwhai is a reflection on both sides of the diagram.
An example
Hammerhead shark (the kōwhaiwhai pattern)

Conclusion

The strategies teachers employed to support students improve their writing skills were varied in all four stages of the MRA model and all teachers used strategies from each stage. The acts of writing were also developed across the four stages. However, the focus for the physical acts occurred in the initial stage of the MRA model. Once students could independently recognise the features of the shapes or diagrams they had to reproduce they quickly moved onto being fluent so little was seen in the intermediate stages. Deeper acts of writing were more evenly spread across all four stages but were only connected to whakamārama and parahau genres.

The audience of the writing was also connected to the stage of the MRA model. For example, if the students were writing for themselves then they were generally fluent in the genre or mathematical writing mode they were using. If the teachers were slightly hesitant about whether the students were completely fluent, then either they would regularly check the writing themselves or set up activities where students would receive immediate feedback about the appropriateness of what they were doing. These activities were ones such as folding paper to produce a 3D shape or using the computer to produce a translated pattern. There were also opportunities through public displays of writing for other students to provide feedback if they could not follow what had been produced. This also gave the writers immediate feedback. The classroom environments at the kura were supportive and comments by teachers and other students were seen as helpful in the style of a *tuakana–teina*, older–younger sibling, relationship identified in the previous project (Meaney et al., 2007).

2. Student writing

This chapter outlines issues to do with writing in mathematics from the students' perspective. Ultimately, the Mathematics: She'll be Write! project was about improving students' learning of mathematics. It is therefore valuable to hear from the students about their perceptions of writing in mathematics as well as to see what changes occurred during the project.

Little previous research has investigated students' perspectives about writing in mathematics. In regard to students' problem solving in mathematics, Albert (2000) investigated their use of spoken and written language. Students felt that "writing helped them keep track of their thinking and solutions" (p. 135). This was reinforced by Albert's observations and interviews while students were engaged in problem solving. Her conclusion was that writing supported students' self-talk and this contributed to their reflection on their problem solving. A similar conclusion was made by Meaney (2002b) after working with students in her junior high school class. However, she also found that unless students valued writing in mathematics, then it was unlikely that they would take advantage of the reflection that writing could provide (Meaney, 2002a).

For this project, we analysed survey results and interviews to discuss students' beliefs about writing in mathematics and also described writing over the year from students at each year level. The amount of writing that students did varied across the year levels and was affected by the topic they were studying as well as their teachers' engagement in the research project. As the teachers' participation is discussed in Chapter 8, this chapter focuses on what students wrote over the year and their beliefs about this.

Writing over time

In order to discover the types of writing that students did and how these changed during the course of the project, we decided to document the writing done by two students from each of the classes. The students were usually the ones chosen by their teachers to be interviewed in September. When the teachers only had one student interviewed then a second student's writing samples were also included. This student was chosen at random. The students who were interviewed were not always the ones we had the most samples from. However, by combining the samples of both students it was possible to get a sense of the writing that was done by all the students in the class over the course of the year. Occasionally, both students contributed the same piece of writing but these double-ups were less frequent than we had expected, suggesting that our collection of samples was not as rigorous as we had thought. Therefore, having two students' samples was a more appropriate method of recording what each student was expected to write over the course of the year.

Some writing was collected in 2006, but it was not systematic and so has not been included in our analysis. The collection of material in 2007 was more systematic, but there were still some problems. Sometimes material was not collected from specific teachers during one of the researchers' visits for a range of reasons.

Consequently, it is difficult to definitively say that students wrote more and at a higher quality as a result of their teachers being part of the project. Nevertheless, it did seem that the number of modes students were expected to use in each year level became more varied as the project progressed. There also seemed to be more of an emphasis on writing explanations and justifications later in the year. However, this may have been because the topics that were covered towards the end of the year lent themselves to being more appropriate for the writing of explanations and justifications.

Table 3 **Writing in year levels across the year**

	Tau 1	Tau 2	Tau 3	Tau 4	Tau 5	Tau 6	Tau 7	Tau 8	Tau 11
Feb	1 Time	1 Time	2 Time				2 Time 1 Calcul	1 Time	1 Probl solve 1 Meas 1 Calcul
March	1 Numb	2 Time 1 2D shape	2 Time 3 Numb		2 Numb		1 Stats graph 1 Word problem		4 Meas
April				1 Numb 1 2D shape				1 Calcul 2 Meas	1 Meas 1 Enlarge
May	1 Pattern		1 Patt 2 Rel graphs 4 Stats graphs	1 Rel graph 2 Stats graphs	1 Fract	1 2D shape	1 Word probl 1 Patt 2 Cart graphs	9 Meas	2 Algebra 2 Cart graphs
June	1 Tally	1 2D shape	3 Numb	4 Numb	1 Stats graph	3 Probl solve	3 Shape & angle 3 Fract & proport 2 Calcul 2 Patt 1 Time	1 3D shape 1 Geom	2 Algebra
July			3 Prob		4 Calcul		4 3D shape	1 Angle 3 Metric convers	1 Iso draw
Aug	3 Prob	2 Probl solve	2 Prob	6 Fract 1 Calc & meas	3 Prob 1 Fract	6 Prob	1 Meas 2 Calcul	1 Angle 4 Transf	2 Geo construct 1 Cart graph
Sept	1 Prob 1 Calc			1 2D shape	1 Prob		2 Meas 1 Fract	1 Transf 1 Prob	4 Pythag
Oct	1 2D shape	5 Fract 1 Transf 1 Patt	1 Transf	3 Transf 4 Calcul 1 2D shape		13 Transf	6 Transf	1 Transf 1 Calcul	1 Pythag
Nov	2 Transf	1 Calcul 1 Transf	1 Transf	1 Transf		3 Transf			2 Angle

Calc = calculation, *transf* = transformation, *probl solve* = problem solving, *numb* = number, *fract* = fraction, *meas* = measure, *patt* = patterns, *iso draw* = isometric drawing, *rel graph* = relation graph, *geo construct* = geometric construction, *Pythag* = Pythagoras, *prob* = probability, *geom* = geometry

Table 8 sets out the topics and number of pages of writing done in each month between February and November 2007, for two students from each class. When there were two pieces of writing that were the same, then only one was included in the numbers in the table. For example, the next two pieces of writing were done by the two students in Year 7. However, as these were the same activity, they were only considered as one piece of writing in Table 8.

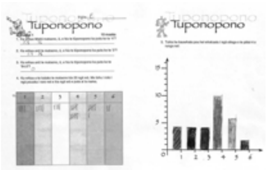
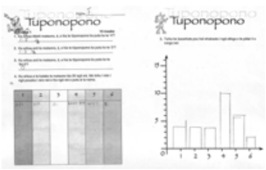
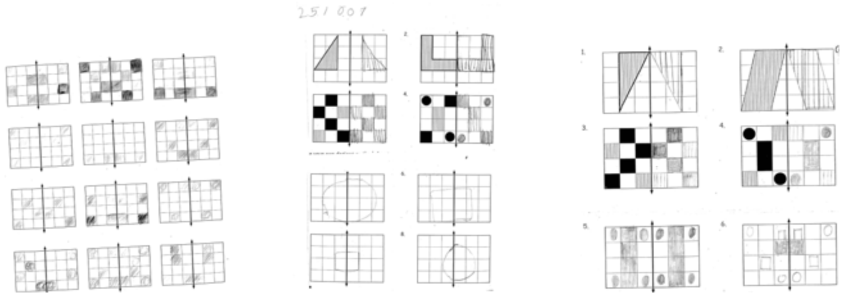
 and 

Table 8 shows that the type of writing students did varied over the course of the year. It also shows that, as could be expected, students are doing more writing in the later year levels. However, there are some exceptions with students in Year 3 doing more writing generally than their peers in the following couple of years.

Sometimes, the same worksheet would be completed by students at several year levels. For example, students in Tau 4 used a number of worksheets on fractions in August 2007. Some of these worksheets were then used by students in Tau 2 in October. As teachers planned their mathematics programmes together in the junior school, there were often possibilities of sharing resources. The lack of resources in te reo Māori is an ongoing issue in kura kaupapa Māori (Meaney, 2001) and so sharing of resources is useful for saving time in planning. The worksheet may be used as an introductory activity at one year level while in a later year level it may be used as a diagnostic test to check what students remembered before the topic was begun. Given that students were achieving at different levels in all classes, it was also possible that there were commonalities in the learning outcomes for some students in different classes. Figure 50 shows three similar worksheets on reflection from three different year levels.

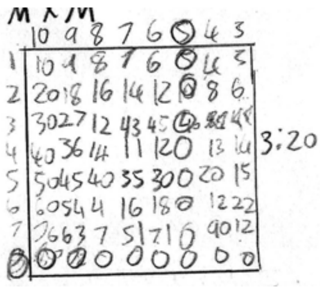
Figure 25 **Tau 2 (left), Tau 3 (middle) and Tau 4 (right)**



The amount of writing did vary across the year but school holidays falling in April, July and September/October meant that the spread was not even. Although T1 had been at the initial discussions in 2006, she had not been at the kura for most of the first term and so there were no writing samples from her class for this period. As well, the last collection of samples was done in the first week in November; which meant that there were few samples for this month. However, it would seem that students were expected to do more writing towards the end of the year than had been expected of them at the beginning of the year.

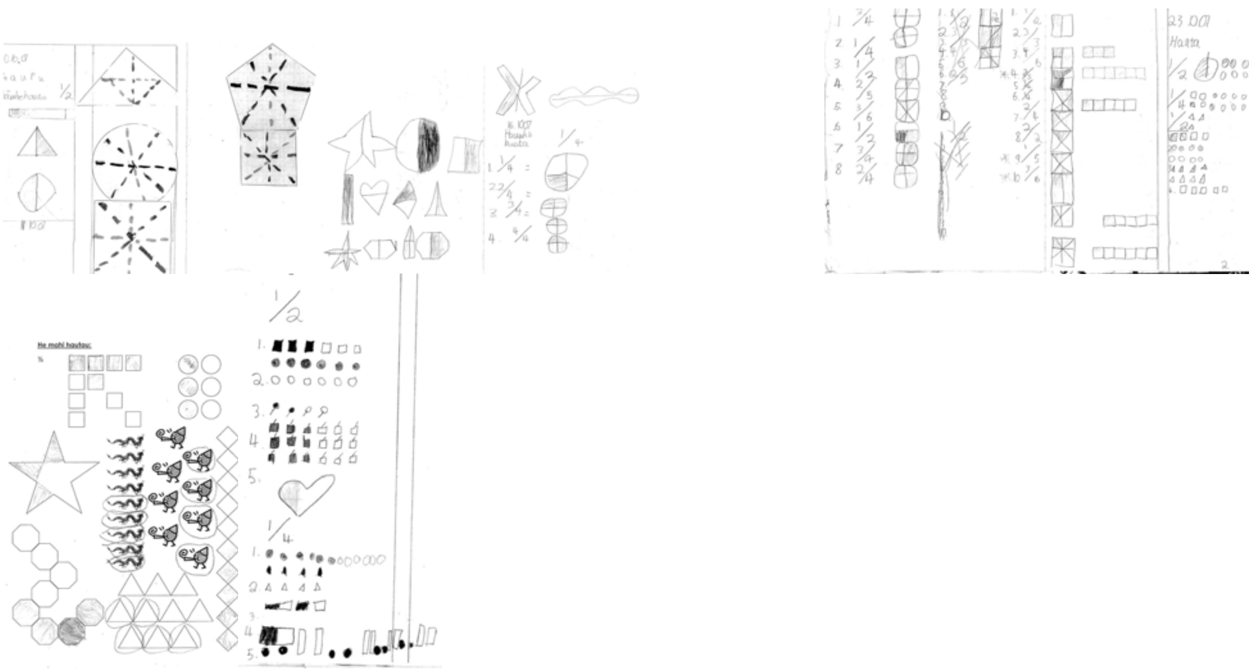
The topic influenced the amount of writing. Number was an underlying theme across the year and was not tied to a particular time of the year as were other topics. However, written examples did not always appear in the data collection. It may be that with the focus of the Poutama Tau on mental strategies there were not many written examples. However, it may also be that these examples were not as valued as other pieces of writing and were not kept in the same way. An exception to this would be the situation in Tau 7 where students produced multiplication or addition tables throughout the year and these appeared regularly in the samples that were collected. The students would record the time it took them to complete the times or addition table. An example of this can be seen in Figure 51.

Figure 26 **Times table**



Some topics had students producing more writing than other topics. It was rarely expected that students would reproduce the same piece of writing in any topic, apart from the multiplication and addition tables seen in Tau 7. For example, there were five pages of writing on fractions done by students in Tau 2 in October. These can seen be in Figure 52.

Figure 27 **Five pages of writing on fractions**



In the pieces of writing, the students related iconic drawings to symbols, but each one required the students to integrate the two modes in different ways. The first one involved the students folding different shapes and recording how they produced two halves. As can be seen in the triangle, the students were not always able to recognise the two halves. On the next page, students drew different shapes and then showed how the first could be split into two halves and then into quarters. In the next sheet, the students represented fractions with different numerators. The final piece of writing showed how fractions of groups of items were determined. As they had been with the fraction of a whole, the students were channelled into being able to produce the conventional mathematical writing about the fractional amounts of a group of objects.

Students' writing is affected by the topic they are writing about. Probability was one area that produced a significant amount of writing across the kura. It also involved students in integrating a variety of different modes. Consequently the sort of writing that students engaged with across different year levels is investigated in the next section.

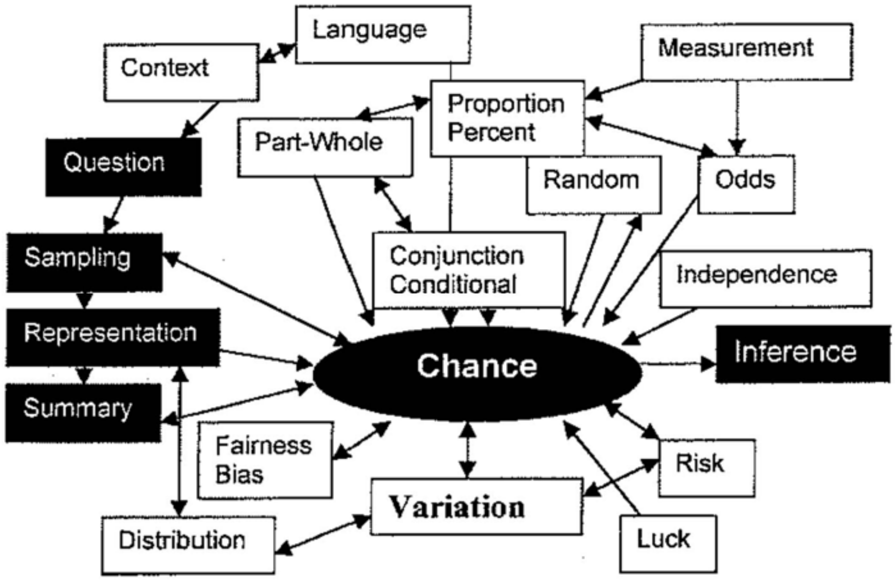
Students' writing about probability

Probability is an interesting topic to investigate in regard to writing. It has been suggested that the different facets of probability are difficult for students to grasp and have to develop over a number of years (Nickson, 2000). In a longitudinal study of how junior high school students developed ideas about probability, Green (1983) found that:

> The concept of ratio is vital to children's understanding of probability
>
> The level of understanding of the language of probability is poor (e.g. words such as 'certain' and 'least')
>
> A systematic approach to the teaching of probability and statistics in schools is necessary to overcome children's misconceptions in connection with the subject. (Nickson, 2000, p. 94)

There is a need to integrate a variety of modes because probability concepts are built upon a range of different ideas. This is one of the reasons why students can find learning probability so difficult. Watson (2006) provided a diagram that showed the main ideas about chance, the precursor to probability, and how they were related. This can be seen in Figure 53.

Figure 28 **Links between ideas and statistical elements related to chance understanding (from Watson, 2006, p. 130)**



The pieces of writing collected from the kura showed that students were building on understanding developed in earlier years. The foundation for investigating the topic was that there were specific terms and expressions needed to discuss probability. Given that most of the students were second-language learners of te reo Māori, it is not surprising that the teachers focused on ensuring students had appropriate language as a beginning point for this topic. Interference from connotations from a student's first language is known to affect their acquisition of second-language probability terms (Kazima, 2006). One of the reflections in the final meeting for the year was that probability was a particularly difficult area for students to grasp because:

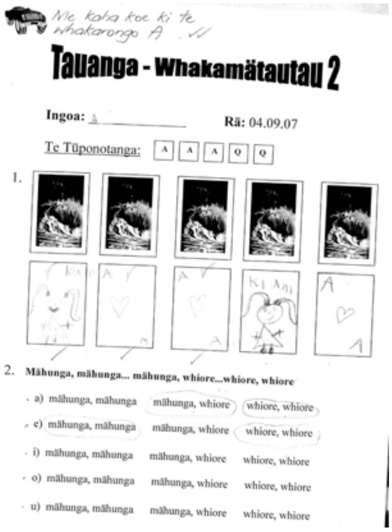
> Probability moves into language that hasn't naturally been strongly supported in Māori. We have some words like puta noa and other things like tera pea but it is not as organised as possible . . . through to probable, to likely, to definite. Those people have worked on that a long time in English and have decided what a possible looks like, and this is what a probable looks like, and this is what a likely looks like and this is what a highly likely looks like, this is what a definitely looks like. (T9, Meeting November 2007)

For example, the word for probability in te reo Māori is *tūponotanga* which traditionally had the English connotation of "by accident" or "chance to hit", that did not have a good outcome**.** Without explicit teaching, students may often be unaware that the same word had different meanings in the everyday context and the mathematical context. As well as concentrating on probability language, the students made use of previous work on statistical graphs in exploring probability concepts.

Probability over the year levels

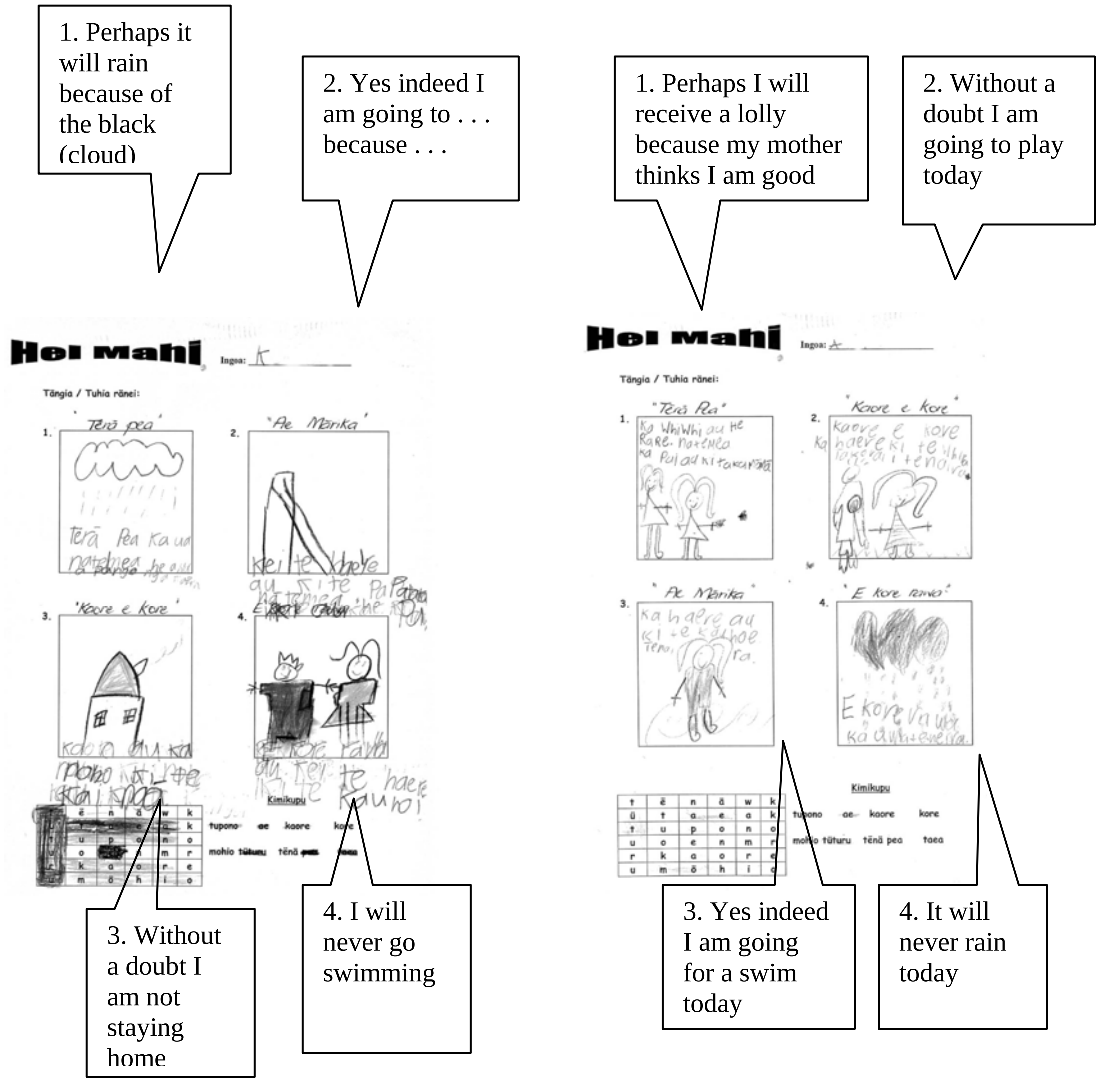
Figures 54 and 55 show two of the pieces of writing that Tau 1 students did on probability. In the first piece, students were expected to draw reproductions of playing cards to show how three aces and two queens could be distributed. They were then asked to make predictions about the throwing of two coins. The students had to circle whether the coins would come up "māhunga, māhunga" (head/head) or "māhunga, whiore" (head/tail) or "whiore, whiore" (tail/tail). This worksheet had students produce drawings and use words connected to ideas to do with probability. They were related to actual activities of turning cards over and tossing coins, thus making the writing strongly connected to activities that students were engaged in.

Figure 29 **Tau 2 student's worksheet on probability**



In the writing samples in Figure 55, students wrote sentences using the phrases written by the teacher above the box. The students also had to draw a picture to accompany their sentences.

Figure 30 **Students' definitions for specific probability terms**

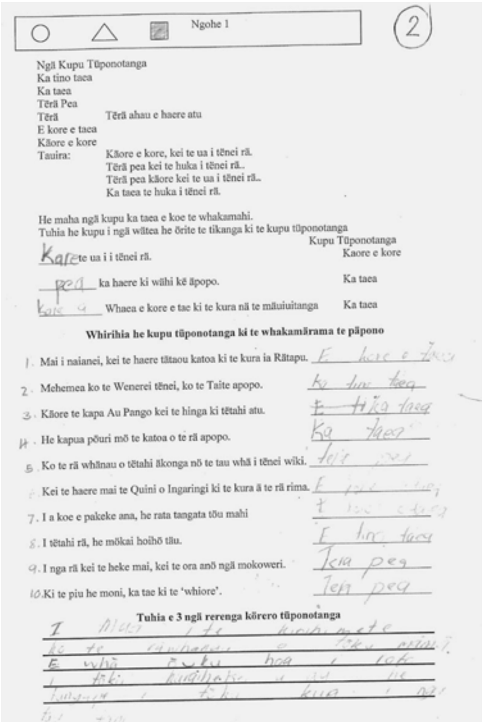


The writing students did about probability in Tau 1 required the students to integrate words with drawings. In Figure 54, the words and the pictures were connected to separate activities; in the examples in Figure 55, students had to match their sentences with their drawings. Although the students were not referring to actual activities as they had been in the previous example, they were expected to draw upon their own experiences. At the bottom of the worksheet in Figure 55, students had to find different probability expressions that had been introduced to students at the beginning of the lesson.

It is interesting to note that students in this year were already being introduced to the areas of language identified by Green (1983) as being problematic. This was not done in a simplistic way as students were writing about variation (Figure 54), one of the key ideas identified by Watson (2006) in regard to chance, through drawings and identifying combinations.

In Tau 3, students also were channelled into using the appropriate probability language. The first work they did was to place terms in a list from “definitely going to happen” to “definitely not going to happen” (Āe ka tino taea, Āe ka taea, E kore e taea). These terms were then used in a variety of different activities, including writing sentences using the expressions. An example of this is shown in Figure 56.

Figure 31 **Using probability expressions in Tau 3**


Ngohe 1

Ngā Kupu Tūponotanga
Ka tino taea
Ka taea
Tērā Pea
Tērā   Tērā ahau e haere atu
E kore e taea
Kāore e kore
Tauira: Kāore e kore, kei te ua i tēnei rā.
Tērā pea kei te huka i tēnei rā..
Tērā pea kāore kei te ua i tēnei rā..
Ka taea te huka i tēnei rā.

He maha ngā kupu ka taea e koe te whakamahi.
Tuhia he kupu i ngā wātea he ōrite te tikanga ki te kupu tūponotanga

Kupu Tūponotanga
Kare te ua i i tēnei rā.   Kaore e kore
pea ka haere ki wāhi kē āpopo.   Ka taea
Whaea e kore e tae ki te kura nā te māuiuitanga   Ka taea

Whirihia he kupu tūponotanga ki te whakamārama te pāpono

1. Mai i naianei, kei te haere tātaou katoa ki te kura ia Rātapu.
2. Mehemea ko te Wenerei tēnei, ko te Taite apopo.
3. Kāore te kapa Au Pango kei te hinga ki tētahi atu.
4. He kapua pōuri mō te katoa o te rā apopo.
5. Ko te rā whānau o tētahi ākonga nō te tau whā i tēnei wiki.
6. Kei te haere mai te Quini o Ingaringi ki te kura ā te rā rima.
7. I a koe e pakeke ana, he rata tangata tōu mahi
8. I tētahi rā, he mōkai hoihō tāu.
9. I nga rā kei te heke mai, kei te ora anō ngā mokoweri.
10. Ki te piu he moni, ka tae ki te ‘whiore’.

Tuhia e 3 ngā rerenga kōrero tūponotanga

Activity 1 **Probability words** Definitely able Able to Then perhaps Perhaps. Then perhaps I will go Definitely not able Not able Example Without a doubt it will rain today Then perhaps it will snow today Then perhaps it will not rain today It can snow today It will not rain today Perhaps I will go to a different place tomorrow From now we will go to school every Sunday (Definitely not) If today is Wednesday, tomorrow is Thursday (Yes indeed) The All Blacks will not lose to anyone (They can) There will be black clouds tomorrow (It’s possible) A year 4 student has a birthday this week (Yes perhaps) The Queen of England is coming to school on the 5th (Definitely not) When you become an adult, you will be a doctor (Definitely not) One day you will have a pet horse (Definitely) In the days to come dinosaurs may come back to life (Yes perhaps) If a coin is tossed it will be tails (Yes perhaps) My mother’s birthday is before Christmas. I have four friends in my class. I have a brother at my school

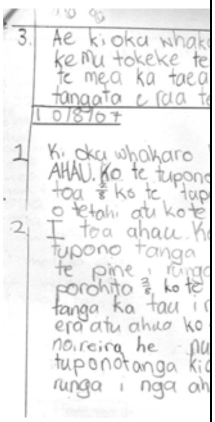
In Tau 5, students engaged in probability experiments using spinners. They used tables to record their results and then wrote about them in paragraphs. The activity involved students in thinking about ideas to do with proportion. Green (1983) had found these areas were not generally done well in school, making it difficult for students to understand probability. An example of a student’s writing can be seen in Figure 57.

Figure 32 **A student's description of their probability experiment from Tau 5**

6/8/07
1. I think this game is about probability
2. I think this is a probability game because you think about a colour, is it correct, is it wrong

8/8/07
1. If the pin falls on a smaller number you know it will land on a bigger one [next]. If it lands on a bigger one it will land on a smaller one [next]

9/8/07
1. I think the odd number will win because the next number above it is even
2. I think odd numbers will win because there are more odd numbers than even numbers



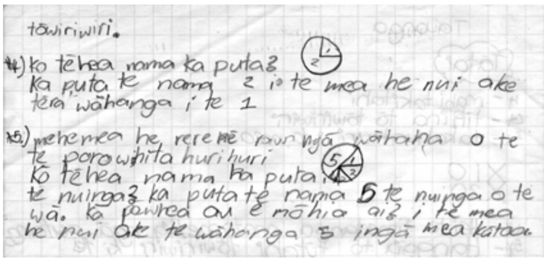
3. Yes, I think this is an unbiased game because 2 people can play

10/8/07
1. I think I will win. The probability is 2/8. The probability of someone else winning is 6/8
2. I won because the probability of the pin (dial) landing on the circle is 2/8. The probability of landing on the other shape is 6/8. Therefore the probability is greater to land on the 6/8 shape

At this level of writing, students had to explain what they had done and what the results showed. This required a higher level of writing than just using the expressions to describe events. However, it was also clear that students were still grappling with expressing their ideas about what made a fair game. Some students were able to discuss how, even though the actual game had allowed one item to be more successful, over a longer run this would not be the case because it had a smaller proportion of the spinner. The teacher felt that some students were still developing an understanding of this idea and that many found orally explaining what had happened easier than having to write about it (T10, Meeting 5 September 2007).

Similar writing was expected of students in Tau 6. Students also worked with spinners and wrote about these experiences. The focus for these students was on looking at how the chances of winning were related to the proportions on the spinner. As was the case in Tau 5, some students were able to understand this while others struggled with seeing that two outcomes had an equal opportunity for occurring if the proportions on the spinner were the same (T7, Meeting 5 September 2007).

Figure 33 **Tau 6 student's explanation about the connection between the spinner proportions and the chances of winning**



1. Work alone
2. Fetch your tōwiri (spinner)
3. Rotate the thing
4. At the beginning, predict outcomes
5. Construct a frequency chart to collect the data that comes up
6. Show the data outcomes on a bar graph

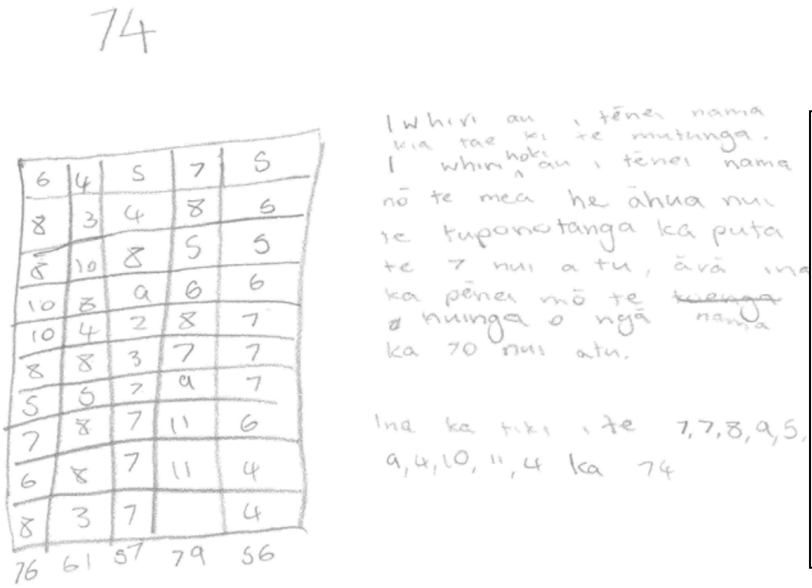
1. If played this is the tōwiri
2. What number comes up? One will come up because the parts are the same

4. Which number will come up? The number 2 because that part is bigger than the 1
5. If the parts of the tōwiri are very different, what number will come up most? The number 5 will appear mostly. How do I know? Because the 5 part is bigger than all the others

This writing involved students in integrating a range of different modes. They had to keep tables of results, draw graphs and explain what had occurred using diagrams of the spinners.

In Tau 8, students were also involved in playing a game. In this case, they had to choose a number between 1 and 100. They then had to throw two dice 10 times to try to get to a total that equalled their chosen number. They could use a calculator to keep track of the cumulative total. At the end of five games, they had to write about whether their chosen number was a "good" number for the total, whether they had a strategy for choosing the possible total and what they could see in the data that may have given them some idea about why the chosen number was a "good" number (Lesson notes from T2). Figure 59 provides an example of one student's writing.

Figure 34 **Tau 8 student's recording of playing a dice game and his understanding about his strategy**

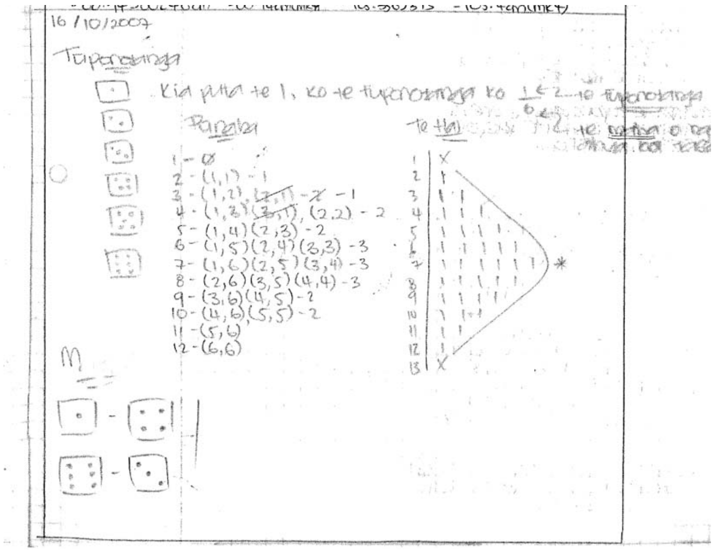


I chose this number to get to the end. I chose this number because the probability it will come up is more than 7. If it is like this for the majority of numbers more than 70 will come up.

This student was able to discuss how seven was a likely number to get from throwing two dice and therefore a total of around 10 lots of seven was a good total to aim for. However, this was a complicated set of ideas about probability, reflecting many of the interlocking ideas in Watson's (2006) diagram and many students did not fully understand what was required of them.

In Tau 11, probability ideas were discussed as classical probability where theoretical outcomes were described (Nickson, 2000). An example of this is shown in Figure 60. This led on to describing possibilities as fractions.

Figure 35 **Tau 11 student’s description of the results from tossing two dice**



6/10/07 Probability
For 1 to come up, the probability is 1/6

1 the probability
/6 the number of outcomes

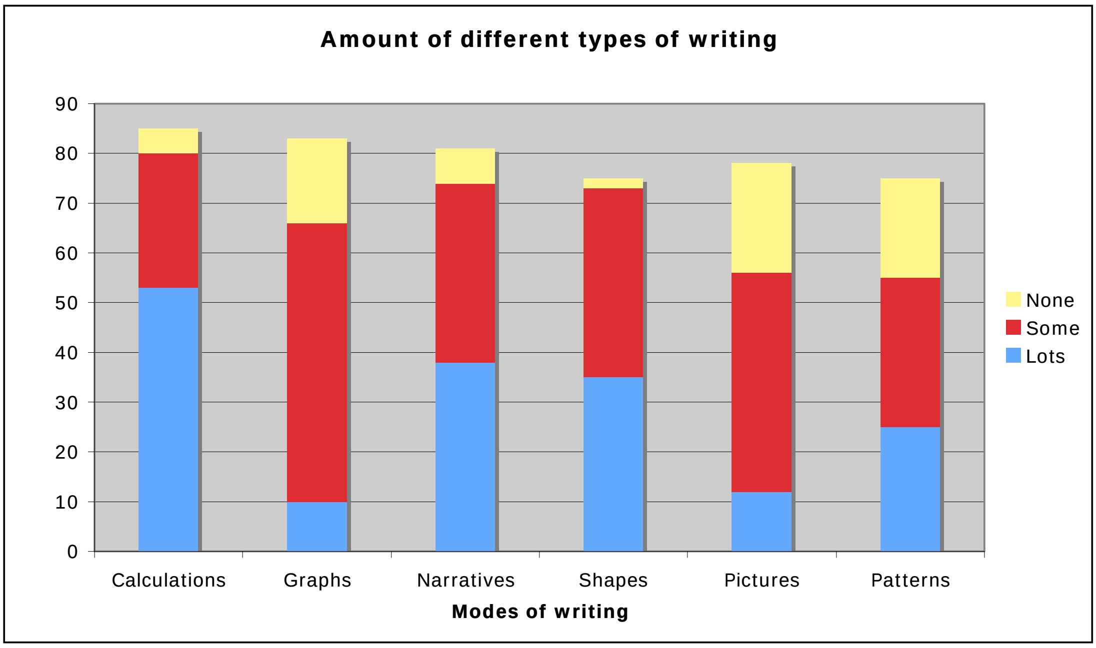
If the writing samples were typical of what occurred during the time a student was at the kura, then by the time students reached Tau 11 and the work with theoretical probabilities, they would have had many experiences of using probability language and participating in activities. Although students may not have grasped all of the ideas covered in particular years, they had many opportunities for meeting the ideas again in later years. Consequently, students also had opportunities for making extensive links between the different ideas that Watson (2006) perceived as being connected to ideas on chance. The kura focused their ideas about probability on students having a thorough control on the terms and expressions needed for discussing it. However, it was an area that the teachers still felt needed improvement.

The tamariki survey

Students from all year levels completed a survey about their beliefs about writing in mathematics. As the students were aged from five to 18, the survey used pictures and multiple choice predominantly. The survey was trialled with two senior students and five Tau 1 students. As a consequence, other students were asked to complete the survey. A blank survey is provided in Appendix C. One hundred and two students, or approximately half the total student population, completed the surveys. Some students did not complete each question so the totals rarely equalled 102. However, the students who failed to answer were different for each question.

The first question was about the types of writing and the amounts students felt they did of each. The results can be seen in Figure 61.

Figure 36 **Graph of different types of writing**



When the "lots" categories are combined with the "some" categories, it can be seen that students felt they often used many different modes when doing mathematical writing. More than half the students felt they were doing "lots" or "some" of each of the different types of writing. Of the different modes, students believed they did lots of calculations. Given that number is the underlying basis for much mathematics, especially with the strong emphasis on Poutama Tau at the kura, then this result is not surprising. However, it was not supported by the data used to construct Table 8.

The next two types of mathematical writing students felt they did much of was narratives and shapes. Just over one-third of students thought they wrote "lots" or "some" of these two modes. Few students felt they did "lots" of graphs or pictures.

Whakamārama and parahau (explanations and justifications) depend on narratives. So it is interesting to note that so many students felt they either did "lots" or "some" narrative writing. It may be that students did this survey in fourth term, just after doing the probability unit in Term 3 and the transformation unit in Term 4. Both these units involved students in doing more narrative mathematical writing than previous units and this may have swayed students' beliefs about how much narrative writing they did.

Figure 37 **Graph of frequency of writing in class**

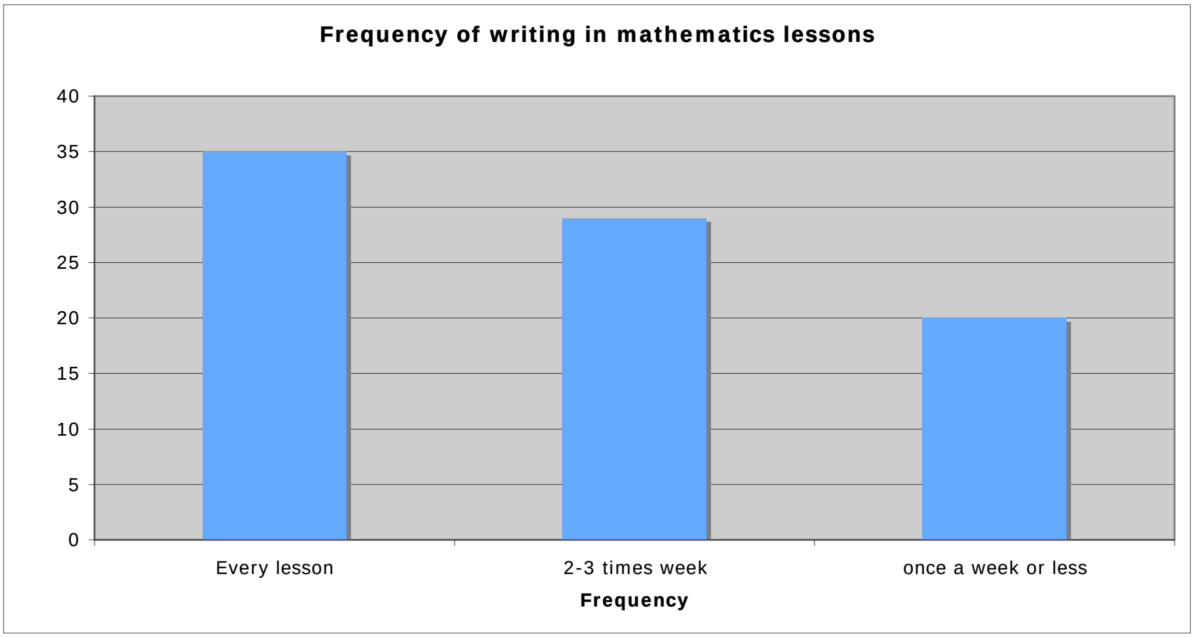
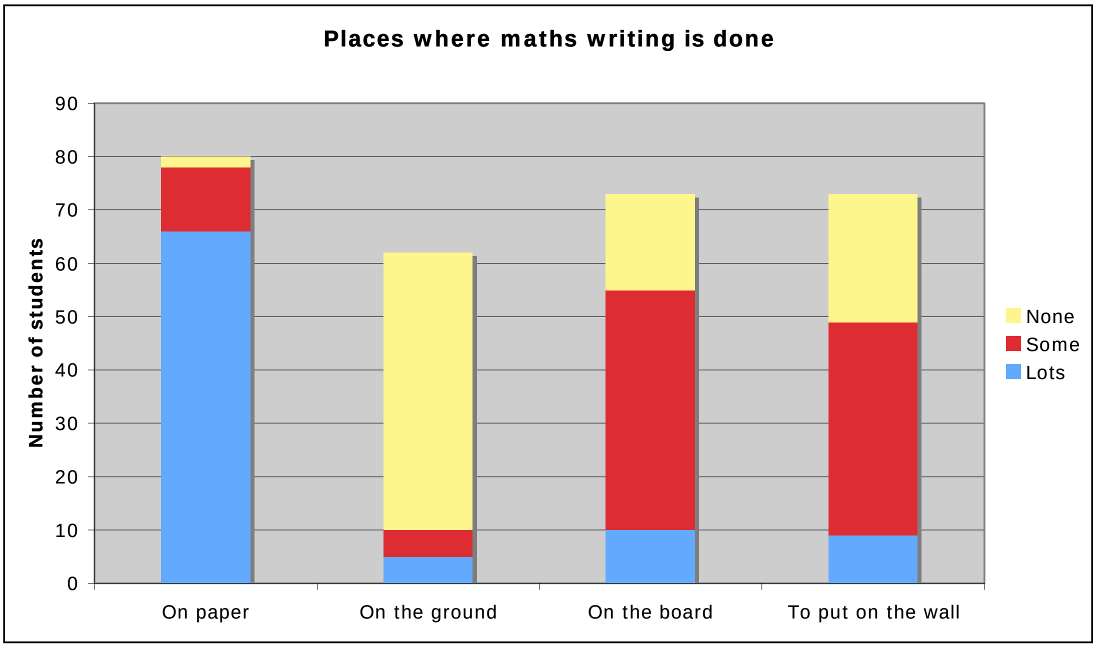


Figure 62 shows students' beliefs about how often they wrote about mathematics. On the whole, the majority of students felt they wrote about mathematics at least two or three times a week. If this was the case, it suggests that the amount of writing collected for Table 8 grossly underestimates how much writing was done. It would be interesting to know whether the students felt the amount of writing or the type of writing had changed during the year. This may have given us a better indication of changes in classroom practices.

Figure 38 **Places where mathematical writing is done**



The majority of students believed they did most of their writing on paper. About half the students also felt they did some writing on the board. Slightly fewer students felt they sometimes wrote material to go up on the wall of their classrooms. If students were regularly, although not frequently, writing in these less permanent forms, this may explain why there were fewer writing samples contributing to Table 8 than had been suggested by Figure 62.

Figure 39 **Audience for students' mathematical writing**

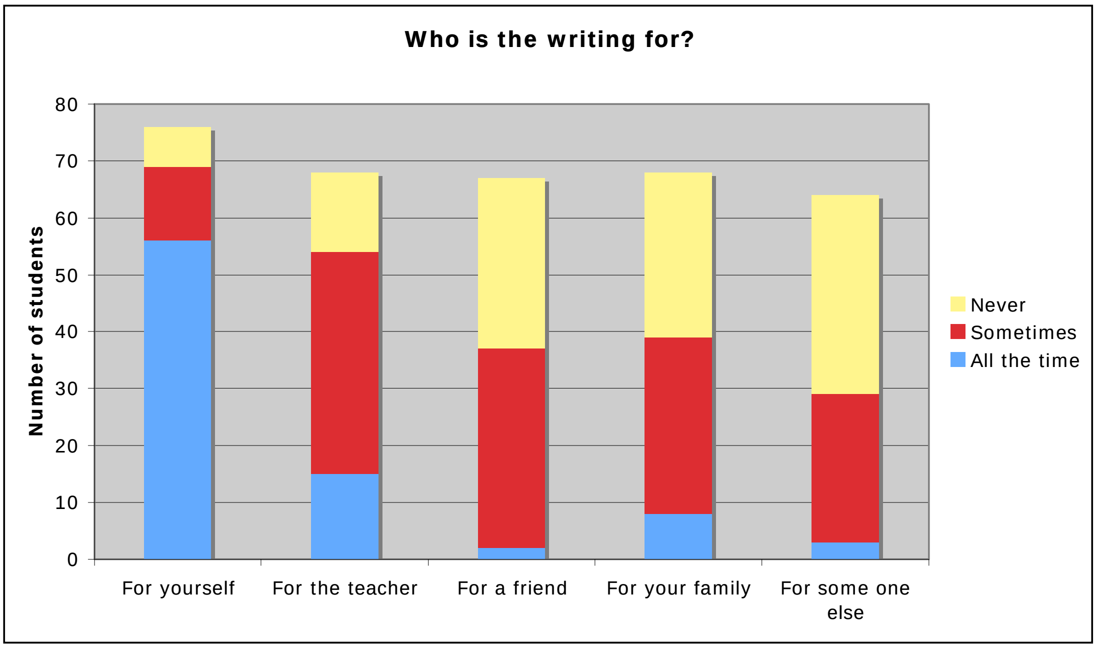


Figure 64 shows that students predominantly felt the writing they did was for themselves. This is a very interesting result as many of the teachers as well as the researchers had felt that students would see mathematical writing as something they did for the teacher. Morgan (1998), in considering the literature on school writing across the curriculum, stated that many studies suggested that "one of the roots of students' difficulties and lack of motivation in their development as writers" **(page ref.)** was the fact that the teacher as examiner was the audience on most occasions. Although many students also felt they wrote sometimes for the teacher, mostly they believed they wrote for themselves.

Students' beliefs that they were writing for themselves suggest that students could use this writing to reflect on their learning. However, without some guidance this may not eventuate. In research with a junior high school student, Meaney (2002a) found that a student who wrote predominantly for himself was unable to use his writing to check what he had done. He left out much of his reasoning because it had been self-evident when he had done the writing. This meant that he and others had difficulty in following what he had done when this writing was read later.

Students also described both their favourite as well as their least favourite modes of mathematical writing. The results for this are shown in Figures 65 and 66. It is quite clear that students felt that calculations were their most favourite mode of writing while narratives were their least favourite type of writing. Given that narratives are connected to the explanations and justifications, then it could indeed be a problem if students do not like to write them.

Figure 40 **Favourite types of writing**

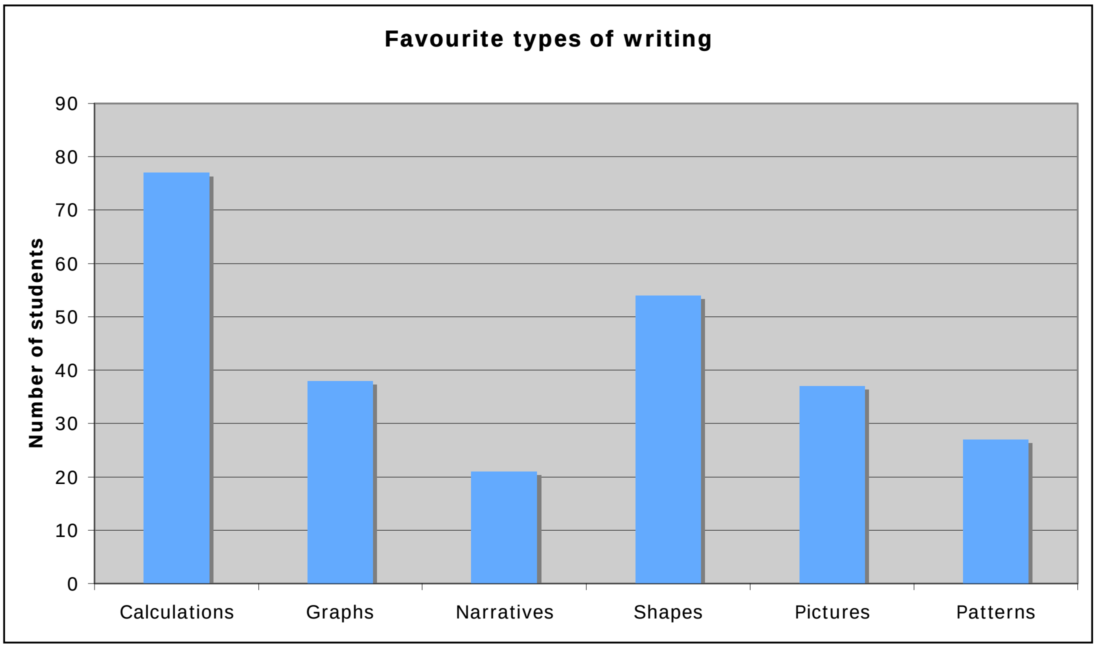
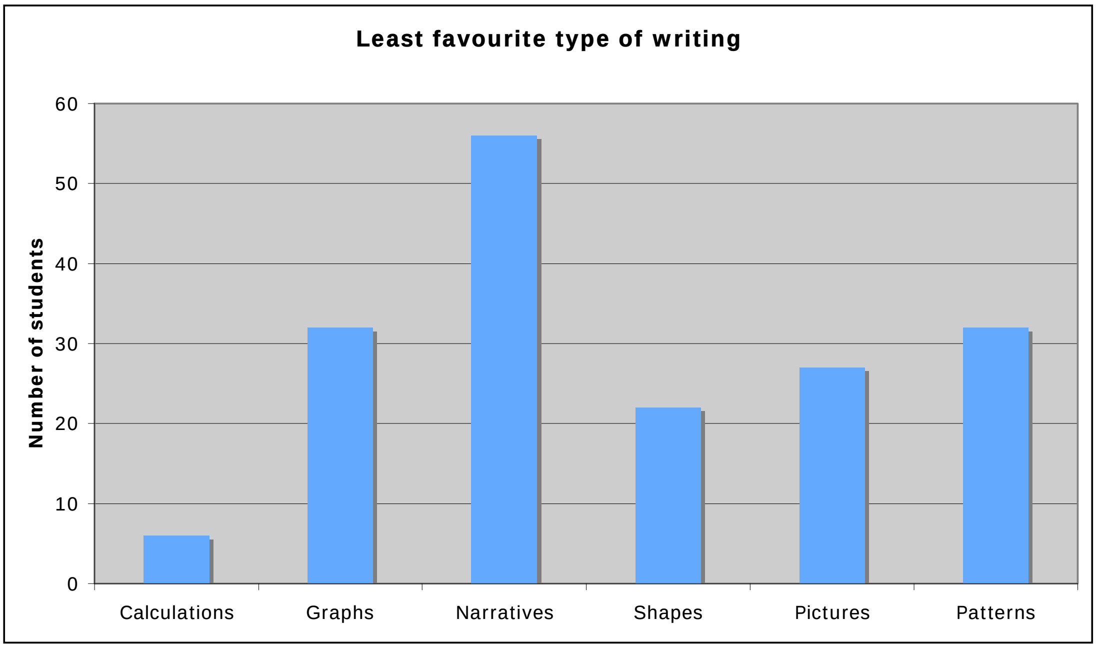


Figure 41 **Least favourite types of writing**



As many students recorded graphs as their favourite as recorded them as their least favourite mode of writing. Students also enjoyed drawing shapes but did not enjoy producing patterns.

In Figure 67, the students described what their mathematical writing was for. The students felt that at least sometimes they wrote to fulfil all three purposes. More students believed they wrote so that they could learn mathematics rather than the other two purposes. The fewest students felt that they wrote in mathematics to help them solve problems.

Figure 42 **Reasons for writing in mathematics**

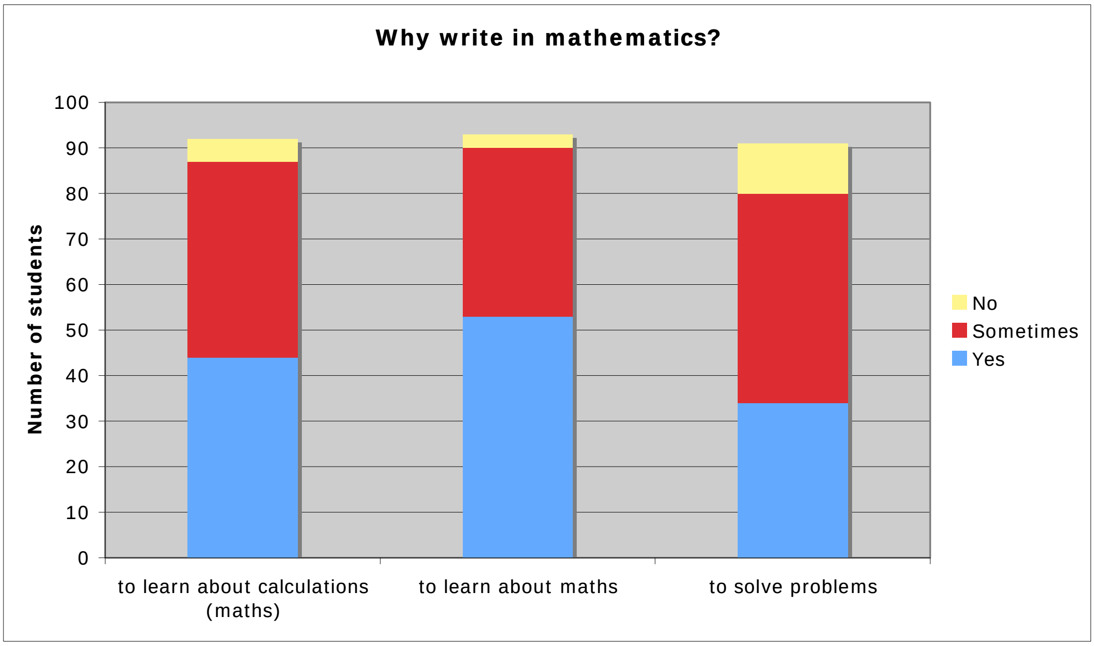
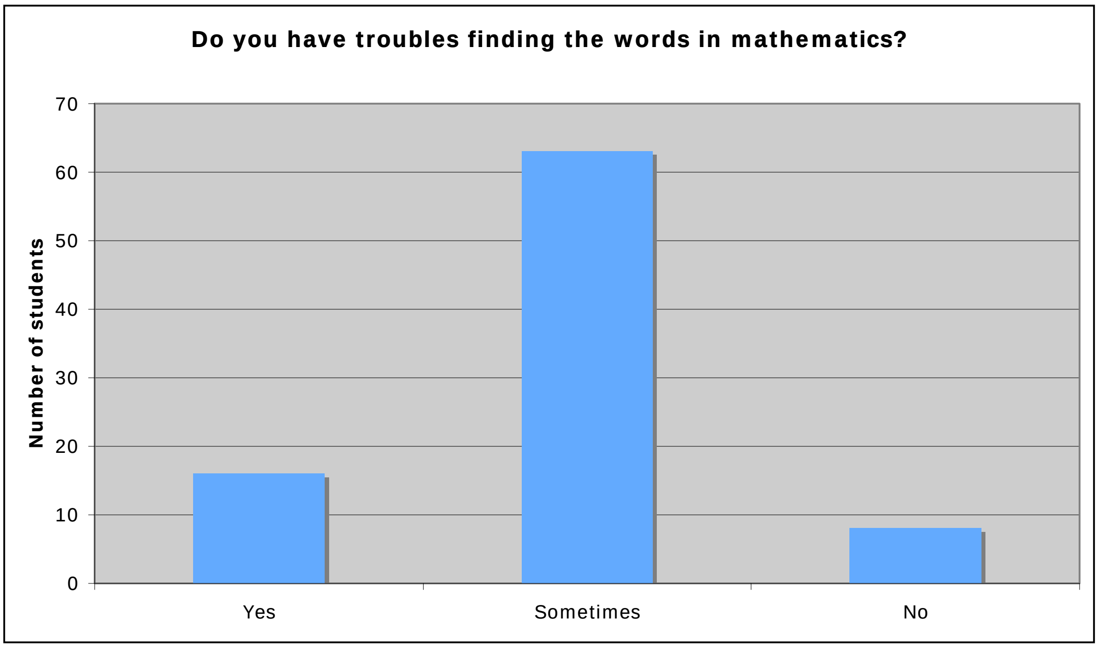


Figure 43 **Difficulties in remembering the te reo Māori mathematical terms**



By far the vast majority of students "sometimes" struggled to remember the te reo Māori mathematical words when describing what they were doing. As second-language learners of te reo Māori who would only encounter the mathematics register in classrooms, it is not surprising that students would "sometimes" find it difficult to recall the appropriate vocabulary. The approach the teachers adopted in focusing on ensuring the students had the appropriate vocabulary would seem to be meeting the needs of the students.

Conclusion

Students at each year level wrote a variety of different kinds of mathematical writing. As students progressed through the kura, they continued to integrate different modes but there was much more use of narratives. This was clear in the pieces of writing about probability that were analysed.

Students were also very clear about their beliefs about writing. They felt they did a lot of calculations and this was their favourite type of writing. They also felt they were expected to use words frequently but this was their least favourite type of writing. Given that explanations and justifications generally require students to use words at least in part, then it could be problematic if students are resistant to writing these. However, contrary to what other researchers have suggested, most students felt the writing they did was for themselves. This has great potential for supporting students to be reflective about their mathematics writing and also about their mathematical learning.

3. Teacher change

In Chapter 6 we described what the teachers did to improve students' writing and in the previous chapter we discussed students' views about writing in mathematics. In this chapter, we describe the impact of the project on teachers' teaching practices and on their ability to reflect on their teaching. On the whole, the teachers felt that the project had resulted in their trying new practices and these had had some impact on students' learning. In adopting these new practices, it was possible to see that the teachers were involved in a teacher inquiry model of professional development and this had supported them to reflect on their professional learning.

The teachers saw the project as an opportunity to improve students' achievement but recognised that this was not always a simple process:

> Now I am just for kids Tamsin and every child making progress, you know. Whether they are Māori or Pākehā I don't care, but for them to do well in life and to be knowledgeable and to be able to impart their knowledge and to be able to share it, all those sort of things. If I can do any little bit to make a child move forward in their lives I am happy, yeah. But I know it is important how we do it. (T3, Interview November 2007)

Doing a professional learning project of this kind involves teachers changing in two ways. The first is in regard to their teaching practice, while the other is in regard to their ability to research their own practice. 2007 was the third year we had received TLRI funding and some teachers had been involved since the beginning. However, other teachers had only been at the kura since the beginning of 2007. This had made these teachers feel a little behind in their understanding of the project. For example, at the end of the year, T10 stated, "I just think that having come so late into the programme, having not really understood what's happening, now I have a better understanding" (Interview November 2007).

In the initial project, Te Reo Tātaitai (Meaney et al., 2007), our primary purpose had been to document the teaching practices that were used to support students using te reo Māori to learn mathematics. Although the teachers did trial some new practices, the project had mainly been about sharing what was already occurring in the different classrooms in the kura. In this project, She'll be Write!, there has been an explicit expectation that teachers would make changes to their teaching practices to enhance student learning. The uptake of the opportunity to change teaching practices was varied for the different teachers. One reason given for these differences was that "the penny drops more slowly if you are not a natural maths teacher" (T8, Interview November 2007). This was supported by a comment by T10 who said in her interview, "I enjoy teaching maths if I have the support." The structure of the professional development opportunities, therefore, had to be accessible to the teachers who were all coming in with different backgrounds and expectations of the outcomes of the project.

This chapter documents how the teachers changed in order to increase the quantity of writing and quality of the writing that was done in their classrooms. It also describes how the teachers reflected on their own practice as part of the research process and how this contributed to the changes they made to their own teaching. In it, we describe the course of the project and the types of experiences that were provided to the teachers.

The teachers completed a survey and were interviewed in November 2006. As well, during staff meetings several teachers discussed ideas they had tried in their classrooms and these were recorded in the minutes or notes. Teachers also discussed with the main researcher their ideas about the project regularly during the year, as well as describing what was happening in their videoed lessons. This chapter draws on all of these sets of data to describe the changes that teachers made. A copy of the teacher survey is found in Appendix D.

Changes in teaching practices

In the survey, teachers were asked about their participation in the project as well as their ideas for a continuation of the project. The questions also asked about the range of modes that the teachers had taught in 2007, as well as about any changes they had made to their teaching practice to improve students' writing. The results suggest that most teachers had increased the number of modes and/or genres as well as tried out different strategies throughout the year. For some teachers, the reasons why they had made changes were because an external force, the project, had channelled them into making these changes. For other teachers, the reasons for making changes had been internalised as they adopted the view that writing in mathematics would be beneficial to students' learning. Sometimes it was a combination where initially the project had contributed to the teachers becoming aware of the issues but as the year progressed they internalised the beliefs about the benefits of writing for students' mathematical learning.

The teachers were asked about the modes they had expected students to use and whether this was a different range from what they had taught previously. Table 9 sets out the modes and/or genres that teachers said they used in the survey, as well as the modes identified in Table 8 of Chapter 7. It also gives a summary of the reasons why teachers thought that they had increased, or not, the modes/genres they had expected students to use. It was decided to include the list of modes from two sources. Completing a survey at the end of a year, during a meeting, can mean that teachers may have not recalled all of the modes they had taught or used with students. The list of topics covered in the first column, that came from Table 8 in Chapter 7, often provides a richer understanding of the variety of modes covered by the teacher than their own recall of what they covered.

Table 4 **Teachers' beliefs about the modes and/or genres they expected students to use**

Teacher and year level	**Modes that students had used from Table 1 Chapter 6**	**Modes that teachers believed they had students use in 2007**	**Is this a different range than 2006?**	**Reasons for differences or not in range**
T3 in Tau 1	Time, number, pattern, tally, probability, calculations, shapes, transformation	Pictures, symbols, writing, numbers	Yes	It's been more focused—children are being made to attend, rather than take part and participate.

T6 in Tau 2	Time, shape, problem solving, fraction, transformation, calculations	Geometry, number, algebra, explanations, drawings, graphs	No	Not a different range but we did a lot more writing this year.
T8 in Tau 3	Time, number, patterns, relation graphs, stats graphs, probability, transformation	Graphs, symbols, explanations, diagrams	Yes	Made some attempt to think about writing. Develop some examples. Hadn't focused on writing before.
T1 in Tau 4	Number, shape, relation graph, stats graph, fraction, calculations, shapes, transformation	Explanation, report, narrative	Yes	Attempting things a lot more and thinking of ways to get understanding out of the children (what genre would suit).
T10 in Tau 5	Number, fraction, stats graph, calculations, probability, fractions	Graphs, tally charts, word problems, justification, explanations/ descriptions	Yes	Due to my own raised awareness of the value of writing in maths—(because of this project).
T7 in Tau 6	Shape, problem solving, probability, transformation	Symbols, graphs, explanations	No	Ultimately all aspects are utilised on a yearly basis.
T5 in Tau 7	Time, calculations, stats graph, word problems, patterns, Cartesian graphs, shape, angles, fraction, proportion, measurement, fraction, transformation	Graphs, vectors, writing equations, Cartesian graphs, nets, 2D polygons, 3D polygons, transformations, cartoons, tables	Yes	Involvement with the research project.
T2 in Tau 8	Time, calculations, measurement, shape, geometry, angle, transformation, probability	Algorithms (graphs, diagrams, equations), questions to answer, explanations, survey questions	Yes/No, depends	The upper levels require "deep" or "explanations" to clarify solutions.
T9 in Tau 11	Problem solving, measurement, calculations, transformation, algebra, isometric drawing, geometric constructions, Cartesian graphs, Pythagoras, angle	Besides constructions and symbols used in equations, most writing has involved self-regulating instructions.	Yes	I had started to concentrate too much on symbols and relied too much on class conversation to develop vocabulary.

It is clear from Table 9 that all of the teachers had used a range of different modes. However, it was interesting to note the number of teachers who mentioned explanations. This suggests it was a genre that they felt was useful for students to master. This is confirmed in the reasons for making changes with what they had done the previous year. In the answers to the survey question on this issue, several teachers mentioned that they were interested in students describing their thinking. Another reason given was participating in the research project had contributed to them increasing the range of modes and/or genres that they expected students to use.

The first question in the survey had asked why the teachers had felt that students should write in mathematics. Many of these answers were directly connected to either having students provide an insight into their thought processes or that they helped the students clarify their thinking. For example, T8 wrote "so they can articulate their understanding and we can see their thought processes (whether correct or incorrect)". T10 wrote "to consolidate understanding—writing requires justifying answers as well as further thinking so that they realise writing is also a significant part of maths".

Questions 9, 10 and 11 were about the new practices that teachers had tried in 2007. The results for this are outlined in Table 10.

Table 5 **New teaching practices in 2007**

Teacher and year level	What were the new practices that were tried in 2007?	Why were these practices tried?	How do you know if they were effective?
T3 in Tau 1	Explained and clarified what was expected of them in more simple and easier to understand language.	Children weren't really getting the gist of what was required from them.	Children gave and showed clear understanding or better understanding using pictures, words, numbers and symbols.
T6 in Tau 2	I try to explain things more clearly and I also write it out for them. We also write achievement objectives for the lesson for all of us to see.	I thought it would make things easier for the students as well as good modelling.	By this term (Term 4) the students are used to writing out their explanations with less help.
T8 in Tau 3	Presenting questions so that they would write their understanding. State what we are writing.	Was one way I thought may assist.	Not sure that it did other than they did start writing their ideas down.
T1 in Tau 4	Words around the classroom, new vocabulary in books, ideas of how to write things.	To see if by making sure that there was a build up of vocabulary. Then explanations would be easier.	As the year has gone on children can write more. Those that can only do a sentence, there is more depth in it.
T10 in Tau 5	Making them justify answers orally and then through writing. Making more displays and adding explanations.	First was done following suggestions. Second was adopted as a simple way to try to encourage writing.	* Feedback * Reo was being used in everyday situations following a unit. Their recall was stronger.
T7 in Tau 6	Creating a set writing plan to help students.	The need for explanations to be more specific, descriptive, and also to see inner strategies of students.	Seeing students being able to write at length and then being able to present.
T5 in Tau 7	Writing with words, nets.	Initially because of the project and later so they HAD to clarify their ideas.	Explanations they gave, and understanding gained.
T2 in Tau 8	Not much more.		
T9 in Tau 11	Using models for instructions including numerals, arrows etc. to supplement words.	To ensure that the writing task didn't drown the understanding required, i.e., in case the task got too big.	Students inform me that they return to their "instructions" or at least I direct them there.

Apart from T2 who had always used a range of writing activities with her mathematics classes, all of the other teachers had tried some new ways to support students' writing in mathematics. These teachers felt that these new practices had been effective in either increasing the quantity and/or the quality of students' writing. For example, T3 felt that her Tau 1 students were able to give a clearer description of their understanding using a range of modes. In the meeting in November, T8 described why she felt that the whole kura should introduce RAVE, as a way to support students' writing:

> I think we would be silly not to introduce the RAVE thing. It gives you a bit more direction and some of us have introduced it this year and it does make a hell of a lot of difference as to giving you a bit more direction, not so much to your teaching, but your end result of how much your kids produce. I have seen a great change in my kids and they are only Year 3s. I am amazed with some

of them, the amount of words they learned just in a three-week period and the amount of writing they did. It might only be a sentence but it is rich. (Meeting November 2007)

However, this impact was not immediate, with many teachers suggesting that it had taken students some time to get to the point of being able to write explanations. In Chapter 7, students had suggested that writing in words was their least favourite type of mathematical writing. It may be that part of this reason was that it took some time before students had enough fluency in being able to write descriptions, explanations or justification to gain the benefits for their own thinking. Therefore, although the teachers saw this as valuable, the students did not see the same value until many months after they had been engaged in these activities, if at all.

The teachers believed participation in the project had resulted in their trying different approaches to the teaching of writing in mathematics. For some of them, the project had made them aware of the importance of writing in mathematics. T3 wrote in her survey, “I learnt how important children’s ability to express themselves clearly was through whatever genre they choose.” For others, being involved in the project had given them insights into their students’ language and/or their mathematical thinking. The process of gaining these insights is covered in the next sections.

Project outline

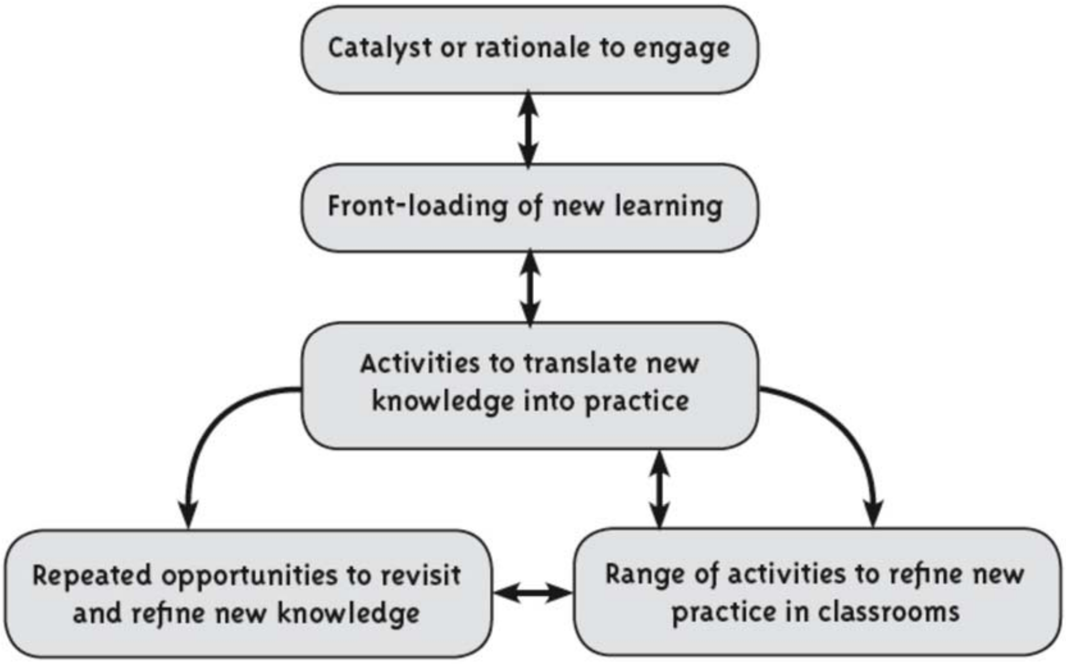
There were several strands of this project that provided experiences to teachers. All of these strands contributed to teachers learning something about their own teaching as well as about their students’ learning. T6 stated that the project had made her think about mathematics and the role of writing in it:

> Thing is, it’s made me think about how much writing we do in maths. Because before, I’d never actually thought of it as writing. Golly gosh, it’s maths sort of thing, I’d never really thought about it as being a written language or anything. So for myself as a kaiako [teacher], it has made me think about it. (Interview November 2007)

This project was significantly different from that of professional development projects such as Te Poutama Tau in that there was no set content or pedagogy that teachers were expected to access or gain. Professional development projects where there is set content to be covered have a process similar to that outlined in Figure 69. When there is knowledge or pedagogy that is seen as best practice, then it is imperative for teachers to be given this knowledge as soon as possible. Without it, teachers would have nothing to trial or reflect on. In our case, we had little previous research to draw upon to help us decide on what was best practice.

In a project such as She’ll be Write! the teachers and the researchers had identified a problem—that students were doing little writing in mathematics—but had no ready-made solution to implement. This then required all of us, teachers and researchers, to share current and past practices and to document implementation of any new practices. It also involved discussions about the contribution that writing could make to students’ mathematical learning.

Figure 44 **Typical sequence of professional learning opportunities from Timperley et al. (2007, p. xxxviii)**



Apart from one project in the United States (see Doerr & Chandler-Olcott, in press), this was an area where little work had been done previously although writing in mathematics was strongly supported by curriculum documents. As Doerr and Chandler-Olcott (in press) noted, the National Council of Teachers of Mathematics (2000) "*Standards* offer little sense of how writing activities might fit together or how students' writing might develop across tasks and over time". The Doerr and Chandler-Olcott project was ongoing at the same time as our own project and so there was little information about this available until Helen Doerr visited New Zealand in September 2007. Although her visit provided valuable input such as the writing strategy of RAVE, which was described in Chapter 6, our project was already well underway.

Our approach centred around a set of regular meetings and these formed the backbone for sharing ideas and planning for implementation. Usually each one had a theme and that became the focus for the discussions. Table 11 sets out the meetings with their focus and their outcomes.

Table 6 **She'll be Write! meetings**

Date	Theme	Outcome
30/8/06	**Setting up** Discussing parameters for the project. Sharing some mathematical writing practices by TM.	Series of research questions developed. Timeline for the research.
13/3/07	**Genres** Sorting mathematical writing samples into genres by teachers. Discussion about the writing that students were currently doing at the kura.	Genres identified and named.
6/6/07	**Benefits of writing in mathematics** Strategy game used as a stimulus for discussion about having students write was beneficial to their learning. Sharing by teachers of writing activities that they had implemented in their classrooms.	Document that is now included in Chapter 6.
5/9/07	**Progressions of writing samples** Writing samples from initial topic progressions were	Initial placement of samples on

	placed by teachers into year-level progressions. Discussion about quality of students' mathematical writing. Sharing by teachers of writing activities that they had implemented in their classrooms.	year-level progressions. This process is described in Chapter 4. Summary of strategies teachers used for supporting writing collated and sent to teachers. These strategies are discussed in Chapter 6.
5/11/07	**Summing up** Sharing by teachers of writing activities that they had implemented in their classrooms. Discussion of future directions for the project.	Decision for all classes to implement RAVE in 2008 into their mathematical writing.

As well as these in-house sessions, the teachers also attended the New Zealand Mathematics Teachers Conference, NZAMT10, in September 2007. This allowed them several days to discuss not just the sessions they attended but also how the information they had heard related to She'll be Write!. T10 stated:

> I was quite excited when I got back. Two things happened for me. Understood what you are doing for the school here in trying to get us to write more. I came away thinking that Helen [Doerr]'s programme was what we needed to achieve, what you were asking us to do. It really made sense to me then. What we should have done was grabbed her and taken her to a classroom and thrashed it out. How do you start? What practical things do you do? As a team, we could have taken a better opportunity with her. I thought it was great opportunity having her there but also a great opportunity lost. (Interview November 2007)

An analysis of the teachers' attendance at NZAMT10 is discussed in more detail in Meaney, Trinick, and Fairhall (in press).

It was clear from comments in the interviews that the teachers were also discussing the mathematics learning of the students in between these meetings. For example, the teachers who had not been able to attend NZAMT10 were provided with details about it from others who had attended. T1 told how T10 had described two ideas that she had gained from the conference. The first one was to use a passport to record students' progress in learning their basic facts. The second one was the use of RAVE.

For the principal, T9, the main gain from having the teachers engage in this project had been that he now had a staff who were happy to discuss mathematics teaching. In his survey, in answer to the question "What had been the most interesting thing for you about being involved in the project?", he wrote, "enjoying the development of staff, leading to more conversations about maths". Until the original TLRI project had begun, this had not been the case. New staff who join the kura are quickly inducted into what is expected of them. This can be daunting especially for beginning teachers (two of whom started at the kura during the three-year project). However, it is now an established part of what being a teacher involves at this kura. Timperley et al. (2007) describe the necessity of having institutional support if a project is to be sustained beyond the initial intervention period.

Teacher inquiry and knowledge-building cycle

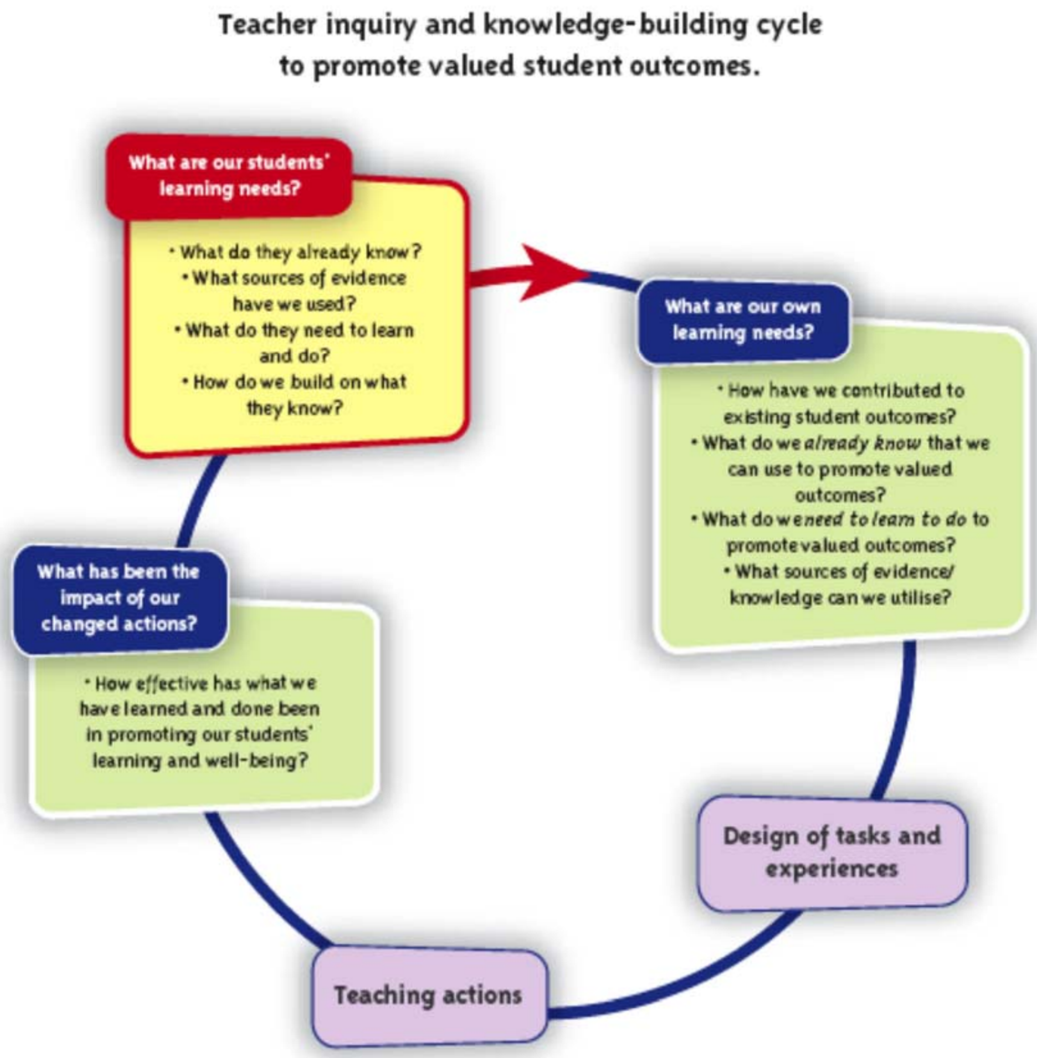
We therefore used many of the same sort of steps as were outlined in Figure 69 but did not have any front loading of new material. We had identified the issue of wanting to increase the amount of writing that students did in mathematics. This issue had been chosen because some of us initially, and all of us eventually, believed it would have an impact on the students' ability to think mathematically. However, our approach was exploratory with much discussion based on the teachers' reflection about their own practice. New practices were instigated and then reflected upon again. As T10 stated:

> If we don't hook on to some strategies that we believe will work and change classroom practice then we won't do anything. You won't see the change that we want. And that's what you want to happen. You want the shift in classroom practice. (Interview November 2007)

It therefore seemed that rather than Figure 69 being typical of what was done during this professional development project, Figure 70 better describes the professional learning that occurred during the project. Figure 70 shows professional learning as a continual cycle of reflecting and implementing new practices. Timperley et al. (2007) described the underlying idea of the cycle as "co- and self-regulatory", by which they meant "that teachers collectively and individually identify important issues, become the drivers for acquiring the knowledge they need to solve them, monitor the impact of their actions, and adjust their practice accordingly" (p. xlii). In order to do this, teachers need to identify students' and teachers' learning needs before moving on to considering designing and implementing teaching activities. The learning needs form the goals that teachers would aim to achieve as a result of participating in the inquiry cycle.

This model has significant correlation with ideas on praxis that were outlined by Freire (1996). Within praxis, action cannot occur without reflection. Reflection needs to happen simultaneously and continually with action and this will result not just in changes to action but in changes to the reflection itself and the knowledge base from which it was drawing (Carr & Kemmis, 1983). Action should be based on thinking about why it was needed and the consequences of following it through. As a result, some of the understanding about the initial situation and the new developing one will be changed and this would also result in further action being needed.

Figure 45 **Teacher inquiry and knowledge-building cycle, from Timperley et al. (2007, inside front cover)**



The following sections discuss three issues that arose during the course of the project. Each of the stages of the inquiry model is used as a starting point to analyse what occurred. However, these sections do not provide a chronological sequence of events because each of the stages was revisited several times and became important to individual teachers at different times. Consequently, although the kura worked on the project as a whole, each teacher was at different stages of this cycle at different times as they considered what was happening in their individual classrooms.

Developing progressions

The topic and year-level progressions that were discussed in Chapter 4 had been developed as a result of an identified need from the last TLRI project, Te Reo Tātaitai (Meaney et al., 2007). However, although the teachers had been engaged in putting them together, few of them knew what to do with them.

Identifying student learning needs

Teachers felt that students often struggled with a topic when they had not covered it for several years. It was not just that students had to recall knowledge and vocabulary but sometimes what they had been taught was phrased in very different ways from how their current teacher was approaching the topic. In the following extract, T2 discusses the usefulness of having the year-level progressions. For her, they were necessary to ensure that there was a steady build up in ideas over the time a child was in the kura:

> T: The research is supposed to feed back into this. We have the writing progressions which is quite useful when we put it into year levels and they had to think about who is introducing what.
>
> T2: And we wouldn't have known that if you hadn't come into the picture. I don't think anybody knows until somebody from the outside comes into the picture and says there is a flow on.
>
> T: It was one of the things that came out of that previous project; people wanted to get a sense of how things developed and where they came from.
>
> T2: And where they came from. Mmmm . . . think with writing it's what you were expecting of the kids. You were doing a lesson. This is what you have to do and that is how they do it. Something like the probability strand. It's where it's common sense and you can't see where their thinking is. It is very hard for many. It's probably a process that needs to be worked up from the bottom . . . all of a sudden you have probability. The last time you had probability was in Year 5. You are in Year 10. It is quite a long way, you know, the way of thinking. (T2 Interview November 2007)

It was, therefore, important to be aware of students' learning needs in this area and take advantage of the information provided in the year-level progressions so that students' learning could be co-ordinated.

Identifying teacher learning needs

The teachers identified that they also did not necessarily have the information to know where the students would go with their mathematics learning:

> We have a little bit of flow about where we want to get our kids to up to Year 6 so that we are covering specific things like, so, like, in Year 2 we cover this, so that they will know that by Year 3. But we, I don't know where my kids need to go to get up to T5's stages. I've no idea what they do up there. And they're like 'Oh, you were in high school', yeah, like 10 years ago. So if we could set those things up. (T6, Interview November 2007)

T6 was very pleased to have the progressions as she saw them as one way to fill in her own lack of knowledge.

Designing tasks and experiences

Although she was yet to use the progressions in this way, T3 felt that they would be useful in helping to design programmes for the students:

> We don't want to compartmentalise anybody but at least we've got a benchmark to look at. Okay, this looks okay for my kids. I would like my tamariki [children] to get to this in terms of the writing in maths. Those that can't, they can't but you have got somewhere to go and have a look and get an idea as to where you should be at. But it's not about boxing them, ae? You don't want to be doing that either but I think it's good to know where and if you're progressing.

The progressions were therefore seen as a way to highlight what students needed to achieve.

Implementing teaching actions

There was discussion about how the progressions could be used. T7 had discussed how they could do the writing in mathematics across the year levels with his wife who worked at another school:

> My wife she says it is very difficult at [her] school because they have this ultimatum, we think this is what they should have when the leave [primary school] and she was talking about the kura and she said it is a great opportunity that we have because we've got wharekura, Year 0 to 13. Now what do we want our stakeholders what do we want them to look at by the time they reach [T9]? Ultimately if we went backwards from what [T9] wants down each of the years what each person should implement and the steps increment as they go up so that ultimately he's not having to try and do basically what should have been done in Year 7 or Year 5. So what does it look like at that end and go backwards from there then you know what Year 0 looks like.

However, T8 saw it differently. She felt that there were too many differences between the senior and junior sections of the kura and this made it difficult to co-ordinate what was done at all the year levels:

> We are all in a unique situation where we can all link together but it can't be wharekura dictated like they hoped because we have our structure in place. That gives the kids coverage. You have to teach the kids all those things. [T9, T2 and T5], this year have been more than happy to jump on board . . . We all did that triangle unit [in 2006] and it worked really well but that's not always going to happen. It doesn't have to happen every term because they are doing unit standards and we're not. We are giving the coverage. We can't have dictation from the wharekura and we can't dictate to the wharekura. There might be just one unit that as a collective we can all do.

The progressions, therefore, had potential to support the kura in providing a co-ordinated coverage but more discussion would need to occur if this were to happen.

Reflecting on the impact of changed teaching actions

In the surveys, teachers mentioned that there was a need for benchmarks and exemplars to show the teachers and the students what were good pieces of writing in different topics. This means that the progressions would need to be developed further or reworked so that teachers could gain some more value from having them as reference material for their planning.

Explanations

One of the benefits that teachers saw in having students do more writing in mathematics was that it would encourage them to give better explanations of their thinking. T7 wrote in his survey that "[writing] helps them to explain their answers a lot clearer. It allows them in their own words to describe exactly what strategies they are using." There was a lot of ongoing discussion about how to ensure that students did improve their ability to write clear explanations. This involved teachers concentrating on the deeper acts of writing that were discussed in Chapter 6. At the end of the year, the teachers were still grappling with helping students improve in this area.

Identifying student learning needs

Teachers felt this was an area their students needed to improve on. Since his original involvement in the project in Term 4, 2005, T7 had grappled with his students saying they "guessed" when he asked them how they got their answers. He had worked consistently on supporting students to give more appropriate explanations. Writing became one way of doing this, because it was permanent and could be referred to many times (Minutes September 2007).

T8 wrote in her survey that students needed to give "more explanations on how they know something is what it is or how to work something out" (T8, Survey November 2007). There was a recognition by some teachers that students were much better at giving oral descriptions than written ones. T8 felt that some students had an expectation that maths writing was about writing numbers or doing graphs and that they needed to be aware that writing was a part of learning mathematics (Minutes September 2007). This would correlate with the finding from the previous chapter that showed that writing narratives was students' least favourite mathematical writing. It is likely that these students needed to see some value in what they were doing.

Identifying teacher learning needs

In the September staff meeting, T10 stated that as a consequence of watching the video of her mathematics lesson, she became aware that she never asked children to write down what they knew for Poutama Tau. She felt that if she were able to do this, it would help cement some of what they were learning. It would also mean that the next day they would have something to refer to if they forgot. This is especially true for multiplication strategies. Often there will be an oral discussion but she had not up to that point got them to write anything down.

However, T10 struggled with how to get students to write down their explanations. In November, she discussed why she wanted to implement RAVE as a consequence of attending NZAMT10. As was described in Chapter 6, RAVE provides guidelines for students to write explanations. She described her initial involvement in the project as something like being in a lolly shop:

> actually I was plucking any out of the air that I thought might work, while I feel I am someone who has been to the lolly shop and I know exactly what it tastes like and I want to try it. (Meeting November 2007)

However, she was unsure that she was having an impact on students' explanations:

> I thought I was being a part of something, I didn't know if I was contributing, but if we went with that [RAVE] I could see myself contributing. I could make a difference. I am not sure I was really making a difference. I was teaching the best I could but I didn't have any new strategies that could help that writing component. (T10, Interview November 2007)

Identifying teachers' learning needs to be connected with different possibilities for supporting this learning. This teacher recognised what she wanted to improve in her practice but this did not lead her immediately to adopting any different teaching practices, even when they were suggested by others. For her it was a matter of discovering a teaching approach that resonated with her current teaching practices. RAVE became the new approach that she wanted to implement.

Designing tasks and experiences

RAVE had been something that was promoted by some of the teachers. Although the teachers could see that RAVE had value, they understood that it was beneficial only if it was adapted to meet their students' needs. The following extract comes from T8's interview:

> T8: Helen had some great things to say. There was only a core bit of her korero [talk] that related to us or that could be used. RAVE is what we have taken from it, Getting used to justifying themselves.
>
> T: That isn't part of RAVE; that's the movement here.
>
> T8: We've not really taken the RAVE, we are making up our own. And we have to be aware of that. RAVE is a guideline. We must be careful not to get stuck into that.

The age of the students would also have an impact on how the RAVE equivalent would be implemented by the teachers. T6 felt that it would need to be modified if it were to be useful for her Tau 2 students:

> It sounds like it would be good for the seniors, like even the Year 6s sound like they were doing really well with it and the Year 5s do well, I think. Yeah but I don't think my babies would be able to, unless we simplify it. (Interview November 2007)

Young students who are just beginning to write could well find the demands of responding to RAVE too much. Therefore, a modified version would need to be put together that would support the writing of explanations for this year level.

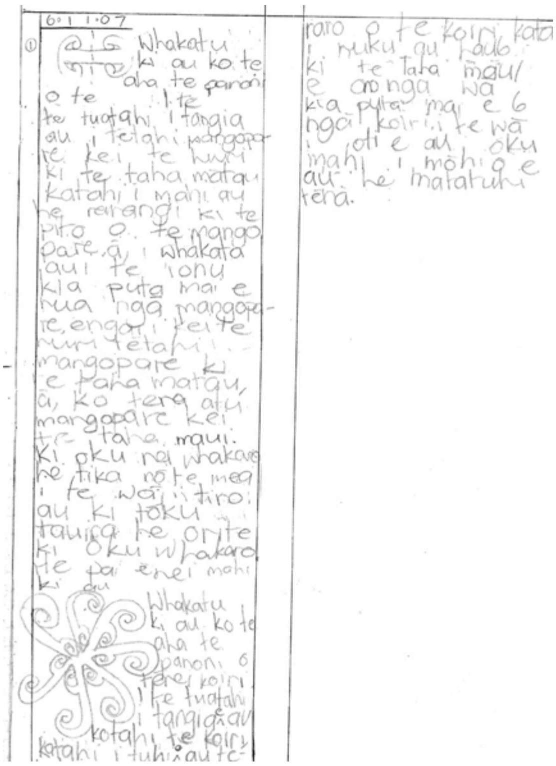
Implementing teaching actions

Different teachers were implementing different strategies in order to support students' writing of explanations. In order to support students moving from oral explanations to written explanations, some of the teachers in the junior section of the kura were writing down students' explanations for them. For example, in the November staff meeting, T1 stated that, "You can write what they say in their own words too; asking them to explain something, you can do the writing for them." This gave these students' exemplars to follow while at the same time valuing the students' own ideas.

T7 had been working with his students on improving their explanations for some time. In the last term, he had used a version of RAVE with his students. An example of his student's explanation is provided in Figure 71. T7 described how he had implemented different activities to support students' writing of explanations:

What I've been producing and role modelling and then getting them to design their own. Then they read all their stuff out and one boy read his out and his answer was quite good which was surprising for him. He said he took it home and his Mum helped him out . . . in terms of explaining what he was trying to say. Straight away in the question, it was a good example for everyone to follow. Read his out and I made everyone look back at their own to see similarities between theirs and his. The whole of them said no there were no similarities . . . Even they could see the value of it to work at their own level. (Interview November 2007)

Figure 46 **T7’s student’s explanation of transformations**



6.11.07
I thought, what is a transformation? Initially I drew a mangopare and turned it to the right, then I drew a line for the edge of the mangopare, then I drew 2 mangopare, but 1 mangopare was to the right, the other mangopare was on the left side. It think it is correct when I look at my example the same. I like doing this work.

I thought what is the transformation of the koiri. First I drew one koiri then I drew another below. I shifted a sixth to the left side and drew 6 more koiri. I know this is an image.

By having students compare their explanations with a good piece of writing, students were able to assess for themselves what features would improve their explanations. This is a very important component of making students responsible for their own learning. It was interesting that this piece of writing was produced after the student talked with his mother about it. Although students would be able to ask their parents for help with their mathematics homework, few parents would be able to talk about the mathematics ideas in te reo Māori. This is because many parents either do not speak te reo Māori or were never taught mathematics through it. Consequently they were only able to talk about mathematics in English.

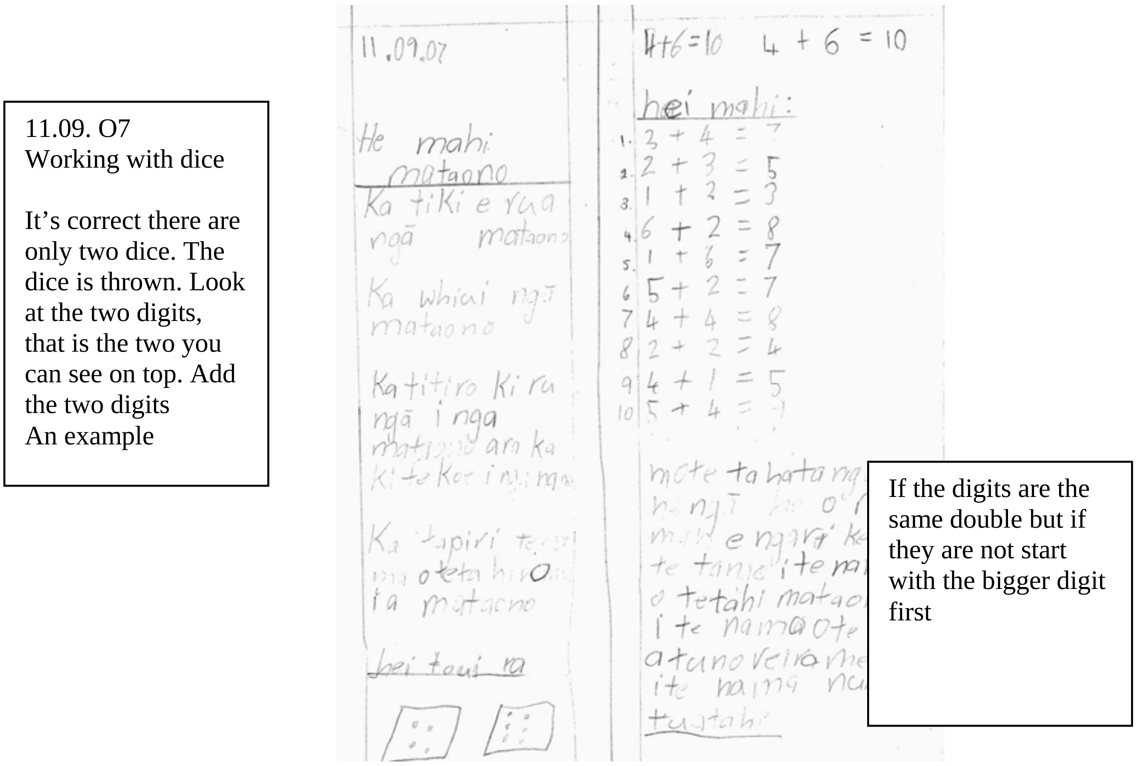
Reflecting on the impact of changed teaching actions

Having students produce written explanations was seen as valuable by the teachers so there was a lot of reflection about the different strategies that various teachers had tried. T1 described how she felt her concentration on having students explain their answers had made a difference to their understanding of mathematical ideas:

But it has been more in my mind when I am trying to get them to explain things to me. Even today it was quite good. I was more aware and that's one of the best things of the project. They need to give me things and explain what they are doing. We've done lots even for basic facts—How do you get it? Why do you get it? They are really good with their place values. They know they are taking a 10 from here and putting it [there]. They can say those things. (Interview November 2007)

The Tau 2 teacher, T6, had already begun having her class write out in words how they would say the symbolic number sentences. An example of this can be seen in Figure 72.

Figure 47 **T3 student's explanation of addition sums**



In describing her impressions of the project, she made the following comment about what she had done to support students explain their thinking in te reo Māori:

They have to write out words. And I think that's worked for my top group because they actually had to think about what they were doing and how they were going to explain it. Before, when we did the whole tāpiri (addition) thing, they'd just go, 'four plus five equals nine' but they're, now, they've had to actually think about how they're going to say it. And what I was getting my kids to do was to try to explain what they were doing, without giving the answer but explain it in a way that somebody else could follow just what they had written. It's quite hard. (T6, Interview November 2007)

T7 had been the teacher who had been the most successful at trying RAVE in his classroom. It was in the process of trying it out that he had made modifications to it:

T: So it was the process of writing that forced their thinking?

T7: Some of them got it wrong but they justified their answer. How come they ended up with it. Then at the end we added another bit where they look at it and say what they thought of it. I thought, why not have a go and see how it ends up? Have a dive in and have a look. I was noticing if I asked them how they got their answer, the answer had been, I just know, I just did it and it came out like this. Now they justify everything they've done, explain to me where they put the rawini tamariki.(?) (Meeting November 2007)

Reflecting on what had happened when he had asked students to explain their answers, T7 found that students were able to justify what it was that they had done. Consequently, he had asked the students to evaluate their explanations and justifications. For this teacher, reflecting on his practice meant that he implemented new practices, not because he felt that the previous one had been inappropriate but because he felt that the students could be pushed further in their mathematical thinking.

Students' use of te reo Māori in pieces of mathematical writing

Improving students' grammar and vocabulary was a concentration on superficial acts of writing as discussed in Chapter 6. These improvements in themselves would not guarantee that students became better at thinking about mathematics. However, the teachers felt that without fluent control of the language the students would struggle with being able to express their thinking clearly and thus gain the advantages to their mathematical thinking.

As a kura kaupapa Māori, the focus was always on ensuring that students use appropriate reo Māori to express themselves. There was also a recognition that they needed to gain the vocabulary necessary for discussing a topic. In the previous chapter, the majority of students said that they at least sometimes struggled to find the appropriate term in te reo Māori when writing in mathematics. As most students were second-language learners, the teachers needed to ensure that students were given support to improve their fluency in the language even while learning mathematics.

Identifying student learning needs

There was much discussion about students having embedded errors in their use of te reo Māori. For example, T9 highlighted that many students continued to use "e" as a verb marker even when they used the passive tense.

T5 found it difficult to have students do writing in mathematics when he knew that their reo Māori was not grammatically correct. He felt that the students were fluent in te reo Māori but their thought patterns were in English and so their reo Māori reflected this. As second-language learners of te reo Māori, students can be expected to have interference from their first language, English. However, one of Doerr and Chandler-Olcott's (in press) teachers in their research project also felt that she was not doing enough writing in her mathematics class because of students' poor written communication skills.

T2 also felt that there were issues with students' writing about mathematics in te reo Māori. In her survey, she commented on the students' omission of grammatical markers when they were writing in mathematics. She went on to state, "even if they have a little to say, [grammar] is important to everything written". She felt that students were not thinking about the best way to express their ideas. It was if students believed that it was sufficient to put down all their ideas in words without needing to ensure that someone else could follow it.

At the junior end of the kura, the teachers were aware of the students' need for appropriate vocabulary:

> The vocab is the be all and end all, for the Year 3s. If they haven't got the vocab they are not going to get anything out. That has been my focus all year. If you look at my books for any new whenu [topic] that we do it has kupu hou [vocabulary list]. There might not have been anything that jumped out at them that they thought was kupu hou. If they thought this word was new it was up to them to write it so it's not just you dictating, it was a natural process happening and realising it themselves. From the vocab you are going to get some writing. (T8, Interview November 2007)

The teachers had identified a number of learning needs of their students. In some cases, these learning needs were seen as a barrier to having students do any writing at all. However, by working with these students, teachers found that the writing became an opportunity for increasing students' fluency in te reo Māori.

Identifying teacher learning needs

The teachers identified knowledge and pedagogy gaps in their own understandings about writing in mathematics. These then also became a focus for finding ways to fill those gaps.

Most of the teachers themselves had not been taught mathematics in te reo Māori. This meant that they often had to learn new vocabulary at the same time as they were expected to teach it. For example, T1 stated:

> I chased my tail for my āhuahanga [geometry] unit. I came to you [T9] asking how to do the rotation. When I came upon it, I didn't know how to say to them, clockwise, anti-clockwise, and all that. So I should have had that at the beginning.

Another issue was knowing what constituted a good piece of writing. T8 felt that this was an issue for many of the teachers. She felt that it was important for the teacher to ask themselves questions such as, "What were your expectations? Were you satisfied with a sentence? Were you hoping for a paragraph? If that was your expectation, what did you do? We have got to get out of just getting a sample and being satisfied with that" (T8, Interview November 2007). Therefore, teachers needed to be able to reflect on their expectations of students' writing and be more explicit with these expectations with students.

T3 could identify that providing students with appropriate reo Māori was not a simple task for teachers because there was a risk that they could restrict rather than support students' fluency in the language:

> I am happy so long as it is not too false about putting the language into these kids. It is about their own experiences, their own knowledge and their own language . . . just putting it slowly into them so it fills their vocabulary so they have that ability and freedom to be able to use it when they need it. Otherwise I just don't want to be teaching this language and the kids not knowing where they are. So it is up to us to make sure that we put it into them carefully and considerately because each one comes with different situations from home so we just have to be careful how we put that language to them. (Interview November 2007)

In having students discuss their emerging mathematical understandings, there is always a tension between encouraging students to use their everyday language so that they are fluent and encouraging them to use the appropriate aspects of the mathematics register that they are still acquiring (Meaney, 2005). Although te reo tātaitai, the mathematics register in te reo Māori, will provide students eventually with succinct, informative ways to describe ideas, being forced to use it before they have fully mastered it may limit their ability to discuss the mathematical understandings.

Designing tasks and experiences

At the November staff meeting, there was discussion about having students repetitively copy grammatical expressions that came up frequently. T9 had done this regularly in his previous school as a way of reducing a number of inherent errors in the students' reo Māori. He stated that the first 20 pages of his high school students' workbooks were filled with writing. This meant that passive voice was reinforced in describing mathematical sentences. By the time the students had completed all of this writing, their reo Māori was much improved. Although he had not done this in recent years, he feels that it is important to begin doing it again. T5 also decided to start the next year by having students write a lot so that the correct structures were drilled into them.

In the September staff meeting, T1 described how she had made more of an effort to put more work and words around the room. She recognised that for some students the transition into writing was quite difficult. So she listened to what students said and then wrote it down for them. Then she put the writing on the wall and reminded students that it was there in subsequent discussions. She also put up some of the things that she said so as to provide another model.

Implementing teaching actions

However, there was a recognition that ensuring a whole-kura approach to this issue needed a lot of organisation:

> There's a lot of correction that needs to be done, but that's throughout their whole programme, not just in maths. And it's like the lack of vocabulary that they've had up till now. But, they're only six-year-olds, their second year of school, but they know the basics of tāpiri [addition] and things like that. It's more the grammar that they're finding hard. I got what T9 was talking about though because it's showing up in Year 2 now, the gaps and things like that. I think that while we were talking, well as everyone else was talking in the hui, they were saying 'we have to work together' and all this stuff and we always say that in every hui that we have but nothing ever gets done . . . And we've actually scheduled to meet but like maths meetings they always get shifted or they get cancelled. But it would be awesome if we actually sat down and did it, because I know that would help me a lot. I mean we sort of do that in junior school. (T6, Interview November 2007)

Several of the teachers had explicitly provided students with a vocabulary list to accompany units of work. For example, T7 provided a specific vocabulary list for the unit on probability because he felt that students needed explicit teaching of these terms (Minutes September 2007). On the other hand, as was mentioned earlier, T8 encouraged students to keep their own vocabulary lists where they had decided themselves what to include.

To support students' acquisition of appropriate reo Māori expressions, T8 related how T3's, T1's and her own class all learnt a series of sentence structures for mathematics. They concentrated on these sentence structures for three weeks and the children were still using them (Minutes September 2007).

Several of the teachers also tried to make connections between the mathematics that students were learning and other experiences they had. For example, in T5's video of a lesson on measurement he asked about different units of measures and the things that students had measured in them. At one stage he suggested that a book was a block of chocolate and asked how many were needed to cover a table. Although the students could give him an answer of 11, they also made it clear that blocks of chocolate were never that big, even at the Warehouse. T7 talked about how he had made use of an idea from another teacher in order to explain the concept of transformations:

> The first week is learning the concept, learning what that actually means if you can utilise things from their own world like [T10] was saying last night, like transformers. I could explain how it would transform from a car into a human. Yeah. Transformers, yep. Utilising that sort of imagery they can understand. Ultimately getting them to look at something that has been translated or transformed or whatever. Look at the end product which has a separate name altogether, the transformed whatever. But the process is the transformation.

Implementing different teaching approaches was necessary to meet the diverse learning needs of the students. In the process, teachers also learnt about different pedagogical strategies as well as te reo tātaitai (the mathematics register).

Reflecting on the impact of changed teaching actions

Implementation of different strategies resulted in reflections on many of these strategies. T8 felt that one of the advantages of teaching mathematics in the junior part of the kura was that it was possible to use a thematic approach so that mathematics writing could be incorporated into the language lessons. However, T1 also thought that there was a need for more team planning as a consequence of her realising her lack of vocabulary when teaching the transformation unit:

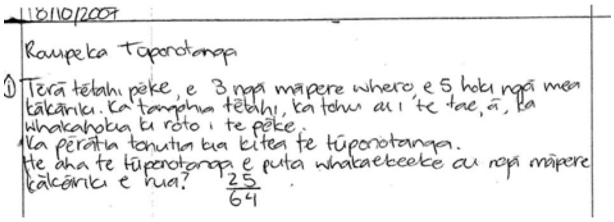
> So my classroom practice would mean me being a bit more onto it and going through things and knowing how to say this and this and having [the vocabulary] ready and since we are all doing the same kaupapa [knowledge base] we should all be using them. Perhaps we could do it together, a bit more team planning. (Meeting November 2007)

In the senior classes, T9 had implemented a policy of having students write rules in their own words and then having them discuss them with him. This allowed him to work on their general reo Māori but also improved the students' language abilities:

> You will see in those notebooks [students' workbooks] what happened is, by increasing the writing, their vocal ability got a lot better. You can explain something to them and they will do it but I am not sure what's going on in their heads. I know we don't need to know exactly what's going on in their heads but what I am talking about is what, the words they're doing from one part to add on to another part. So when it comes to explaining it stays in the picture . . . so you'll notice near the end that in the last month or so with that level ones [Tau 11 students], I'll give them something then they've got to go down and write down what's the rule. If it has been a show-and-tell sort of thing, go down, write the rule, bring it back, lets discuss it, and I'll say something such as, 'That means to me that I start up here' and they will say, 'No, no, you are meant to start down here'. So, [I ask them] 'Why use 'Kei'? You should be using 'e'. So I know to go from here to there. Little things like that.' (Meeting November 2007)

Two examples of his students' writing about probability are given in Figure 73.

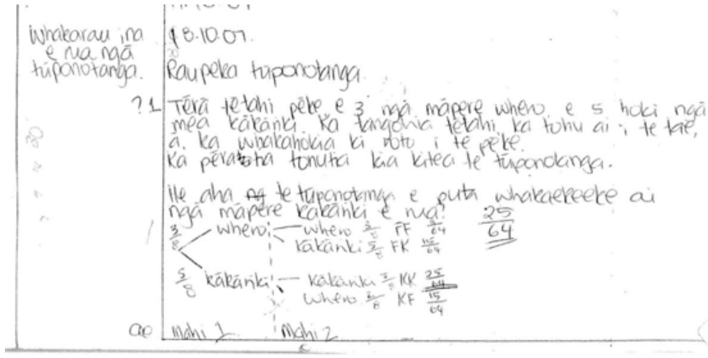
Figure 48 **Two examples of Tau 11 students' writing about probability**



18/10/2007

Raupeka Tūponotanga

1 Tērā tētahi pēke, e 3 ngā māpere whero, e 5 hoki ngā mea kākāriki. Ka tangohia tētahi, ka tohu ai i te tae, ā, ka whakahokia ki roto i te pēke.
Ka pērātia tonutia kia kitea te tūponotanga.
He aha te tūponotanga e puta whakaeteeke ai ngā māpere kākāriki e rua? 25/64



Whakarau i na e rua ngā tūponotanga.

18.10.07.

Raupeka tūponotanga

?1 Tērā tētahi pēke e 3 ngā māpere whero e 5 hoki ngā mea kākāriki. Ka tangohia tētahi, ka tohu ai i te tae, ā. ka whakahokia ki roto i te pēke.
Ka pērātia tonutia kia kitea te tūponotanga.

He aha te tūponotanga e puta whakaeteeke ai ngā māpere kākāriki e rua? 25/64

T9 used the improvements that he could see in the students' use of vocabulary and grammar as support for his continued use of a conferencing approach to students' writing.

Conclusion

Teacher change was varied. Although all teachers noted some changes in how they engaged students in writing in mathematics, the impact was not the same. Some teachers used the vehicle of a project on writing in mathematics to find a way of dealing with the issue of students not being able to explain their mathematical thinking. This issue resulted in T7 trying and modifying a version of RAVE with his students. He could see significant improvement in both their thinking and their writing as a result. For other teachers, they had tried different ideas but nothing had really resonated with them until the end of the year. Being involved in the project had been the force that had kept them interested, but this alone was not sufficient to make them change their teaching practices. For other of the teachers, something happened along the way so that they had instigated some changes they felt were having a significant impact on their students' mathematical writing.

It was clear that in making changes to their teaching practices, the teachers did engage both individually and collectively in a teacher-inquiry cycle. This chapter outlines three different issues that teachers engaged with over the course of the project. Being able to reflect on their own professional learning and having a supportive network of teachers within the kura to discuss ideas with meant that they were able to continually monitor the impact of their teaching practices on students' learning needs.

4. Conclusion

The project was about how to improve students' writing in mathematics as a way to help them improve their mathematical thinking. The research was based in a kura kaupapa Māori and involved 10 teachers of mathematics considering how to increase the quantity and quality of their students' writing. The project arose from findings from a previous TLRI project (Meaney et al., 2007) that showed that the students at the kura were doing only limited amounts of writing in mathematics.

This new project, Mathematics: She'll be write!, involved documenting the writing that was being done in the kura and organising it into genres and progressions. The research also identified the strategies that teachers were using to support mathematical writing. These strategies were ones teachers had used previously as well as new ones they had recently adopted. It was expected that teachers would try new strategies as part of participating in the project.

The theoretical framework for the whole project was that writing was a sociocultural activity that responds to changes in the activity that is being written about, the relationship between the writer and their audience and the method of presentation. These three premises are what Halliday (Halliday & Hasan, 1985) called the field, tenor and mode. Research done using his systemic functional grammar shows how different kinds of meaning are attached to these premises.

The research methodology was ethnographical in that it looked at a particular situation and reports just one set of teachers' investigations of the mathematical writing that occurred in their classrooms. The research used a number of data gathering and data analysis methods to respond to the different research questions.

There are three parts to this conclusion. The first one is a summary of the findings. The second part is a description of the limitations of the research. The final section is about the directions the kura is now considering for further research.

Summary of findings

The research had two prongs in that it was about documenting what writing in mathematics might look like across the kura and also about identifying the strategies the teachers used in supporting writing. Chapters 3 to 5 discuss the classification of the writing samples and how the categories relate to students' learning and doing mathematics. Chapter 6 describes the strategies the teachers used to support students' writing, while Chapter 7 investigates students' perceptions about writing in mathematics. The final chapter examines changes that teachers made as a result of being part of the project.

In order to investigate the first prong of the research, more than 2,000 pieces of writing were collected during the year. At a meeting in the first term the teachers decided to categorise the samples into three genres:

whakaahua (description); whakamārama (explanation); and parahau (justification). As well as these genres, the different modes used in mathematical writing were also identified. The list of these from Chapter 3 is provided in Table 12.

Table 7 **Mathematical modes used in different genres**

Whakaahua	– Combination		
	– Geometry	– Angles	
		– Lines	
		– 2D shapes	
		– Rectangles	
		– Squares	
		– Triangles	
		– 3D shapes	
		– Cubes	
		– Rectangle prism	
		– Square pyramid	
		– Tetrahedra	
		– Triangular prism	
		– Tech drawing	
		– Transformations	– Combined
			– Enlargements
			– Reflection
			– Rotation
			– Translation
	– Graphs	– Cartesian	
		– Relations	
		– Statistics	
	– Iconic diagrams	– Clock face (Time)	
		– Iconic	
	– Narrative		
	– Patterns	– Combined	
		– Iconic	
		– Symbolic	
	– Symbols	– Algebra	
		– Decimals	
		– Fractions	
		– Integers	
		– Whole numbers	
	– Tallies		
Whakamārama	– Combination		
	– Geometric	– Transformations	– Combinations
			– Reflections
			– Translations
	– Narrative		
	– Symbolic		
Parahau	– Combination		
	– Narrative		

There appeared to be a relationship between the genres, the modes and the audience for the writing. Learning to write whakaahua involves students in learning the conventions associated with mathematical writing and consequently their teachers are likely to be their audience. Frequently, the students only use one mode to describe mathematical objects. Writing whakamārama and parahau requires students to think about the mathematics that they are doing. This often involved a combination of modes and can be written either for others or for themselves as part of the reflection process in learning. How explicit students are in producing their pieces of writing seems to depend upon whether the audience shared in the activity that was the stimulus for the writing.

Whakaahua were the largest set of samples we collected. They were arranged in topic and year-level progressions. The topic progressions showed how extra layers of meaning were added to mathematical ideas. For example, ideas about patterns showed distinct stages from moving between producing simple patterns to providing an algebraic formula to explain how they were formed. Students began learning about patterns through iconic patterns before looking at symbolic patterns. Although the two kinds of patterns coexist for a while, symbolic patterns eventually became the only patterns that senior students engaged with. Some mathematical ideas such as tallies do not change once they have been introduced, while other ideas, such as isometric drawing, appear only briefly in students' mathematical writing. Year-level progressions developed by the teachers suggest that, although the topic progressions are mostly linear, this is not always the case. Sometimes several stages of the topic progressions could be covered at the same time and occasionally later stages may be introduced earlier but continue on for more years.

Whakamārama and parahau were considered by the teachers to be more beneficial for students learning about mathematics. This is because they required students to think about what they were doing and thus be more reflective about their learning. The combinations of modes that students used suggested that, although mathematics does not have to be read from left to right, often the most salient pieces of information were on the left-hand side of the page. Issues about the quality of the writing were discussed by the teachers in regard to the mathematical accuracy of the writing, the ability to integrate different modes, and stylistic concerns.

Chapter 6 described the strategies teachers used to support students becoming writers of mathematics. These strategies linked to the four stages of the mathematics register acquisition (MRA) model but teachers also showed awareness of the need for students to make use of three different kinds of acts of writing. These acts of writing referred to being able to manipulate the writing instrument in physical acts of writing, through to revising the pieces of writing so that they became a tool for thinking mathematically in deeper acts of writing. These acts of writing were connected to the genres as well as to the four stages of the MRA model.

Students' opinions on writing in mathematics were provided in Chapter 7, as well as a description of the writing by students in each year level. Students believed that they mostly wrote in their books. They mostly wrote for themselves and sometimes wrote for the teacher. Their favourite kind of writing was doing calculations and their least favourite was writing narratives. This is potentially problematic for the teachers' programme of increasing the quality of students' writing through supporting their writing of explanations. This is because explanations and justifications often require narrative input to be combined with other modes of mathematical writing.

The final chapter was about teachers' change in teaching practice as well as in regard to their ability to be inquirers into their own professional learning. The teachers all believed that they had made some changes to their teaching practices although they were not always certain that these had resulted in improved student learning. However, several of the teachers could relate specific instances where they felt that students had increased the amount and variety of what they wrote. The teachers felt that this was making the students more aware of their mathematical learning processes. Three issues were also used to show how the teachers collectively and individually went through an inquiry and knowledge-generating cycle as a result of considering student and teacher learning needs.

The findings of the research were substantial, especially given that this is an area that has received very little investigation previously. As an ethnography, the results are not generalisable beyond this kura. However, teachers at other kura and also in mainstream schools could find that some of the findings have resonance with their own situations.

Limitations

An ethnographic case study can begin with research questions, but in the collection and ongoing analysis of data it is likely that these questions would change. This was the case with this research. However, the change in the research questions has meant that the data that were collected were not always sufficient to answer the new questions. Although over 2,000 pieces of writing were collected over the course of the year, it was clear that we had not collected enough to be able to say exactly what any student had written over the year or definitively how their writing had changed as a consequence of their teachers participating in the research. However, given the enormous time it took to tame the pieces of writing into electronic files that could be managed and classified, it is hard to imagine how we could have dealt with any more pieces of writing.

It was extremely interesting to talk with Helen Doerr from Syracuse University who had been involved in a similar project over the same period of time with fewer teachers. The amount of funding she received was substantially more and she was amazed at how much we had accomplished on our shoestring budget. The TLRI does a great job of funding research projects. However, as we worked across all year levels and had 10 teachers involved in the project, it would be more useful if we had been able to apply for a different level of funding so that we could have made use of the resources that we had in other ways.

One of our aims for the project had been to have an outside expert provide some professional development to the teachers on writing in te reo Māori or in mathematical writing. This was to widen the level of expertise that the teachers could draw upon. It soon became clear that there was no one whom we could call upon to provide this professional support. In the long term, given that the teachers were all developing their own understandings about the purposes and benefits of writing in mathematics, it was probably more appropriate that they worked through the issues themselves. It did, however, mean that being part of the project and having to turn up to meetings were the only reasons that teachers continued to experiment with writing in their mathematics classrooms for some time. The turning point for some was the attendance at NZAMT10 and listening to Helen Doerr. It is difficult to know whether, if such an event had been provided earlier in the programme, it would have had the same impact. By the time teachers attended NZAMT10, they had already been experimenting with different ways to support writing for three terms and been involved in many discussions about it. It may be that our original idea of providing outside professional development support early in the year may not have had the same impact.

Working in te reo Māori has its difficulties as people who are able to transcribe and translate for a report written in English are not readily available. As had been the case with our previous TLRI project, it was difficult to locate a transcriber of the video data that we had collected. This held up our data analysis and also resulted in our deciding not to try to undertake interviews with whānau that had been one of our original intentions.

We also continued to struggle to collect high-quality videos. This was partly due to the general difficulties of noise levels in classrooms but also of not being able to place the remote microphone in an appropriate place. We found out quite late in the research that it could not be placed in teachers' pockets without it being knocked so that no sound was recorded. As each year of the project has progressed, we have learnt an enormous amount about the logistics of recording in classrooms.

There were limitations in the data collection for this research. However, given the funding and time we had for the research, our results are substantial and robust. They also lead us on to what further research needs to be done.

Ideas for future writing development

Although the teachers had all believed that they had made some changes to their teaching practice, in the last staff meeting and also in the final interviews there was a sense that more could be done to support students' writing in mathematics. The following extract came from T10 and describes how she felt it was important for the kura to adopt RAVE in 2008:

> Helen was my highlight because for me being new on the programme, I saw where we were wanting to go . . . the difficulty for me was I didn't know I had the strategies to produce that, change my practice, or to change the practice of the children, and when I listened to Helen and saw the programme she had, that was what I thought was going to change my practice to achieve the outcome that we had. But unfortunately, I also went to one other really good forum. I decided to work on that instead which is on our Poutama Tau basic facts and decided that Term 4 is not a good idea really to try something new that you really wanted the children to really grasp, it went a bit airy fairy. But I think RAVE is the way for us to go but I do believe that we need to decide, do we want to do this? We have to do it as a whole school so that everyone starts together. If we make mistakes, we can share them and when we are incredibly successful then someone says, this really works, I think we should go this way. And we can iron out the wobbles together. It also means that you can talk together about what you might try and how you might try it. I also thought that what we could achieve today was a decision, yes or no, whether we go ahead or not but a small group will need to be put together, how we might do it and when we will achieve those things and what we will achieve in that time frame and they need to be realistic, knowing that everyone takes on everything else, but so we can tick those off as we go. This is really successful. We can call it our own name because it looks slightly different because we run it in the school. But it was the strategy that I lacked, it was the practice I lacked to try to get the children to write, whereas I thought that was an awesome strategy, it was the practice that I lacked, that I could try. I came away from talking to her saying, I think I can do that. This is exactly where we need to go. My disappointment about the conference was because Helen was there we should have captured her in a classroom and found a time when everyone had their other courses and sat down and said, what is the first thing you think that we should do? It was difficult to have those conversations over kai or when the band was playing that ghastly music. We yabbered to her as much as we

> could. But I thought to myself afterwards we should have taken that hour on whatever day it was and [said], let’s thrash it out now. Because I thought, this is what we need to get my children need to get them writing in maths. (T10, Meeting 5 November 2007)

At the end of 2007, the teachers in the primary section of the kura decided to investigate how to introduce RAVE into their classes. Consequently, T10 was going to approach Helen Doerr for advice via email.

2008 will also see two of the most experienced mathematics teachers take a year’s leave from July. This will result not only in new staff coming into the kura but also new structures being put into place. Consequently, one of the issues to be investigated is that of sustainability of the project, including the incorporation of the new teachers into existing activities. Without funding for 2008, it will be very much up to the teachers to move the project forward with only the resources provided by the kura. Sustainability is an issue for many projects once the funding stops. It is hoped that we can collect data to enable us to investigate this issue.

A note from a researcher

The project has been a fascinating one to work on. The enthusiasm of the teachers and the curiosity that comes from working in an area that no one had investigated previously has been immensely rewarding. It has also been fascinating to see the changes in teachers as they tried things with their own students. In 2004, mathematics was quite a scary subject for some teachers when we first began to discuss the possibilities of working together. Over the past three years, it has become something not only that a teacher teaches but something they discuss with other teachers. It has been wonderful to be part of that process, even if only as the “fly on the edge of the porridge bowl” (Meaney, 2004).

It would be wonderful to see some of the data that we have gathered over the past three years turned into resource materials for other kura. With permission from the parents it may be possible to combine videos with transcripts and pieces of writing to put together a multimedia professional development package that could be used in mathematics inservice days for Māori-immersion teachers of mathematics.

Project team

At Te Kura Kaupapa Māori o te Koutu, the following teachers were part of the project team:

Aroha Fairhall

Tracy Best

Ngāwaiata Sellars

Ranara Leach

Horomona Horo

Heeni Maangi

Anahera Katipa

Maika Te Amo

Vianey Douglas

Hera Smith joined the project late in 2007 but was not interviewed or videoed.

The research team was:

Uenuku Fairhall, Principal of Te Kura Kaupapa Māori o te Koutu

Tony Trinick, Associate Dean Māori at the University of Auckland’s Faculty of Education

Dr Tamsin Meaney, Senior Lecturer, University of Otago

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Appendix A: Overview of the topic progressions

Te mahere tuhituhi pāngarau (writing in mathematics)

Kaupae (stage)	**Geometric**		**Iconic**	**Symbolic**		**Narrative**
	Shapes	Transformations		Whole numbers	Fractions	
1	Recognise the outline of basic shapes √ Identify basic shapes	Use grid lines to draw simple reflected object Draw simple translations Use fold lines to draw reflected shape Draw reflected object without grid lines	a) Scaffolded into making iconic representations. b) Able to follow a model	a) Scaffolded to trace the outline of the numerals b) Draw an amount to match the numeral provided	a) Shade in the appropriate part of the diagram. At this level they are just working with a single whole b) Recognise the fraction and shade the appropriate amount. At this stage they are finding the fractional part of a group of things	Student's not independent writing Recognise words and colours
2	Relate shape to what is seen in the environment Recognise that the shapes are found in the environment	Draw own objects and reflect accurately Draw own objects and translate accurately in one direction Draw simple rotations	a) Read and respond to pictures b) Respond with pictures to answer written questions	a) Recognise the sameness of the pictures and use this to answer questions using symbols b) Produce a numeral and connect it to the right number of objects. The objects are clearly linked to the numerals	a) Supported to write fractions to describe diagrams b) Write own fractions and clearly relating them to diagrams c) Use diagrams to show fractional parts of amounts	Use single words or phrases to describe

				c) Connect the symbols with the words d) Recognise the arrangement of the digits, represents the value of the number e) Round numbers to the nearest 10	d) Independently produce equivalent fractions	
3	Make rough drawing of shapes √ Draw sketches that contain all of the essential features of the shapes	Draw reflections with vertical and horizontal orientation Enlarge simple shapes in grid lines Simple enlargement shows scale factor Make own patterns using rotated shapes Draw own objects and translate accurately in one direction	a) Provide more complex representations to respond to questions b) Copy pictures drawn on the board to illustrate mathematical explanations c) Recognise and use perspective in a similar manner to when they are sketching 3D shapes d) Draw pictures representing real objects (roughly drawn still). Extra information is provided with the	a) Scaffolded into joining numbers together into a consecutive sequence b) Scaffolded to create a backward sequence of consecutive whole numbers c) Multi-digit numbers are placed in an appropriate sentence d) Independently writing a series of numbers e) Students have to provide the information themselves	The fractions are ordered	a) Choose to use words to answer word questions b) Although the answers are still words or phrases there is a need to group them

			sketches e) Draw credible representations of real objects	f) Recognise the order of numbers. Use =, <, > signs to show the relationships between amounts g) Order numbers forward and backward to 100		
4	Draw using ruler √	Reflections and translations from a variety of orientations. Labels provided Enlargement shows scale factor a centre of enlargement Rotate shapes around a point and label accurately	Arrows are used to describe movement on a hundreds board from one number to another. This is more abstract than the sketches used at earlier levels	a) Pictures are provided to support students to give numbers for answers b) Numbers are now used as answers to specific one-step problems c) Whole numbers are used in equations but not just as answers to calculations. Numerals are used as answers in different contexts	a) Use diagrams to work with fractions to produce answers b) Fractions are used in questions that students need to answer	a) Short sentences are used to describe something in words b) Use more complex sentences to respond to questions c) More complex sentences are used to describe something
5	Draw and label diagrams with measurements √			a) Use symbols to describe the relationship between a set of objects or numbers √	a) Simple addition of fractions	Use more complex sentences to describe

				b) Numerals used to describe simple relationships c) Create number story families d) The number stories have more numbers involved but are still simple one-step calculations e) The problems provide larger numbers but still just involve one-step calculations f) Work with inequalities and produce a statement that is true		
6	Various features of different shapes are labelled. Thus the similarities between shapes can be suggested √ Draw shapes that use right angles	Shapes reflected and described in words		a) Calculations arranged vertically. At this stage there is no advantage in arranging the calculations in this way b) The calculations are more complex because the numbers contain several digits. At this		A series/sequence of sentences used to describe

				stage, there is a point in arranging the calculations this way to help get them correct c) The calculations are now without lines so that the students have less support to work out the answers		
7	Draw diagrams that contain compass construction marks			a) Calculate using other operations than addition. At this level students are supported with pictures b) The descriptions are involving other calculations than just addition. No scaffolding is provided c) The simple calculations are now arranged vertically d) The calculations are more complex	Use other operations than addition for their work with fractions	
8	Draw diagrams that contain angles, measurements and construction					

	marks					
9	Further information is added to diagram					
10	A lot of information is provided about the shapes √					
11	Significant amounts of information are added to the diagrams					

Appendix B: Year-level description progressions

Geometry
- Years 0–2
- Years 3–5
- Years 6–8

Graphs
- Years 0–2
- Years 3–5
- Years 6–8
- Years 9–11

Iconic
- Years 0–2
- Years 3–5
- Years 6–8

Narratives
- Years 0–2
- Years 3–5

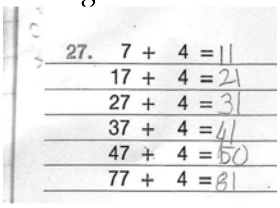
Patterns
- Years 0–2
- Years 3–5
- Years 6–8

Symbols
- Years 0–2
- Years 3–5
- Years 6–8
- Years 9-11

Appendix C: Patapatai tamariki

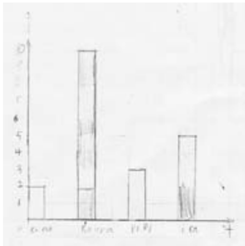
1. He aha ngā **momo tuhiuhi** e mahi ai koe i ngā akoranga Tātai?

Tātainga



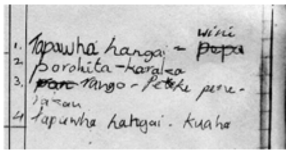
Ka maha/Ko ētahi/Kāre kau

Kauwhata



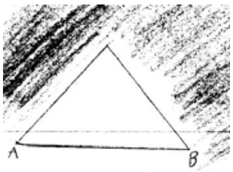
Ka maha/Ko ētahi/Kāre kau

Tuhinga Kōrero



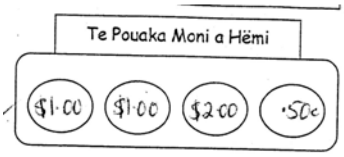
Ka maha/Ko ētahi/Kāre kau

Āhua



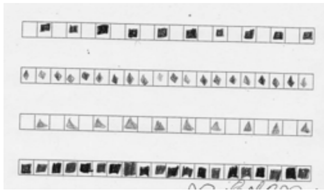
Ka maha/Ko ētahi/Kāre kau

Pikitia



Ka maha/Ko ētahi/Kāre kau

Tauira



Ka maha/Ko ētahi/Kāre kau

2. **E hia ngā wā** e tuhituhi ai koe i ngā akoranga Tātai?

I ngā akoranga katoa

I te nuinga o ngā akoranga
(2-3 ngā wā i te wiki)

I ētahi o ngā akoranga
(Kotahi te wā i te wiki)

3. **Ki hea** koe tuhituhi ai i te Tātai?

Ki roto i nga pukapuka

Kia maha ngā wā/I ētahi wā/
Kāore rawa

Ki runga i te papa

Kia maha ngā wā I ētahi wā/
Kāore rawa

Ki runga i te papatuhituhi

Kia maha ngā wā/I ētahi wā/
Kāore rawa

Hei iri ki runga i te pakitara

Ki tetahi atu wāhi

Kia maha ngā wā/I ētahi wā/
Kāore rawa

Kia maha ngā wā/I ētahi wā/
Kāore rawa

4. **Ma wai** āu tuhi**nga**?

… māu āno

Kia maha ngā wā / I ētahi wā/
Kāore rawa

… mā tō kaiako

Kia maha ngā wā/ I ētahi wā/
Kāore rawa

… mā ōu hoa

Kia maha ngā wā / I ētahi wā /
Kāore rawa

… mā tō whānau

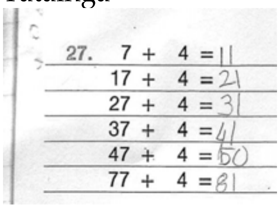
Kia maha ngā wā / I ētahi wā/
Kāore rawa

… mā tētahi atu

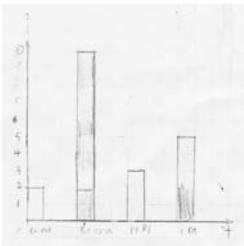
Kia maha ngā wā / I ētahi wā/
Kāore rawa

5. He aha ngā momo tuhituhi Tātai **e pai ana** ki a koe?

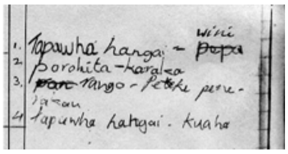
Tātainga



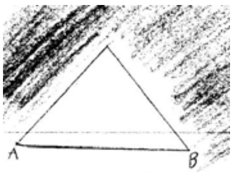
Kauwhata



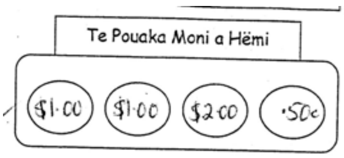
Tuhinga Korero



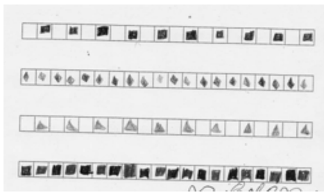
Āhua



Pikitia

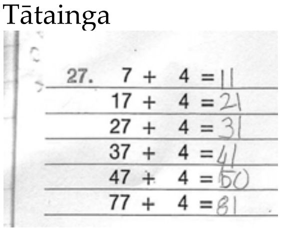


Tauira

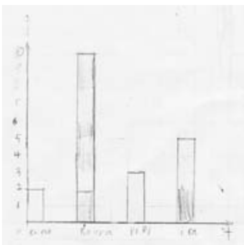


6. He aha ngā momo tuhinga Tātai **kāre i te pai** ki a koe?

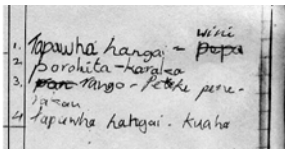
Tātainga



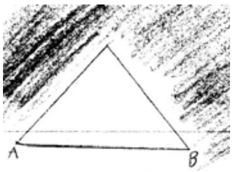
Kauwhata



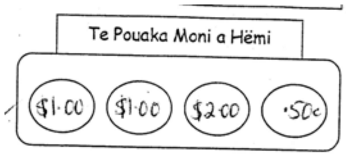
Tuhinga Kōrero



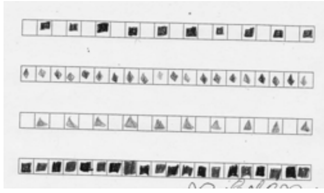
Āhua



Pikitia



Tauira



7. **Ka pakari ake i koe** te tuhituhi i ngā akoranga Tātai …

… kia ako tātainga? Āe/Ētahi wā / Kāo

… kia ako i ngā tikanga Tātai? Āe/I ētahi wā / Kāo

… kia whakaoti rapanga? Āe/I ētahi wā/Kāo

8. He uaua ki te rapu i te **kupu tika** mo ou tuhiuhi mo te Tātai?

Āe / I ētahi wā / Kāo

Appendix D: Teacher survey

1. Why do you think students should do writing in mathematics?

2. What kinds of writing (genres) have you had students do this year in maths lessons?

3. Do you think that this is a different range to what you have done last year?
   Yes/No

4. Why do you think that is?

5. What other kinds of writing would you like to see students use?

6. Why is this the case?

7. What knowledge of te reo Māori do you think that students need to improve their writing in mathematics?

8. Why is this the case?

9. What have you tried that was different this year to help students in their writing in mathematics?

10. Why did you choose to try these things out?

11. How do you know if they were effective?

12. What has been the most interesting thing for you about being involved in the project?

13. What strategies would you like to use next year to help students in their writing in mathematics?

14. If the project was to continue, what support would you like?