Acquiring the Mathematics Register in te reo Mäori

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Acquiring the mathematics register is often assumed to occur when learning mathematics. However, when students learn in a second language and are taught by teachers who are also not teaching in their native language, this may not be a straight-forward process. This paper describes the strategies that teachers in a Mäori immersion school (kura kaupapa Mäori) used to scaffold and model the mathematics register. Although most strategies could be seen in many classrooms, there were some strategies that seemed to be related to the students and teachers using te reo Mäori as the language of instruction.

Kö ta te rangatira kai he körero

As described in the whakatuaaki above, language is the food of chiefs because fluency in it provides access to and control of learning. Khisty and Chevl (2002) summarised the impact of this by stating, "[i]n essence, those with power are literate or in control of a discourse" (p. 167). Analysis of the student data from the Mäori medium numeracy project (*Te Poutama Tau*) found that language proficiency was a significant factor in student achievement in the higher stages of the number framework (Christensen, 2003). In kura kaupapa Mäori, students often have te reo Mäori as a second language, with various degrees of fluency in it. This means that there is a need to understand more about how to support students learning mathematical content at the same time that they are learning te reo Mäori and in particular the mathematics register, te reo tätaitai. This situation is complicated by the newness of this register in te reo Mäori (Christensen, 2003; Meaney, Fairhall, & Trinick, 2006).

During 2005 and 2006, the scaffolding and modelling of students' mathematical language by the teachers in a kura kaupapa Mäori was documented. It involved a partnership between seven teachers of mathematics and three researchers who are the authors of this paper. The kura teaches mathematics to students from Year 0 to Year 13. The teachers in the primary section of the school were also participating in *Te Poutama Tau* and felt that this research would complement that project. The final stage of the research investigated how this knowledge affected the teaching practice of those involved and this enabled an appropriate evaluation of the research for its practical value to be undertaken. Better understanding of how the mathematics register is acquired is likely to be of benefit not just to kura kaupapa teachers and their students but to others considering language issues in other content areas.

This paper provides information on the first part of the project, the strategies that the teachers used to support students learning te reo tätaitai. The role of the teacher has been emphasised in providing the environment in which learning should occur (Anghileri, 2002). This learning includes expectations about the interpretation and production of mathematical language (Khisty & Chevl, 2002). Research by Khisty and Chevl (2002) showed the importance of the teacher's own use of mathematical language when students were learning in a second language. When teachers did not use mathematical language fluently, their students were unable to describe mathematical ideas.

The two main ways that support is provided to students to learn and use the mathematics register are modelling and scaffolding. Modelling is when a teacher uses mathematical language within an appropriate context. For example, if a student provides a response to a mathematical task in everyday language, a teacher might rephrase it in more appropriate mathematical language (Chapman, 1997).

Scaffolding is when a teacher provides part of a response with the student completing the rest. Wood, Bruner, and Ross (1976) originally described the scaffolding by an adult as that which "enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts" (p. 90). As time goes on, a teacher would expect to reduce the amount of scaffolding and modelling that is provided, thus transferring the responsibility for using the language from the teacher to the student. However, as Williams and Baxter (1996) stated, there is a risk that this transfer of responsibility fails to occur in many classrooms: "Edwards and Mercer pointed out that handover, or the process of gradually shifting control of learning from teacher to student, was missing in the classrooms they observed" (p. 25).

Although the work of Bickmore-Brand and Gawned (1990) would suggest that the effect of modelling and scaffolding of mathematical language has been known for some time, there has been limited research on what are effective modelling and scaffolding strategies. Chapman's (1997) study would be the most comprehensive. From watching a secondary mathematics class for a term, Chapman described how teachers reframed student responses so that they: clearly showed the relationship to the theme of the lesson; focussed on the typical linear, metonymic structure rather than the metaphorical content; and became more certain and less hesitant (what she labelled as high modality). Although Chapman concentrated on the teacher's role within the interactions, researchers such as Rogoff (1988) showed that students themselves have a major influence on the types of scaffolding and modelling that are offered to them.

There is also cross-cultural research on mother-child interactions which suggests that the ways that scaffolding are undertaken are culturally determined (Kermani & Brenner, 1996). Research in reading classrooms for Hawaiian students suggested that reading achievement increased when discourse interaction patterns more closely matched those of a traditional Hawaiian cultural activity, such as talk story (Au, 1980). Therefore, Māori teachers teaching Māori children in te reo Māori may not use scaffolding strategies similar to those identified by Chapman. Nelson-Barber and Estrin (1995) suggested that:

> [u]nfortunately much of the knowledge on culturally influenced notions of good teaching remains unrecorded and unformalized because, as a whole, educators (researchers and practitioners alike) have made little effort to elicit the perspectives and experiences, or study the classrooms, of teachers who are highly effective with non-mainstream students (p. 5).

Methodology

The ethnographic research tradition was used in this research for two reasons. The first is that research in kura kaupapa Māori needs to be in alignment with Kaupapa Māori or Māori-centred research tradition. The second was because the project was about evaluating the effectiveness of different modelling and scaffolding strategies requiring an in-depth consideration of what this meant. Christensen (2003) summarised the five dimensions that contribute to Kaupapa Māori research. Each of these dimensions is described in the following paragraphs, with an indication of how they were met in this project.

A Mäori World View

There is a need for the unique Mäori world view to be reflected in what is researched, how it is analysed and written up. In considering how te reo Tätaitai is scaffolded, there is a need to be aware of those strategies that are unique to the language and culture of the teachers and the students. If Mäori students are to improve their educational achievement, the role of culture in learning needs to be acknowledged. It cannot be assumed that good teaching for students from diverse backgrounds will always look the same (Alton-Lee, 2005). It is therefore important that effective practices that resonate with cultural practices are documented, and this was one of our aims for this project.

Culturally Safe Research Practices

There is a need for Mäori to feel that they will not be exploited as a consequence of being involved in research. Irwin (1994, cited in Christensen, 2003) suggested "mentoring by kaumätua and research being undertaken by a Mäori researcher as two aspects of culturally safe practices" (p. 14). In our project, two of the principal researchers are respected Mäori mathematics educators. Their involvement has provided a mentoring role for the teachers who were involved in researching their own practices. Regular meetings with teachers meant that the project could evolve to meet the needs of the kura as the teachers' opinions and ideas were incorporated into what was being researched and how this was being done.

Challenges to Existing Power Relationships

It is important that Kaupapa Mäori research results in Mäori development. In order to do this, the way that Mäori have traditionally been portrayed needs to be reconsidered. This will support students' active movement into the wider society as the primary benefactors from the research. By documenting effective strategies and acknowledging their relationship to culture, we anticipate that the impact of this research will not just support students at this kura but be of value to students at other kura.

Accountability and Mediation

There is a need to ensure that control of the research remains with Mäori so that "the research is worthwhile and contributes to Mäori development" (Christensen, 2003, p. 15). This will ensure continued validation of the research so that it reflects a Mäori world view and culturally safe research practices. In our research, we did not have a supervisory group. However, the project was jointly run by the researchers, two of whom were Mäori, with frequent meetings with the teachers who were also researchers of their own practice. As a group research project, there were opportunities for reassessment as it progressed. The project therefore was accountable to the people who were involved in it.

The Researcher is Concerned with Mäori Advancement

The positioning of the researcher is important in Kaupapa Mäori in order for the different issues of doing research, such as the need for Mäori development, ethics, and being systematic, to be considered. This research was a joint activity that valued the different skills and experiences brought to the research project. This ensured that the

various demands of the research were dealt with adequately. All of those involved in the project are concerned with Mäori advancement.

Method

Data was primarily collected through videoing each of the seven teachers' mathematics lessons in both 2005 and 2006. The classroom interactions were transcribed and the teachers then watched them with a university researcher. The joint analysis involved identifying the modelling and scaffolding strategies that the teachers used in the classroom. These were arranged around the stages in the Mathematics Register Acquisition (MRA) model (Meaney, 2006). These stages and their strategies are described in the next section.

Findings

Our original research question had been about identifying the *effective* strategies used by teachers to support students in acquiring aspects of the mathematics register. However, it soon became clear from our analysis that a scaffolding or modelling strategy could not be judged as effective in isolation from the whole lesson or in fact from classroom practices in general.

Noticing

The Noticing 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. The strategies that were identified for this stage were:

- providing opportunity for the new terms to be used appropriately
- using linguistic markers to highlight what was to come
- using intonation to emphasise a correct term after students used an incorrect one
- repeating new terms and expressions several times in appropriate places
- rephrasing the expressions by using other terms
- writing the new term in an equation which is related to what has just been discussed
- giving definitions verbally and through diagrams
- emphasising the relationship between ideas using diagrams or physical materials and words
- modelling a new term/skill (idea) as it is being explained
- after teacher explanation, having students say back the new term
- having students repeat the final answer after the teacher has modelled finding the solution
- relating new terms to already known ones
- using a set of leading questions so that students are channelled into using a particular term
- using fill-in-the-blank sentences
- acknowledging the difficulty of learning some terms (ideas)
- providing a rationale for the need to learn a new term (idea)
- requesting students' attention before introducing a new term
- describing a new term as being important in a subsequent lesson

This stage is characterised by teachers 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. Quite often when a new term is being introduced, the teachers repeat it many times, often associating it with activities.

In one of Teacher 6's (T6) lessons on introducing division, she used *whakawehe* (division) 41 times and the students (äkonga) used it 10 times. These repetitions were spaced, giving students time to absorb the vocabulary. Spacing repetition has been noted as important in vocabulary acquisition in second language learning (McNaughton, MacDonald, Barber, Farry, & Woodard, 2006). In the extract, the teacher had the students separate blocks into groups. This allowed her to introduce the term *whakawehe,* which then became the focus of the lesson.

T6: Nā ka ono, waru, tekau, i kaute ahau i ngā ( ) ana ( ). E hia ngä mea paraone? E whä ngā röpü. He rereke, äe. He mahi mämä tënei. Ko te tumanako, he mahi mämä mä koutou. E whä ngā röpü taki, ana. E hia ngā tae ia tae. E whä ngā röpü. Nuku atu i ö koutou pukapuka kia taea e koe te waiho ngā mataono ki mua i a koe, kua pënei koe.
Äkonga: Äe.
T6: Kua whakatakoto koe i o mea pënei [teacher observes students]: Nö reira, titiro mai, he mea kowhai i përä hoki koe.
Äkonga: Käo.
T6: Anä, he aha te pätai mä koutou? I tënei rä. Käore au i te hoatu te whakawehe ki a koutou nërä mä koutou. Kia whakaaro, āe, me whakaaro pea e koutou. Mehemea i ahau e rua ngā röpü takitoru. E hia te katoa o ia takiwha? E hia te katoa o ngā tor- toru?
Äkonga: Ono
T6: Ka tahi, rua, toru, whä, ono, ko tënei te whakarau aha e ono.
Äkonga: Toru, toru
T6: Tuhia te whakawehe möku. E hia te katoa ehara ko te toru [throws pen to child]
Äkonga: ( )
T6: Timata i te aha, ka pai.

It would seem that for a strategy to be an effective, it must contribute to students hearing new vocabulary or grammatical expressions frequently and gaining meaning from them. At this stage, the understanding that students are expected to acquire is usually a definition. However, the teachers giving a rationale also provided another kind of meaning to the new aspect of the register that they were highlighting.

Intake

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. However, the teacher is still very much in control and students' contributions are usually short, thus providing them with little opportunity to provide inappropriate responses.

Teacher check on their students' understanding by asking them for definitions. If the definitions were concise and clear, then the students were at the Output stage. When the teacher or other students had to provide extra clarification, prompts, and/or information, then the students were more likely still to be learning how to use the terms and so would be at the Intake stage. In the extract, the teacher commanded a student to explain what was happening when two lines met on the graph (*tutakitanga* and *rerekë*). The student went up to the whiteboard and was helped in the explanation by suggestions from other students and from the teacher.

T7: Inanahi, i tuhi au ngä rärangi e rua me te pätai ki a koutou. Ah, käre, i te pätai he tono ki a koutou, körerohia mai te tutakitanga o ngä rärangi e rua. Nö reira, Äkonga 1 haere ki te tuhi i ngä rärangi e rua
Äkonga 1: E ai ki töku mea
T7: Oh, koinä täu e kï ai he rerekë

Äkonga: Whä ripeka, oh, mäku e tuhi engari, pätai mäu e whäki mai
Äkonga 1: [stands up and goes towards whiteboard]
T7: Äkonga 2, hoki ki a koutou kei te pai kë mehemea i tino pango te rärangi o waenganui o ngä tua, he uaua te kite i runga i tënä
Äkonga 2: Oh
Äkonga 1: Oh he aha tënä?
Äkonga 2: Oh
Äkonga: Whä kei runga rua ki te taha
Äkonga: I whakaaro au i tuhi au e rima
T7: Koinä te tutakitanga, në?

The strategies that teachers used at the Intake stage of scaffolding students' acquisition of te reo tätatai were:

- choral responses with the students
- having students as a group do choral responses
- giving the first syllable of a term so that students are reminded of the term and then complete it
- asking students for names, definitions, or explanations of terms
- having students model the use of terms/skills (ideas)
- asking students for examples of a term
- using the similarities between concepts (e.g. 7 + 3 and 70 + 30) as an entry into having students reflect on the differences
- having students draw their own diagrams or use materials to show a particular term
- repeating or having students repeat appropriate responses
- elaborating on students' responses in words and with diagrams
- asking further questions to help students reflect on what they were describing and to check on what they know or have done
- having students provide a rationale for what they are learning
- ignoring inappropriate answers and just acknowledging appropriate ones
- querying students' inappropriate responses
- suggesting that students' inappropriate responses are close
- having students work backwards from an inappropriate answer to the question which was asked
- using specific amounts to illustrate a general rule (idea)
- focusing students back onto the main idea being discussed to help solve a problem
- using student-devised terms in giving an explanation
- going over an activity which requires the use of the new language as a whole class before expecting students to do the activity as individuals
- showing students the relationship between what they already know and can do and the new language term or skill
- having students answer a series of closed questions to lead them to using the new term/skill (idea)
- after modelling how a new term or skill is used, having students repeat the action
- recording in writing what had been discussed or done
- students can query obvious errors by the teacher or another student

The function of the Intake stage is for students to form understandings of when and how new aspects of the mathematics register are to be used. Effective strategies, therefore, are ones that support students exploring when and how to use these new aspects of the mathematics register. This support would include providing students with both positive and negative feedback about their experimentation with the new aspects.

Integration

By the Integration stage, students have a good understanding of the new aspects of the mathematics register. They just need to be reminded that they have good skills and

knowledge and that they should be making use of them. For example, listening is a skill that students need to become fluent in. In the following discussion, the teacher seemed to be predicting that some students would struggle to follow the logic so she used words and commands to ensure that they paid full attention to the important sections.

T1: Tekau ngä tapa, tekau ngä mata me ngä akitu, tekau mä rua ngä tapa tapirihia kia rua, ä, ka tekau mä rua kë tërä. He oi anö, i mutu i te karaehe i kï mai kë tëtahi; "Whaea kei te hë tëtahi o ngä mahi, me kï ngä kaute, kua hë tëtahi o ngä wähanga." Ko [Äkonga 1] tërä, he aha täu i kite ai?
Äkonga 1: E waru ngä tapa?
T1: E?
Äkonga 1: Waru ngä tapa.
T1: Me whai kë mehemea kei te tika ia. Tahi, rua, toru, whä, rima, ono, whitu, waru, nä reira, käore ko te tekau! Nä reira, kei te tika te maha o ngä mata me ngä akitu?
Äkonga: Äe!
T1: Äta whakaaro koa!
Äkonga: Äe!
T1: Äe, i te mea he aha tëtahi atu huarahi i kite kë?
Äkonga: Tapirihia te rima ki te rima?
T1: Nä reira, kei te körero, i rongo koe, koutou i a ia e kii ana? Körero mai anö koa, tama.
Äkonga: Tapirihia te rima ki te rima*?*
T1: Tapirihia te maha o ngä mata ki te maha o ngä akitu, kua puta kë ko te tekau, nëhä? Te maha o ngä tapa me kï waru inäianei, he aha te huarahi e whai ake? Äe!

This was part of a discussion of how Euler's rule (Vertices + Faces – Edges = 2) worked on a pyramid and how some of what had been discussed on the previous day had been incorrect. The *kë* highlighted for the listeners that they should notice and be surprised by what follows. It, therefore, acted as a scaffolding device for students' listening. They needed to listen so that they could understand the differences between what had been said on both days. This was further emphasised by the teacher with the command "*Äta whakaaro koa!*", which was to understand carefully and occurred a few turns later. Once the student had responded to the initial question, the teacher emphasised that the students needed to listen. She then had the student repeat what he had said. All of these examples suggest that the teacher was confident that the students would understand what was being discussed but, because of its complexity, she needed to remind them to be careful so that they would not miss the information.

The function of this stage is to have students use new aspects of the mathematics register 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 language that they have gained. 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 Intake stage. The strategies at the Integration stage included:

- using commands and linguistic markers to highlight for listeners that they need to pay extra attention to what they are hearing and doing
- encouraging students to make contributions to the teacher and to each other
- reminding students to think about what they already know
- asking a student to repeat a good response
- if a slight correction is needed, the teacher repeat the response correctly
- summarising what a student has said
- if a slight correction is needed, the teacher can model doing the action so that the student self-corrects their own response

- prompting in a general way for more details
- having students write a summary of, or record as a diagram what they have learnt
- facilitating an environment where students will correct each other
- asking students to say whether an answer/term is correct
- repeating the question if the students appear to have responded to a different one
- having students complete appropriate actions as they respond to questions

Effective strategies are ones that allow students to have major control of their use of the mathematics register but enable the teacher to remind students about what they know and can do.

Output

The final stage of the MRA model allows students to show their fluency in using the mathematics register. Its function is for students to be able to show what they know and can do without any support from the teacher. At this stage, there are only the two following strategies:

- providing opportunities for students to use their acquired aspects of the mathematics register between themselves and with the teacher
- providing an environment in which the students can query the language use of the teacher

The teacher's role is simply to provide opportunities for students to make use of the fluency that they have acquired. An effective strategy is, therefore, one that supports this provision. This extract comes from T1's fifth lesson, where a student had to describe the arrangement of five blocks to another student. The second student could not see the arrangement and relied entirely on the first student's description. Many students struggled initially with being able to describe the arrangement of groups of different coloured multi-link blocks. However, it was clear from this student's response that he had full control of the location expressions and knew how to use them to give a clear description in this activity.

> Ākonga: E rua ngā mea o te kōwhai ki te taha, kotahi te mea kōwhai, oh, e rua ngā whero ki te taha. Kotahi te mea köwhai o ia huapae.

Combining Strategies

When considered in isolation, some strategies employed by teachers at the various stages of the MRA model could be considered less effective than others. For example, having students repeat an answer, after the teacher has gone through an explanation to reach it, is perhaps not going to highlight for students new aspects of the mathematics register very effectively. However, when this is one strategy of many, all designed to support students to become aware of these new aspects, then it could be seen as having more value. In each of the lessons, if the teachers used strategies from any of the MRA stages, they would always use more than one strategy. Combining a range of strategies, therefore, seems to be part of what makes effective support for students who are operating at the different stages.

Mäori Scaffolding and Modelling Strategies

In considering the modelling and scaffolding strategies for supporting the acquisition of the mathematics register, all of the strategies can be considered culturally appropriate

because they were used by these teachers. Many of the strategies used by the teachers in this project would also be seen in English medium classrooms both in New Zealand and in other countries. However, the use of the linguistic resources within te reo Mäori for scaffolding is one strategy that is unique. Words, such as *ara* and *kë*, that warn listeners about the type of material that will follow are not found in English. Given that Mäori immersion education was set up to reverse the decline in Mäori language (Spolsky, 2003), there has been a recognition that "the authenticity of the language is maintained" (Christensen, 2003). Concerns have been raised about the possible implications for te reo Mäori as a consequence of its use for discussing mathematics (Barton, Fairhall, & Trinick, 1998). It, therefore, is interesting to find authentic resources within te reo Mäori that can be of value in the teaching of mathematics.

Another feature, although not unique to kura kaupapa Mäori classrooms but that seemed to be more strongly observed in the video recordings, was the number of student contributions to the interactions. Even at the Noticing stage, which is where teachers have the most responsibility for doing the cognitive work, students have an active role in contributing to the discussions. It was quite clear that the originators of interactions could be students as often as it was the teacher. Video recordings of pairs of senior students show them working together as "teacher" and "learner". The lack of reticence in taking up either role is considered to be an outcome of the valued *tuakana-teina*, older-younger sibling, relationship. Mäori children do not traditionally segregate themselves into age-based peer groups, rather there is the expectation that they will take responsibility for each other, whether younger or older. This can be seen in interactions around the learning of mathematics.

It would seem that strategies that reflect a Mäori world view are those that use the features of te reo Mäori effectively and those that support students to become active participants in interpreting and producing the mathematics register appropriately.

Conclusion

The setting up of kura kaupapa Mäori was done to support the revival of te reo Mäori. Consequently mathematics has been taught through this language to students who are not only learning mathematics but also learning the mathematics register in te reo Mäori. This research has begun an investigation with teachers about how they support students to learn te reo tätaitai.

In this paper we have outlined the strategies that teachers used in the four stages of the MRA model. It was noted that all of the teachers used a variety of strategies when operating at each of the stages, except for the final stage, Output. As this stage was about the students fluently using te reo tätaitai in authentic situations, it was unsurprising that the teacher's role was one of providing appropriate opportunities that would allow students to us the new aspects of the mathematics register.

We also documented strategies that seemed to be related to the language and the culture of the students and their teachers. These strategies are interesting because they encourage the use of what is already present to be incorporated into the mathematics teaching. For teachers in other kura, this information means that they no longer have to rely only on adapting what is considered best practice in English medium classrooms.

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