Te Ara Poutama: The Impact of the Te Poutama Tau Project on Mathematics Achievement

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The foci of Te Poutama Tau (the Māori-medium numeracy project) is threefold: to develop the discipline to support Māori-medium pāngarau/mathematics, to raise Māori student achievement in pāngarau by improving the professional capability of teachers, and to continue the revitalisation of te reo Māori. This paper reports on the pāngarau achievement of a cohort of year 4 and a cohort of year 7 students who participated in Te Poutama Tau in 2007. This study used the Assessment Tools for Teaching and Learning (asTTle) test to examine the impact of Te Poutama Tau on pāngarau/mathematics achievement. The results show that the year 4 cohort performed below the asTTle national norms for Māori-medium schools. This is primarily due to results in algebra. The year 7 students, on the other hand, performed well above the asTTle national norms for Māori-medium schools, although not significantly so in algebra.

Background

The New Zealand Numeracy Development Projects (NDP) were developed in response to concerns about the quality of mathematics teaching and the results of New Zealand students in the Third International Mathematics and Science Study (TIMMS) (Garden, 1997; Thomas & Tagg, 2004). Although Māori-medium schools did not participate in the TIMMS study (the study was only available in the medium of English), it was recommended that the NDP be also extended to include Māori-medium schools (Christensen, 2003). The teaching of numeracy in any language is a complex area; teaching in the medium of Māori is a relatively new and emerging discipline, and teachers require considerable support. Not all English-medium development projects are suitable for translation into Māori-medium contexts. However, the NDP model provided teachers in Māori medium with very valuable support in a number of key areas, including a well-developed Number Framework, an effective teaching model, and the support of numeracy facilitators (Christensen, 2003, 2004; Trinick & Stevenson, 2005, 2006, 2007).

Te Poutama Tau (the Māori-medium numeracy project) was first implemented in schools in 2002 as a pilot study (Christensen, 2003). Since then, more than 123 schools have participated in the project. This is a significant number for Māori medium. Te Poutama Tau has been well informed by annual evaluation reports and a range of papers that have examined the impact of Te Poutama Tau on students' learning as well as the experiences of facilitators and teachers who have participated in the project. Findings from the evaluations indicate positive outcomes for students and teachers in the learning of pāngarau (Christensen, 2003, 2004; Trinick & Stevenson, 2005, 2006, 2007). Additional research has focused on schools that made very positive mean stage gains in the Number Framework (Trinick & Stevenson, 2005, 2006) and perspectives of students in Te Poutama Tau (Hāwera, Taylor, Young-Loveridge, & Sharma, 2007).

Methodology

The catalyst for Te Poutama Tau was the desire to provide support to Māori-medium teachers and to improve Māori mathematics achievement. Over the last 25 years or so, mathematics education has evolved to stress conceptual understanding, higher level problem-solving processes, and students' internal construction of mathematical meanings in place of, or in addition to, procedural

learning. The development of number sense in students is a widely accepted goal of mathematics education. The use of mental strategies is considered a key component of number sense, in particular, flexibility in thinking about numbers and operations (Sowder, 1992). The diagnostic interview used in Te Poutama Tau is designed to provide teachers with information about the knowledge and mental strategies of their students and to assist teachers with instructional decision-making. The diagnostic interview consists of a series of problems presented to students individually, with follow-up questioning to ascertain the strategy used to reach the problem solution. In traditional pencil-and-paper testing, students may use algorithms and the teacher has little way of knowing what strategy the students used.

It is also important to know how students in Te Poutama Tau are performing in other areas of mathematics and whether they are transferring their knowledge to solving problems that differ in form and context. Additionally, how would these students perform in traditional written-type tests against the national norms for Māori-medium schools generated by the Assessment Tools for Teaching and Learning (asTTle) test?

AsTTle

AsTTle is an educational resource for assessing literacy and numeracy (in both English and Māori) developed for the Ministry of Education by the University of Auckland. It provides teachers, students, and parents with information about a student's level of achievement, relative to the 1992 *Mathematics in New Zealand Curriculum* achievement outcomes, for levels 2–6 and national norms of performance for students in years 4–12. AsTTle reports students' results based on curriculum level (each level is divided into basic, proficient, and advanced).

Teachers can use asTTle to create 40–50 minute "pencil-and-paper tests", which means that students must be able to read and write. Such tests probe knowledge and are therefore not useful for examining thinking or the strategies used to answer or solve mathematical problems. Once the tests are scored, the asTTle tool generates graphic reports that allow teachers to analyse student achievement against curriculum levels, curriculum objectives, and population norms.

AsTTle is based on Item Response Theory (IRT), which is a measurement theory that underpins international programmes such as TIMMS, PIRLS (Progress in International Reading Literacy Study), and PISA (Programme for International Student Assessment). Measurement theory suggests that constructs (real-world concept elements) such as mathematical ability (including sub topics such as geometrical and/or statistical ability) are real and can be measured by instruments (that is, tests) that have been well crafted (found to be both reliable and valid). IRT suggests that student scores in any asTTle test are calculated on *both* student ability (performance in a test) and characteristics of the test items (the questions), that is, their difficulty, their discrimination, and so on.

Aims of the Research

1. What aspects of the asTTle test did students perform well in? What are the gaps? What are the areas of weakness?
2. How do Te Poutama Tau students' asTTle data compare with the asTTle national norms for Māori-medium schools?

Method

Participants

A range of Māori-medium schools were asked if they would participate in the study, with the final selection based on gathering data from as wide a cross representation of schools as possible. The four schools selected were either from larger centres or smaller towns and were full primary or full primary with attached wharekura (Māori-medium secondary). It was decided to concentrate on year 4 and year 7 students. Year 4 was selected because this is the youngest cohort that can be reliably tested using asTTle. Additionally, in 2006, year 3 student progress was not as positive as the other year groups (Trinick & Stevenson, 2007). Why this was so is not clear. A number of reasons were considered, including this being the age group where students were possibly transitioning to part–whole and experiencing a possible change in teaching pedagogy from years 1–2 to years 3–4 (Trinick & Stevenson, 2007). Year 7 was chosen to provide a comparison for showing differences and similarities. The schools involved could also use the data to focus on gaps and weaknesses when the students moved to year 8, before they transitioned to wharekura (Māori-medium secondary schools) or to English-medium secondary schools.

The Test

An asTTle test in te reo Māori, focusing on number, was generated for each year group and test scripts were sent out to the schools participating in the research. Both tests consisted of 32 test items, which were selected to give coverage of number items from the number, measurement, and algebra strands from the 1992 *Mathematics in New Zealand Curriculum*. The aim of this research was to gain maximum information on students' performance on number and items relevant to Te Poutama Tau. The nature of asTTle is such that individual test items cannot be selected without losing the capability of the asTTle tool to generate national norms (because norms are not available for individual test items). Tables 1, 2, and 3 show how many times each of the 32 test items related to a particular achievement objective.

Table 1
Achievement Objectives 1992 Mathematics in New Zealand Curriculum *(Number Strand)*

AsTTle Learning Pathways (Number)	Year 4	Year 7
Recall basic addition and subtraction facts	1	1
Recall basic multiplication facts	2	2
Demonstrate the ability to use basic multiplication facts	5	5
Order any set of three or more whole numbers (up to 99)		1
Explain meaning of digits in 2- or 3- digit whole numbers		1
Order decimals up to 3 places		1
Express quantities as fractions or percentages of a whole		1
Find a fraction or percentage of a quantity		1
Write and solve whole story problems using +, –, x, ÷	3	2
Write and solve whole number with combinations of +, –, x, ÷	3	2
Write and solve fraction problems involving $\frac{1}{2}, \frac{1}{4}, \frac{1}{3}, \frac{1}{5}$	2	2
Write and solve decimal problems using +, –, x, ÷	3	6

Table 2
Achievement Objectives 1992 Mathematics in New Zealand Curriculum *(Algebra Strand)*

AsTTle Learning Pathways (Algebra)	Year 4	Year 7
Continue sequential pattern and describe rule	2	2
Describe rules for continuing number and spatial patterns	5	5
Make up and use a rule to create a sequential pattern	1	
Solve problems of the type x + 15 = 39	1	
State general rule for a set of similar practical problems	1	
Use mathematical symbols =, <, >	3	2
Solve simple linear equations such as 2x + 4 = 16		1
Use graphs to illustrate relationships		1
Use graphs to represent number, or informal, relations		1

Table 3
Achievement Objectives 1992 Mathematics in New Zealand Curriculum *(Measurement Strand)*

AsTTle Learning Pathways (Measurement)	Year 4	Year 7
Describe/interpret position with direction/distance language	1	
Draw and interpret simple scale maps	2	
Measure with appropriate metric units length/mass/capacity	5	7
Measuring using a range of units and scales	2	1
Read and interpret everyday statements involving time	3	
Read and know units of time (minute/hour/day/week/month/year)	2	1
Measure and read scales to nearest gradation		1
Read and construct a variety of scales, timetables, and charts		1
Read and interpret everyday statements involving time		1
Reasonably estimate length/mass/area/volume/temperature		3

Test scripts were sent to each participating school. The classroom teacher administered the tests and sent them back to the researcher for marking. Once the scripts had been marked, a report was compiled for each of the participating schools. This report included four major reports for teachers, each of which provided different analyses of each year group. These included:

- comparing student performance against a nationally representative sample;
- comparing student performance in relation to curriculum levels and difficulty;
- identifying curriculum outcomes that students have or have not achieved and in which they have strengths or gaps;
- allocating each student in a curriculum level either "at the beginning", "proficient", or "advanced stages". (This report is ideal for assisting the teacher to group students.)

AsTTle Tests: Results

All reporting of results in this section is based on the aggregated results of year 4's and Year 7's and is displayed using three types of reports.

The Reports

The reports are primarily aimed at answering this feedback question: "How are the students doing in comparison to similar students in New Zealand?" AsTTle answers this by providing comparative or normative information for the group of students in this sample.

Group performance

Student achievement by year is shown in box-and-whisker plots that display both the New Zealand norms and distribution of the student scores. The reports show the average of the year group and the range of achievement of the group. The box-and-whisker plots are based on five score points attained by students: the top score, the bottom score, the median, and the lower quartile and upper quartile scores. The white box plot represents the performance of the students in this research project and the grey shaded plot represents the performance of the year 4 and year 7 New Zealand Māori-medium reference population. Groups that have short ranges within the box and/or the whiskers are more similar in their performance than those with wide ranges. Groups whose median scores are at the top or bottom of the New Zealand box probably differ from the New Zealand norm by more than chance.

Curriculum functions

This report shows the aggregated results for each strand of the 1992 mathematics curriculum that was selected in these particular tests.

Learning pathways report

The reports for years 4 and 7 were identified by generating learning pathway reports to answer the question, "What are the weaknesses and strengths of student performance in regard to the curriculum outcomes listed in tables 1–3?" A percentage is given of the student cohorts that are identified as having achieved/not achieved, and gaps/strengths are shown in regard to the curriculum outcomes. For this paper, achieved and strengths have been aggregated and are reported under performance highlights. This shows where more than 60% of the cohort is identified as having achieved or having strengths in a particular achievement outcome. Not achieved and gaps are aggregated as performance concerns. This is where more than 60% of the cohort is identified as having not achieved in a particular achievement outcome and there are gaps in their knowledge.

Results of the Year 4 Students

Group Performance

Figure 1 shows that the median for the year 4 students in this study was approximately 200 points below the asTTle national norms for Māori-medium schools. There were some students performing above the asTTle national norms, but overall, these results show a significant difference. This result is somewhat surprising, considering the focus of Te Poutama Tau on number and aspects of algebra. The group performance was significantly dragged down by algebra results (see algebra in Figure 2). Why this particular cohort was achieving below the asTTle national norms is not clear.

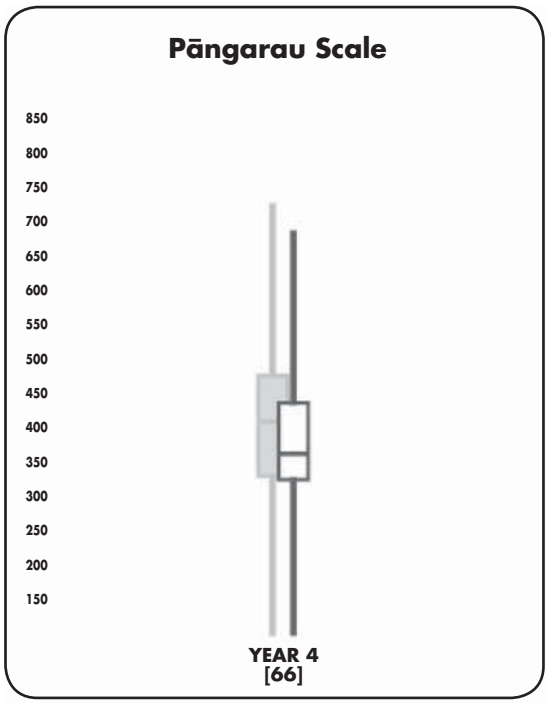

Figure 1. Group performance of year 4 students

Curriculum Functions Report

These figures show that the year 4 students were close to the asTTle national norms in number and measurement but significantly lower in algebra.

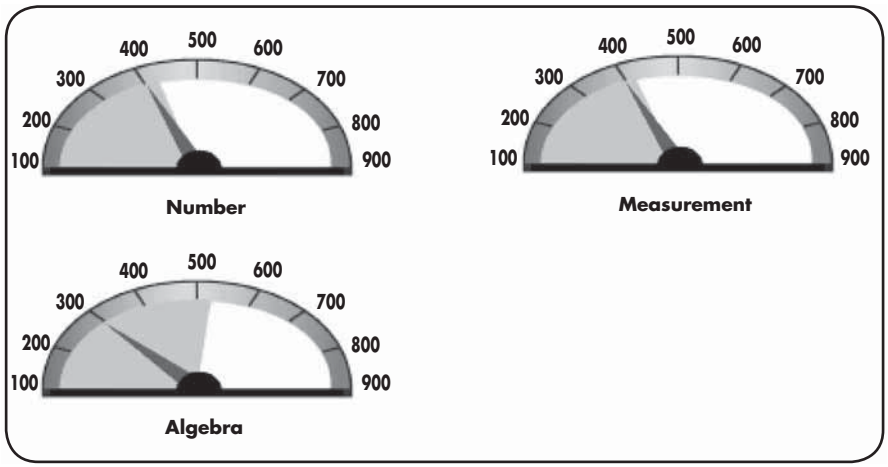

Figure 2. Student performance in relevant strands of the 1992 *Mathematics in New Zealand Curriculum*

Learning Pathways Report

Performance Highlights

Number

The year 4 students in this research study performed positively in the questions that involved giving change for money, showing sums of money by two or more combinations of notes and coins, and recalling basic multiplication facts (see Table 1).

Measurement

Students performed reasonably well in questions related to measuring with appropriate metric units and scales (see Table 2).

Performance Concerns

Number

The year 4 students performed reasonably well in recalling multiplication facts but struggled with the application of the facts.

The year 4 students also performed poorly in the questions that involved writing and solving story problems with +, –, x, and ÷. However, overall, the year 4 students in this research achieved close to the asTTle national norms for Māori-medium schools in number.

Measurement

Areas for concern include drawing and interpreting simple scale maps, measuring using a range of scale, and reading and knowing units of time (see Table 3).

Algebra

Students performed poorly in most of the algebra questions, including using the mathematical symbols =, <, >. These algebra questions also included questions that required entering the correct symbol to show a relationship between two quantities, for example, 80 ☐ 90, 9 x 2 ☐ 6 x 3, and ☐ + 8 < 10. Making, describing, and using rules for number and spatial patterns is also an area where a significant number of students were below the asTTle national norms for Māori-medium schools (see Table 2).

Results of the Year Seven Students

Group Performance

The year 7 students in this study performed significantly better than the asTTle national norms for Māori-medium schools (see Figure 3). The range of performance is much narrower, suggesting that most students were closer in ability and most performed well above these norms.

The top scores off the scale were much higher in comparison to the asTTle national norms. Significantly, there was not a long tail of low scores.

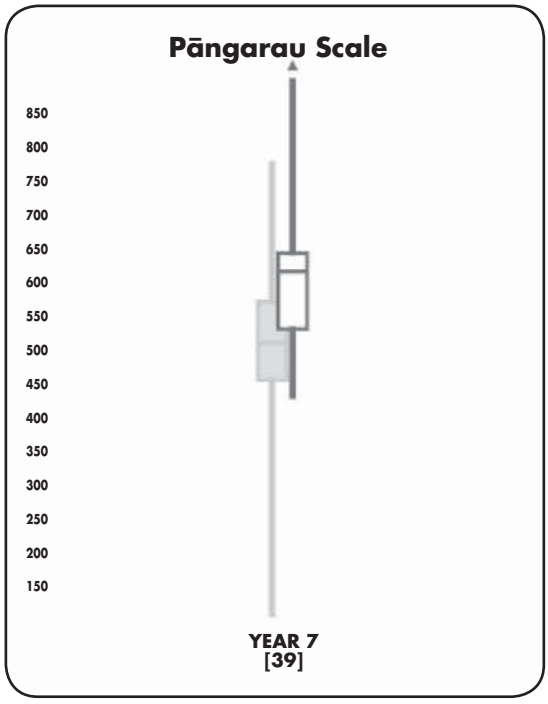

Figure 3. Year 7 group performance

Curriculum Functions Report

In the area of number and measurement, this cohort performed well above the asTTle national norms for Māori-medium schools, although not significantly so in algebra.

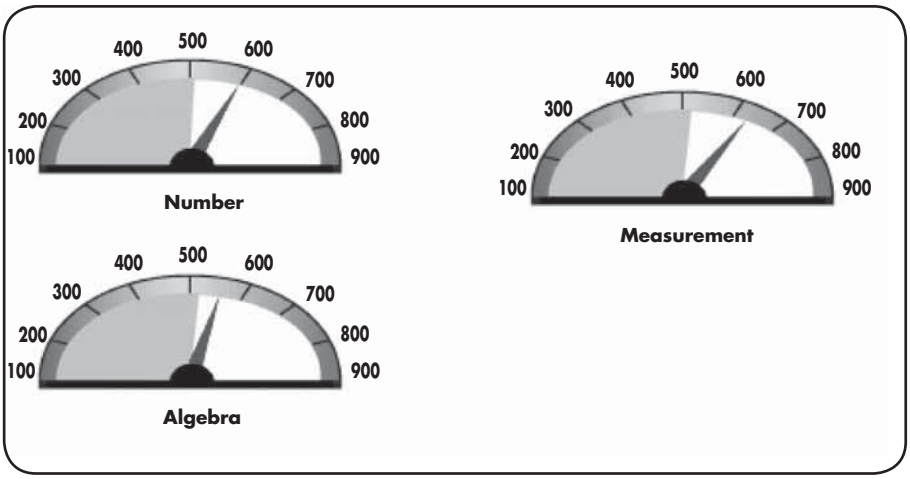

Figure 4. Year 7 curriculum functions report

Learning Pathway Report

Performance Highlights

Number

The year 7 students in this study performed well above the asTTle national norms for Māori-medium schools in the questions that involved recalling the basic addition/subtraction and multiplication/division facts (see Table 1). Students also performed particularly well in explaining the meaning of digits in 2- and 3- digit whole numbers, expressing quantities as fractions or percentages of a whole, and finding a fraction or percentage of a quantity. Significant focus is given to understanding and developing mental strategies in Te Poutama Tau to solve these types of problems. So this is a very positive outcome.

Measurement

In comparison to the year 4 cohort, the year 7 cohort did significantly well in the questions that relate to the measuring, reading, and constructing scales learning outcomes (see Table 2).

Algebra

Overall, this cohort of students performed above the asTTle national norms for Māori-medium schools. They performed well in questions linked to learning outcomes such as continuing sequential patterns, describing rules, and using graphs to represent number. This area is much improved in comparison to the year 4 cohort.

Performance Concerns

Number

Although the year 7 students performed well in recalling multiplication basic facts, they did not do so well in using these facts, partly because of confusion over the wording of the two application of multiplication facts questions that also involved completing a sequence. When questioned subsequently, many of the students did not realise question 4 (the top row) related to question 5

(the bottom row), and vice versa. Many students saw the two rows as independent of each other (see Figure 5). These students may well have completed both missing parts of the sequence if the wording had been clearer.

Questions 4 and 5. Complete the sequence in the boxes:

1	2	3	4	5	12	
1	4	9	16	25		225

Figure 5. Questions 4 and 5, Number

Measurement

Although the students did reasonably in reading and knowing units of time, questions related to learning outcomes about interpreting everyday statements involving time were not as well achieved (see Table 3).

Algebra

The only area where there was significant "not achieved" was for the outcome where students have to use graphs to represent number and relations (see Table 3). Also, although not a major concern, 45% of the year 7's did not achieve using the mathematical symbols.

Discussion and Concluding Comment

The performance of the year 7 students in the four Te Poutama Tau schools in this study is very encouraging. The students performed significantly above the asTTle national norms for Māori-medium schools. The positive results may be due to a range of variables, including teacher effectiveness and/or participation in other types of interventions, such as literacy-type programmes. It is worth noting that the majority of the year 7 students would have participated in Te Poutama Tau earlier in their schooling. All the schools involved in this research study have participated previously in Te Poutama Tau, in either 2002, 2003, or 2004.

The performance of the year 4 students may be partly explained by fewer years of involvement in Te Poutama Tau. This group could be tested again as year 5 students and their results compared with asTTle national norms to see if the pattern of achievement continues. (It is not known at this point in time if these particular schools will also be participating in 2008.) Some of the areas of concern can be relatively easy to address, for example, using the mathematical symbols =, <, >. Others are significantly more complex, such as describing or making up and using a rule to create a sequential pattern. What is clear is that both cohorts did not perform as well in the area of algebra as expected. With a targeted focus on this area for 2008, many of the issues may well be addressed.

The following research questions for further investigation arise from the research that has been discussed in this report and from discussions with Te Poutama Tau facilitators:

- Retest another cohort of year 4 and year 7 students using asTTle. Are the results consistent with the 2007 results?
- Compare students' asTTle results with their performance in IKAN forms. (IKAN [Individual Knowledge Assessment for Numeracy] forms can be used to determine students' stages on the knowledge domains.) This will provide a comparison of student knowledge.

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