

CHAPTER 1: INTRODUCTION

KEY POINTS

- TIMSS-98, also known as TIMSS-R, was a repeat of the Third International Mathematics and Science Study (TIMSS-94).
- Whereas TIMSS-94 assessed students at the middle primary, upper primary, and lower secondary levels, TIMSS-98 had a narrower focus with the international component of the study administered at just the lower secondary level.
- The international component of the study was designed to measure trends in student achievement and involved New Zealand's Year 9 students. The results were published in an earlier report, *Trends in Year 9 students' mathematics and science achievement*, published in early 2001.
- New Zealand also administered a national version of TIMSS-R at the middle primary level in order to compare the performance of Year 5 students in 1994 with their counterparts in 1998. This report presents the results from this aspect of the study.

WHAT WAS TIMSS-98?

TIMSS-98, also known as TIMSS-R, was a repeat of the Third International Mathematics and Science Study (TIMSS), an extensive study on curricula, student achievement, and class and school environment undertaken in more than 40 countries during the period 1992 to 1997. In New Zealand, the assessment component of TIMSS was administered in 1994.

TIMSS-98¹ was designed to measure trends in student achievement four years after the study was first administered in 1994, as well as to examine the contexts for learning mathematics and science.

Whereas TIMSS-94 assessed students at the middle primary, upper primary, and lower secondary levels, TIMSS-98 had a narrower focus with the international component of the study administered at just the lower secondary level.

A NATIONAL VERSION OF TIMSS-98 AT THE MIDDLE PRIMARY LEVEL

New Zealand wished to gather comprehensive trend information at the middle primary level as well as at the lower secondary level, therefore chose to administer a repeat of TIMSS-94 at the middle primary level. The study allowed the performance of Year 5 students in 1998 to be compared with the performance of their 1994 counterparts². In addition to trend information, the TIMSS-98 results provide the opportunity to assess what impact the new curricula are having in improving the performance of students in mathematics and science four years on from TIMSS-94. The findings from this national study are the subject of this report.

THE RESULTS OF TIMSS-94 AND THE IMPACT ON TIMSS-98

Overview of TIMSS-94

TIMSS-94 was the largest and most comprehensive International Association for the Evaluation of Educational Achievement (IEA)³ study to date, collecting data on achievement in mathematics and science at three different educational levels — middle primary (Years 4 and 5 students⁴), upper primary and lower secondary (Years 8 and 9 students)⁵, and final year of schooling. Student achievement was placed in context through background information gathered on curricula, and from students, teachers, and school principals. Importantly for New Zealand, new mathematics and science curricula were just being introduced when the TIMSS-94 testing was completed; that is, the students' achievement was essentially a product of the old curricula.

¹ *TIMSS-94 and TIMSS-98 are hereafter used to distinguish between the two assessments.*

² *Year 5 students in 'standard 3'. The international grade equivalent was grade 4.*

³ *The IEA is an independent cooperative of national research institutions with its headquarters based in Amsterdam, the Netherlands. The New Zealand Ministry of Education is a member institution of IEA.*

⁴ *The actual class levels were standards 2 and 3; students at these class levels are mostly Years 4 and 5 students.*

⁵ *The actual class levels were forms 2 and 3 or Years 8 and 9 students.*

Key findings from TIMSS-94 at the middle primary level

The key achievement results for middle primary school students who participated in TIMSS-94 were:

Mathematics:

- The means for both Years 4 and 5 students were statistically significantly below the international means for their counterparts from 26 countries (ie, Grades 3 and 4 respectively).
- The means for Years 4 and 5 students were also statistically significantly below those students from countries with whom New Zealand has traditional links (eg, English-speaking or that have similar education systems). These countries included Australia, Canada, and the United States.
- An area of particular weakness for New Zealand students was *Whole Numbers*.
- Girls, on average, achieved higher scores in mathematics than their male counterparts (Chamberlain, M, 1997).

Science:

- New Zealand Years 4 and 5 students achieved, on average, around about the international means.
- Notwithstanding their performance overall, their performance was found to be statistically significantly lower than their counterparts in Australia, England, and the United States.
- *Physical Science* was identified as an area of relative weakness for New Zealand students.
- Although not of statistical significance, New Zealand was just one of three out of 26 countries where girls' mean achievement was higher than that of boys' mean achievement. This difference was largely attributed to girls out performing boys in *Life Science* (Chamberlain, G, 1997).

For details of the national and international reports published for TIMSS-94, refer to Appendix A.

The impact of TIMSS-94 in New Zealand

Although the first of the TIMSS-94 findings became available in late 1996 it was the release of the middle primary school results in mid-1997 that highlighted areas of concern in mathematics and science education in New Zealand. The TIMSS results, combined with reported difficulties teachers were experiencing in implementing the new mathematics and science curricula, particularly in the primary sector was the impetus for the Minister of Education to establish the Mathematics and Science Taskforce in August 1997 (Ministry of Education, 1997).

The taskforce made a number of recommendations to which the New Zealand Ministry of Education has responded. These have included the establishment of a comprehensive publishing programme involving new and revised resource material for both students and teachers, particularly in primary schools. Other resources included a video and two CD Roms to support the new learning materials and the development of additional items for the online Assessment Resource Banks (ARBs). The publishing programme began in 1998 and still continues. In 1999, Te Kete Ipurangi (TKI), the Ministry of Education's online learning centre, was also launched as part of the 1998 Information Technology and Communications Strategy and is an example of another facility for supporting teachers in mathematics and science and other curriculum areas.

However, due to the timeframe of less than one year between the implementation of the programme and the assessment at the end of 1998 it is unlikely that any of these developments would have had a significant impact on the results for Year 5 students in 1998.

What can be learnt from TIMSS-98?

The main questions to be answered by undertaking a replication of TIMSS-94 at the middle primary level included:

- To what extent has the achievement of New Zealand Year 5 students changed in mathematics and science over the four-year period from 1994 to 1998?
- Have the relatively new mathematics (introduced in 1993) and science curricula (introduced in 1995) resulted in improvements in achievement?
- Have there been any changes in the organisation and processes of classroom instructional practices for mathematics and science?⁶
- Have students' attitudes towards mathematics and science changed over time?

WHO CARRIED OUT THE ADMINISTRATION OF TIMSS-98?

In New Zealand the Comparative Education Research Unit in the Ministry of Education was responsible for carrying out the TIMSS-98 activities at both the middle primary and lower secondary levels.⁷

RATIONALE FOR THE STUDY

Conceptual Framework

The conceptual model for TIMSS-94, and thus the model for TIMSS-98, was based on the *intended*, *implemented* and *attained* curricula.

The *intended* curriculum refers to the aims, content, and methods for each of mathematics and science education as defined by a country's educational authorities. *Intended* curricula are described in documents such as curriculum guides, prescriptions, syllabuses, and policy statements. Textbooks, resources and examinations also reflect the essence of *intended* curricula. As well as being set within a specific educational context, *intended* curricula are also set within the context of a society. Societal factors — for example goals and expectations the society holds for education, the role of private education, the status accorded to teachers, the resources society has, and the proportion of those resources allocated to education — all have an influence on the national intentions.

Teachers interpret, translate, and implement the intentions of curricula according to their own experiences and beliefs. The educational milieu in which the *implemented* curriculum is placed embodies institutional arrangements made at the school and class levels but is also largely influenced by system

⁶ This question is beyond the scope of this report.

⁷ The lower secondary component of TIMSS-98 was administered under the auspices of the IEA. (See footnote 3.) A consortium were responsible for managing the international activities required for the project: Lynch School of Education at Boston College, (Massachusetts) and the Educational Testing Service, (Princeton) United States; the IEA's Data Processing Centre in Hamburg, Germany; and Statistics Canada in Ottawa, Canada.

level arrangements. The local community, while often reflecting society-at-large, provides the context for the setting of the *implemented* curriculum.

The *attained* curriculum consists of the concepts, processes, skills, and attitudes towards mathematics and science students have acquired during their schooling. It can also be placed in the broader context of institutional arrangements as well as students' backgrounds (Robitaille et al, 1993; Robitaille & Maxwell, 1996).

For a more detailed account readers should refer to Garden (1996a, 1996b or 1997).

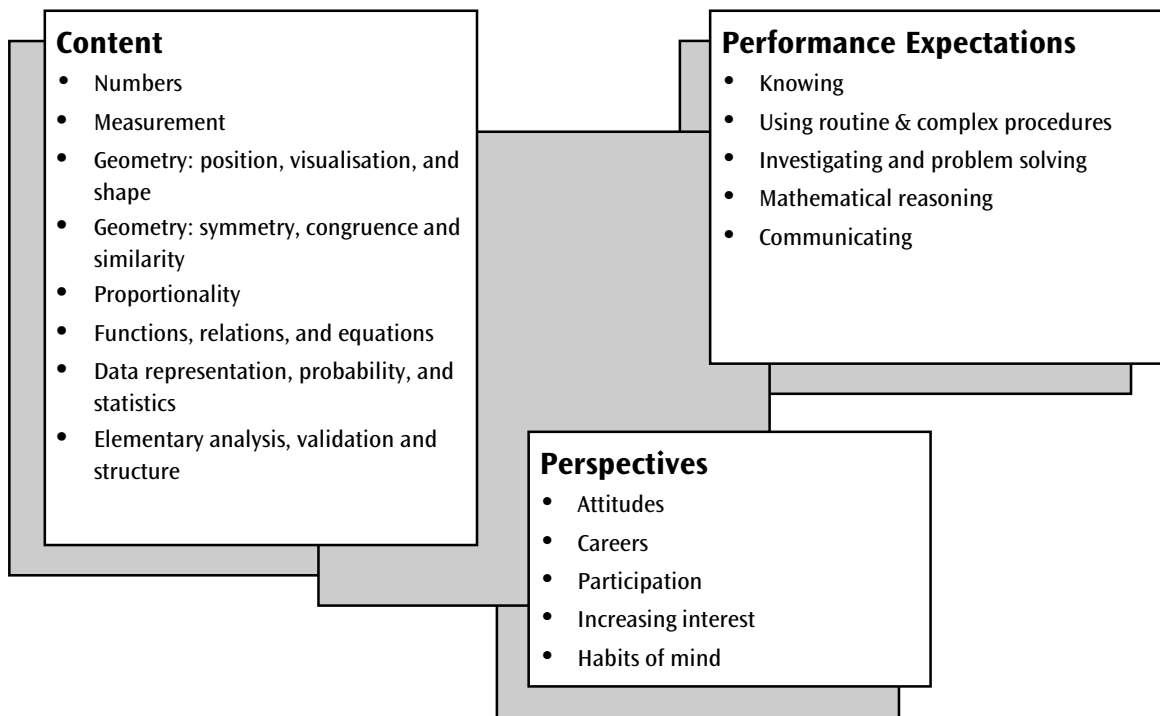
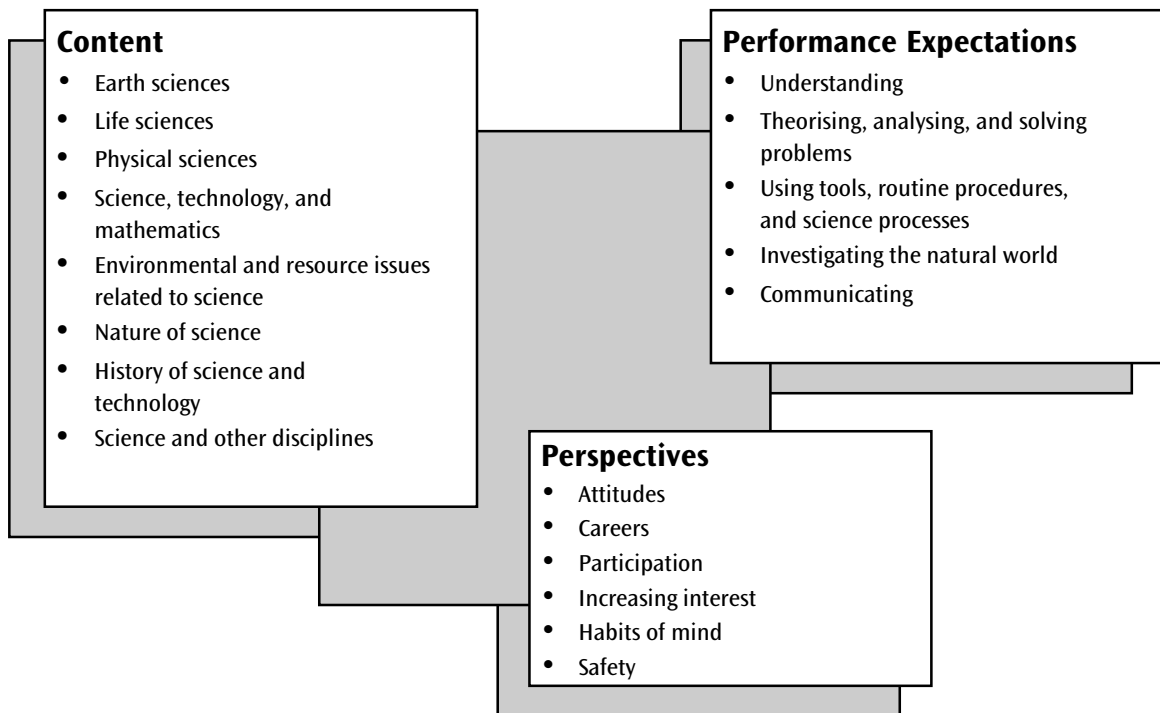
Curriculum Frameworks

The development of a curriculum framework for each of mathematics and science was a particularly important activity for TIMSS-94. These frameworks provided a basis on which to analyse the *intended* curriculum of countries in the Curriculum Analysis component of the study⁸, as well as providing the basis for developing the achievement tests and aspects of the context questionnaires. The framework used for TIMSS-94 was used again in the lower secondary level element (ie, the international part) of TIMSS-98.

There were three dimensions to each of the framework: *content*, *performance expectations*, and *perspectives*. *Content* referred to the subject areas in mathematics and science (eg, Number, Earth Science). *Performance expectations* encompassed the cognitive behaviours that students were expected to display in order to answer the various test questions (eg, knowing, understanding). The *perspectives* aspect of the framework reflected the types of curricular goals that were important for promoting educational outcomes such as attitudes and interest in mathematics and science. Figures 1.1 and 1.2 present a summary of the mathematics and science framework; more detailed accounts can be seen in Robitaille, et al (1993).

For example, in mathematics about one-quarter of the *Whole Numbers* items were categorised as *routine*. Similarly for science, approximately one-third of the *Physical Science* items required students to demonstrate *theorising, analysing and solving problem* skills. For more details refer to Adams and Gonzalez (1996).

⁸ See Many Visions, Many Aims Volumes I & II (Schmidt et al, 1997a & 1997b) for details on cross-national investigation of curricular intentions in school mathematics and science. Also see Mullis et al (2000) and Martin et al (2000) for details from TIMSS-98.

Figure 1.1: The mathematics curriculum framework**Figure 1.2: The science curriculum framework**

POPULATION DEFINITION

As already noted TIMSS-98 had a narrower focus than was the case with TIMSS-94; this was also the case with the student population definition.

The population for TIMSS-98 was defined as: *the upper of the two adjacent class-levels used in TIMSS-94*. Using the class nomenclature, this equated to *standard 3 and involved mostly Year 5 students*.

In TIMSS-94, the original middle primary population of interest was defined as those students who were in the two adjacent class-levels containing the most 9-year-olds. In New Zealand this involved two class levels — standards 2 and 3 (mostly Years 4 and 5) students.

SAMPLING

The sampling was conducted at two levels — firstly, the selection of schools and secondly, the selection of classes or groups. The sampling frame comprised all schools with at least five Year 5 students, except for special schools and the Correspondence School. Schools were sorted (or implicitly stratified) according to their school roll size and the urban or rural nature of the community in which they were located. A random sample of schools was drawn with the probability of selection being proportional to the total number of Year 5 students enrolled in the school; that is, larger schools were more likely to be selected than smaller schools, but schools of equal size were equally likely to be selected.

The selected schools were then asked to supply a list of all their mathematics classes or groups with Year 5 students, as well as a list of the corresponding teacher(s) who taught science to the class. A mathematics grouping was then randomly selected, with those students completing the assessment and a background questionnaire. The teacher(s) who taught mathematics and science to the selected grouping completed a teacher questionnaire.

TABLE 1.1 A SUMMARY OF NEW ZEALAND'S DESIGNED AND ACHIEVED SAMPLES AT YEAR 5 IN TIMSS-98

| Total number of schools in designed sample (N) | Total number of schools in achieved sample (N) | Total number of students in achieved sample (N) |
|--|--|---|
| 150 | 148 | 2416 |

INSTRUMENTATION

Achievement data were collected from students in 1998 using the same test used in TIMSS-94. Whereas new test questions were developed by the international consortium to replace the group of questions released after TIMSS-94 at the lower secondary level, this was not the case at the middle primary level. New Zealand was the only country to undertake a repeat at the middle primary level in 1998, therefore the same achievement test and student context questionnaire were used as those in TIMSS-94.

The test was a 'pencil and paper' test with about three-quarters of the questions in multiple-choice format. The remaining test items were in an open-ended format. The test items, both mathematics and science, were distributed over eight different booklets. Each student was randomly assigned to one of these booklets. There were two testing sessions comprising a total time of 64 minutes.

Students also completed a 20-minute background questionnaire after the achievement test. The background information collected included demographic data and students' attitudes towards mathematics and science.

Teacher and school questionnaires were also administered to the teacher(s) of the selected class and the principal of the school. These took from 20 to 30 minutes to complete. The type of data sought here included information on resources, leadership and management practices, qualifications, classroom practices and attitudes towards teaching.⁹

DATA COLLECTION

Data for TIMSS-98 were collected in the fourth school term in October and November 1998.

REPORTING STUDENT ACHIEVEMENT RESULTS

The achievement scores in this report are presented in the form of *Item Response Theory* (IRT) scale scores. IRT scale scores incorporate information about the characteristics of both the test items (eg, difficulty) and the students taking the test, and allow for the fact that each student received one of the eight randomly assigned test booklets. See Technical Note TN.1 in Appendix E at the end of this report for details.

IRT scale scores were used to summarise the international TIMSS-94 results. However, it is important to note that the scale scores in this report that refer to TIMSS-94 are not the same scale scores reported in earlier international reports for that study.

The original TIMSS-94 scale scores were determined on the basis of results from two classes at each population level. Therefore, in order to make the 1994 scores directly comparable with the narrow population definition used at the lower secondary for TIMSS-98, it was necessary to rescale the original TIMSS-94 achievement data, using just the upper of the two class levels. The international consortium responsible for the administration of TIMSS-98 undertook the rescaling of all the achievement data collected in 1994.

⁹ The information collected from teachers and principals is not included in this report.

Two other approaches are used in this report to describe student achievement results — mean percent correct scores and the proportion (or percentage) of students answering individual items correctly.

1. *Mean percent correct scores* (or the mean across sets of test items). This approach was taken to report student achievement results in the TIMSS-94 national reports; it was also used to summarise student performance internationally in the different content areas.

In this report, this approach is used to examine student achievement on two sets of items:

- *Trend* items — the items (approximately one-third of the item pool, all in multiple-choice format) that were kept secured after the completion of TIMSS-94; and
- *Released* items — the items (approximately two-thirds of the item pool, including some multiple choice and all the items in open-ended format) that were released into the public domain by IEA after the publication of the international reports on TIMSS-94.

As noted previously, since New Zealand was the only country to undertake a repeat of TIMSS-98 at the middle primary level no new test items were developed to replace the items released into the public domain after TIMSS-94 (ie, the *released* items). In New Zealand, the *released* items were, for example, made available through the New Zealand Council for Education Research's (NZCER) Assessment Resource Banks. While there is no evidence of systematic use of these items by New Zealand schools, it is possible that some students had previously been exposed to *released* items prior to TIMSS-98 testing. This then, is the principal reason that analyses of *trend* items have been reported — *trend* results substantiate overall findings when they are consistent and place caveats around overall findings where they are inconsistent.

2. *The percentage of students who answered each individual item correctly*. Examples of test items are presented in this report. This approach was also used when reporting examples of test items for TIMSS-94, as well as reporting on the performance of New Zealand students on the open-ended questions.

CHAPTER SUMMARY

This chapter has provided a brief overview to the background to this national study based on the Third International Mathematics and Science Study (TIMSS). In order to gather comprehensive trend data at the middle primary level, as well as the lower secondary level, New Zealand made the decision to conduct a replication of TIMSS with Year 5 students. This national study was administered at the same time as the repeat of international study involving Year 9 students.

Achievement data as well as contextual information were collected from Year 5 students in 1998. Since New Zealand was the only country to undertake a repeat at the middle primary level in 1998, the same achievement test and student context questionnaire were used as those in TIMSS-94.

Year 5 student achievement results are summarised in the form of Item Response Theory scale scores, while mean percent correct scores are used to summarise student performance on the *trend* (or secured) test questions that were used in both TIMSS-94 and TIMSS-98.

