General Issues Arising from the Data

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CHAPTER 9

GENERAL ISSUES ARISING FROM THE DATA

The universal inclusion of mathematics and science in the educational programmes of children throughout the world is in recognition of the extent to which expertise in these subjects underpins the economic prosperity and general well-being of nations, and the capacity of citizens to make full and informed contributions to their societies. This report presents results derived from data provided by almost 5000 standards 2 and 3 students, and their 288 teachers, from 149 schools late in 1994 as part of the Third International Mathematics and Science Study (TIMSS).

More complex analyses will be needed to determine relationships between student, classroom, school, and system characteristics and achievement in mathematics and science with greater certainty. Nevertheless these preliminary results, taken in conjunction with findings from previous studies, will provide a basis for questioning the efficacy of current policies and practices intended to provide children with a sound beginning to their mathematics and science education. Findings that are of interest to decision-makers at all levels of education, and to the community-at-large, have been presented in the report.

The TIMSS tests and questionnaires, as well as being responded to by large and representative samples, were prepared and administered in accord with the strict quality control procedures imposed by the international study centre. In addition, as in all participating countries, an independent quality assurance monitor made a study of how TIMSS was conducted in New Zealand and reported (favourably) to the international study centre.

THE CHALLENGE

That the mathematics and science achievement of New Zealand standards 2 and 3 students is amenable to improvement, and that such improvement would be very desirable, is apparent from results presented in Chapters 4 and 5. In mathematics, only three countries — Norway, Iceland, and Iran — have mean scores significantly below that of New Zealand at the standard 2 level, and only four countries — Portugal, Iceland, Iran, and Kuwait — are significantly lower at the standard 3 level. New Zealand was bracketed on similar scores with Cyprus, Greece, Thailand, and Portugal at standard 2 level, and England, Cyprus, Norway, Thailand, and Greece at the standard 3 level. All other countries had significantly higher mean scores. In science, New Zealand is about the middle of the range of all countries, but is not higher than any of the English-speaking countries. Although a few countries did not fulfil all of the TIMSS sampling requirements, none had means likely to have been sufficiently biased to change this situation.
As the report points out, lasting improvements in educational achievement are seldom effected by changing only one or two conditions in the system. Because achievement is an outcome of the action, and interaction, of many variables, policies on a broad front are necessary. In seeking to develop policies to improve mathematics and science achievement, the first step is to critically examine what is known about all of the variables thought to contribute, or to be an impediment, to learning in the subjects. Being able to contrast New Zealand conditions and practices with those of other countries gives policy-makers the advantage of being able to either confirm, or discard, beliefs about what features of systems, schools, and classrooms enhance teaching and learning which have currency in this country, and to rethink issues which may have been taken as givens.

The objective of this chapter is to draw attention to some of those aspects of education in New Zealand which are thought to impact on achievement in mathematics and science, and for which the TIMSS data prompt questions about whether changes might be considered. In particular, aspects in which education in New Zealand differs from that in other more successful participating countries will be highlighted. Data collected in TIMSS covered a wide range of variables from system level to student level, so that several important variables can be expected to influence achievement generally, and not just achievement in mathematics and science.

It must be remembered that data was collected almost three years before publication of this report and that in the interim government has introduced new policies in education, some of which are relevant to issues raised in this chapter. For example, professional development for teachers; publications designed to guide teachers in implementing aspects of the new curricula have been produced; and interventions to reduce bullying made.

Success in learning mathematics and science at any level of the school system depends on having intended curricula suitable for the developmental stages and prior learning of the students for whom it is intended. Structures and conditions of schooling which enable the curricula to be delivered efficiently and without unnecessary impediment, and schools having the resources necessary to deliver the curricula and allocating adequate time for them to be well taught, are necessary. Most importantly, teachers must be equipped to provide quality teaching and deliver the implemented curricula as intended, and students must have been satisfactorily prepared and supported in prior years to make it possible for them to take full advantage of the learning experiences provided.

THE INTENDED CURRICULUM

New intended curricula (Curriculum Statements) in mathematics and science were being introduced at about the time TIMSS data were collected. These would not have affected mean scores for New Zealand students to a measurable extent, but the new, as well as the former, official mathematics and science curricula were included in the TIMSS analysis of intended curricula.

The TIMSS Curriculum Analysis revealed that reforms in mathematics and science curricula had been made, or were in the process of being made, in many countries. New Zealand reforms were similar in nature to those in the United States and England. Alterations to subject-matter content were negligible, the most significant change being to an outcomes-based curriculum design with recommended approaches for teaching and assessment.
This approach makes new demands on teacher expertise, but TIMSS data indicates that at the time of
the study teachers may not have had access to adequate resources to assist them in translating the
intended curricula into classroom practice. As did the Second International Mathematics Study,
TIMSS reveals a wide gap between what is intended to be taught and what is actually taught in many
classrooms. Data supplied by teachers about the resources they used to support their teaching
indicated that there was a need for teacher-guide material sufficiently detailed to provide teachers
with the means to close this gap.

According to the international curriculum analysis data, New Zealand mathematics students are
expected to cover more mathematics topics per year than students in most other countries. On the
other hand, on average, topics are included in the curriculum for more years than in most other
countries. This raises the issue as to whether the desired objective might be to cover less topics each
year, but to do so in more depth, or to a point where they are more thoroughly learned.

There are also some interesting differences in timing of certain topics (for example, common and
decimal fractions are taught much later in New Zealand than in most countries) but readers
interested in matters of content detail should see curriculum analysis publications referred to in
Chapter 1. The data and findings in Chapters 4 and 5 give rise to a number of curriculum-related
issues which subject-matter specialists concerned with policy will find of interest, but this final
chapter will be concerned largely with variables other than curriculum.

THE SYSTEM

A perennial debate amongst national research coordinators representing their countries in
international surveys, centres on whether student achievement should be compared on the basis of
age, or on the basis of equivalent grades, or on comparability of curricula. An exhaustive procedure
to minimise problems due to curricular variation was undertaken, and sampling two adjacent grades
allowed measures of achievement for comparable grades, as well as age measures of achievement, to
be obtained.

The dilemma over ages and grades arises because of the different ages at which children start school
in the various countries. Of the more than 40 countries that took part in some aspect of TIMSS,
most had a school entry age of six years, the next most common age of entry was seven, and New
Zealand was one of a very few in which children began school below the age of six years. New
Zealand nine-year-olds thus have at least one, and in some cases two, more years of schooling than
children in most other countries. In addition, a relatively high proportion of our children (over 80%)
experience some form of pre-school education, yet by the age of nine years their average
performance in mathematics and science falls short of that of children in a majority of other TIMSS
population 1 countries.

Although there have been recent changes in the respective intended curricula, there is a case for re-
examination of the nature and delivery of pre-school and junior school programmes involving
mathematics and science. The following are among the curriculum-related questions to which
answers might be sought in determining what actions might be taken to improve achievement: Are
the pre-mathematics, mathematics, and science-related activities it is expected children will
experience in these years appropriate for their age? Are all children intellectually challenged in these areas? Or are other demands on pre-school professionals, or lack of suitable resources, leading to neglect in these learning areas?

Another aspect of early schooling in which New Zealand schools are unusual is in allowing continuous entry of new-entrants throughout the year. Common practice internationally is to have one, two, or three entry points in a school year. Although entry immediately on reaching five-years-of-age has become a distinguishing feature of the New Zealand system, there may be issues of teaching and learning efficiency that should be examined.

SCHOOLS AND CLASSROOMS

A good feature of the New Zealand system is that in their mathematics and science education, primary school children in rural schools do not appear to be disadvantaged in comparison to children in urban schools. About one-quarter of New Zealand 9-year-olds are educated in rural schools, many of which are very small. The mean size of New Zealand schools, overall, is about the middle of the range of means for participating countries. In Korea and Singapore, some schools at this level have enrolments running into the thousands.

Data supplied by principals, and especially principals who are required to do a substantial amount of teaching, indicate that they have heavy workloads. They engage in a wide range of activities, many of which require special skills, in fulfilling their roles. In addition, the data suggests that there is still a degree of uncertainty about the respective responsibilities of principals and boards of trustees. It may be that the adequacy and effectiveness of current arrangements for the preparation and training of principals for their management role are in need of review.

Class sizes in New Zealand tend to be higher than the averages for most participating countries (six countries reported higher averages at the level equivalent to standard 3). However, there was no simple relationship between class size alone and student achievement, either between countries, or within New Zealand. Compared with other countries, New Zealand has a large proportion of children in multi-grade (composite) classes. In part this is due to the many small schools, but larger schools also tend to use this form of organisation. New Zealand teachers also report using small group organisation to a greater extent than do teachers in most other countries. Thought, and perhaps research, could be devoted to questioning whether advantages claimed for these practices outweigh disadvantages.

Many teachers, as well as principals, expressed a desire for more computer software but relatively few teachers (or students) reported using computers to any significant extent with the software they currently have available. There would need to be further study to find what sort of software teachers are seeking, and also to establish whether or not the use of computers enhances learning in mathematics and science for standards 2 and 3 students.

Absence of equipment for the teaching of science was said to be impeding the teaching of science, and there can be little doubt that science can not be taught efficiently without a reasonable range of equipment and materials being to hand. The most obvious shortcoming, however, was lack of
written guide material for teachers. Many teachers indicated that they relied on the curriculum statements for guidance, but interpreting these documents in terms of effective day-to-day classroom implementation would have been a major challenge for most teachers. In contrast to teachers in most other countries, a substantial number of teachers indicated that they did not have the support of textbooks. For children in every classroom to have the opportunity to experience coherent, developmentally appropriate programmes of learning in mathematics and science, their teachers need supporting written material to assist them to translate the intentions of the official curriculum statements into classroom practice.

It may be that the reported use of calculators and computers in classrooms provides an example of the need for quality teacher guidance. The previous mathematics curriculum guide encouraged the use of calculators and computers in teaching mathematics. Current curriculum statements in both mathematics and science do likewise. Computers are seldom used in standards 2 and 3 classrooms but from TIMSS data it seems calculators are used widely and frequently in these, to a greater extent than in any other participating country. Indeed, in most countries calculators are hardly used at all at this level. There seems a likely connection between this and the fact that on an item asking students to add two four-digit numbers, New Zealand was amongst the countries with the worst results; and on another item asking students to subtract one four-digit number from another, New Zealand had the worst results of all countries.

In items dealing with numeric place value, one of the prime topics in which calculators can be used to enhance learning, New Zealand students consistently performed poorly. Calculators are potentially useful aids to learning in mathematics, but there should be guidance to teachers as to when, for what, and how best to utilise them to bring this about.

Commonsense would tell us that a child who feels unsafe is unlikely to be at their best in class. While this is likely to extend across all curriculum areas, this study was able to examine this relationship in terms of mathematics and science. Negative relationships were found between frequency of bullying and theft and achievement in mathematics and science. Disturbingly, proportions of New Zealand students who reported having experienced bullying or theft of their property were amongst the highest in the world. These proportions of students were very much higher than would be expected from principals’ reports of staff time spent on these issues. It is possible that tolerance levels in these areas is high in New Zealand schools, or that for some reason students do not bother to report offences.

Classroom disturbance was a problem very commonly reported both by teachers and by principals. It was the behavioural problem that was considered to occur most frequently and to involve the greatest number of students, and was the only behaviour which principals reported as involving more than 10 percent of students. Disruptive students in a class prevent all members of the class from achieving to their potential, and doubtless contribute to teacher dissatisfaction with their vocation.
TEACHERS

The most direct influence on student achievement in mathematics or science is the teacher. New Zealand standards 2 and 3 teachers, as in almost all other countries, are predominantly women and the modal age-grouping is 40–49 years. At the between-country level, there is no obvious link between the gender of teachers and the achievement of their students. Nor was there a significant relationship between length of teaching experience and student achievement.

Effectiveness in teaching mathematics and science depends on teachers having adequate subject-matter knowledge, being well-trained in how to maximise students’ learning of the subjects, having positive attitudes to the subjects, and ensuring that students are given sufficient time to learn.

Entry to colleges of education is possible with relatively meagre knowledge of mathematics or science. Add to this the fact that college of education minimum requirements for studying these subjects, and how best to teach them, as described in this report seem worryingly low. It is then inevitable that many teachers must begin their careers ill-equipped to provide students at any level with effective programmes in mathematics and science.

Lack of confidence in teaching mathematics or science stemming from inadequate subject-matter or pedagogical knowledge has two important side-effects. First, teachers in this position are likely to have poor attitudes to the subject and to unwittingly communicate these to their students. Second, teachers may avoid teaching the subject. New Zealand schools tend to allocate less time than most other countries to the teaching of mathematics and science to standards 2 and 3 children and, as statistics in the report show, classes are often taught the subjects for less than the allocated time.

New Zealand students have performed very well, internationally, in reading literacy and reading comprehension studies, and student estimates in TIMSS of the number of books in their homes gave New Zealand one of the highest measures. Mean time allocated for reading instruction added to that for writing, literature, and other language activities takes up more than 50 percent of the school week. In comparison mathematics lessons, on average, take up 14 percent and science lessons about half of that. While teaching reading and writing are of prime concern at this level, the imbalance of time allocations seems to be greater than desirable if achievement in mathematics and science is to be improved.

It is likely that lack of confidence in teaching core subjects is one of the contributing factors causing teachers to want to change careers. More than half of the standards 2 and 3 teachers indicated that they would change career if the opportunity arose. This, along with the data showing wide-spread teacher perceptions that their work was not appreciated by society, indicates low morale amongst teachers which in turn may have led to teachers performing below their potential in the classroom.

Assessment is another area in which many teachers appeared to need guidance. Assessment of student progress is an essential component of effective teaching. It exposes shortcomings in the teaching programme, if they exist, as well as any areas of misunderstanding individual students may have, so that both the teacher and the students can take steps to improve the situation. TIMSS data revealed over-reliance by some teachers on unreliable assessment procedures at the time of the study, and suggest that many students were not receiving informative feedback from assessment. The Assessment Resource Banks which have recently become available should assist in alleviating this problem.
Although most New Zealand students were given homework on a reasonably regular basis, they were somewhat less likely than students in most countries to be set regular homework in mathematics or science, as were those of England, Scotland, and the Netherlands. A significant minority of teachers set little or no homework.

**STUDENTS**

Academic success of individual students is strongly related to characteristics of the students and their home circumstances. Some student and home background variables cannot be altered, and others cannot be altered by the school. But others, such as the availability of books in the home and encouragement to read them, a suitable place for homework to be done, parental interest in children’s schoolwork and press for them to do their best in school, can be influenced by parents. It is therefore important that agencies, including schools, that have a role in parent education try to reach all parents and other caregivers to motivate them to provide the best possible support for their children’s learning, and guide them in how to do so.

In spite of some members from all ethnic groupings registering very high performance, average performance of Pacific Islands and Maori children continues to lag well behind that of Pakeha/European. There is also a strong suggestion that although standards 2 and 3 girls’ performance in science relative to that of boys is very good, even at this level their attitudes and achievement are beginning to deteriorate, so that by the time they reach forms 2 and 3, girls’ average science achievement lags behind that of boys and many girls have developed negative attitudes to the subject.

Low average performance of Pacific Islands and Maori children relative to that of other ethnic groupings is not surprising, given that these children are more likely to come from homes with low socio-economic status. The data show that these children are less likely to have access to certain home possessions (books, calculator, computer, provision for homework) likely to stimulate learning in mathematics and science. Even though books are available through schools, Maori and Pacific Islands children are less likely to read for pleasure, and less likely to spend time doing mathematics or science homework (especially if they are boys).

Socio-economic status is almost invariably found to be related to educational achievement, and TIMSS data is no exception. Data from principals also confirms the strong links between socio-economic status and some of the other variables likely to lead to low achievement, such as poor nutrition, learning difficulties, and health problems. However, part of the reason for the wide range of class means within each TFEA decile (see Chapter 4) will be due to differences in the quality of mathematics and science teaching, and pre-school and general school experiences the students have received. It cannot be assumed that children from low socio-economic status homes will necessarily have low achievement.

New Zealand population 1 girls performed better in mathematics and in science, on average, than the boys and this is very uncommon amongst TIMSS countries. However, a smaller percentage of standard 3 girls than standard 2 girls have positive feelings about learning mathematics. It was also found that form 3 girls are less likely than are form 2 girls to have positive attitudes to learning mathematics and science. Forms 2 and 3 girls’ mean achievement in science is lower than that of the boys. While a majority of students have positive attitudes to learning mathematics and science, it
appears that beginning from a fairly young age there is an increasing proportion of students having lost interest in the subject, with a concomitant decline in their achievement. This effect is considerably greater for girls than for boys.

The phenomenon, observed in previous studies, of countries with the highest mean achievement also having higher proportions of students saying they do not enjoy learning the subjects was also noted in TIMSS. In general, the mathematics and science taught to population 1 children in these countries is at a higher level than in other countries. A high proportion of New Zealand children, whose mean achievement is low relative to a majority of countries, report that they ‘like learning mathematics’ and ‘like learning science’. While it is desirable that children enjoy learning, it needs to be remembered that enjoyment and satisfaction derive from persevering with and solving difficult problems as well as from ‘fun’ activities. New Zealand policy-makers may wish to consider whether teachers should receive more positive encouragement to provide challenging material for all students, especially those of above average ability.

CONCLUSION

One of the brighter features of student performance in TIMSS was that their mathematics performance relative to that of other countries improves markedly between population 1 and population 2. But even then the mean is only about ‘the middle of the pack’. Science performance is at about the mean for both populations. If New Zealand students could be given a better knowledge and skill base in the early years, they might well perform on a par with the best of the Western countries.

Almost all standards 2 and 3 students believe that it is important to learn mathematics and science, and believe that ‘significant others’ see it as important for them to learn these subjects. All New Zealand children have the opportunity to learn these subjects, but it seems certain that too many are not given the opportunity to reach their full potential. All of those involved in mathematics and science education in New Zealand wishing to progress towards this goal will weigh the evidence emerging from TIMSS and determine areas in which change can lead to improvement. This concluding chapter suggests some factors at each of the levels of the educational structure, but there are many more throughout the preceding chapters.

Secondary analyses of the data will be undertaken at international and national centres, but the data will also be made available to individual researchers in the near future. It is hoped that the TIMSS data will be fully exploited in the search for sound findings on which policies to improve the outcomes of mathematics and science education for students and for New Zealand can be based.