

mathematics textbooks across the world

some evidence from the
third international mathematics and
science study

Derek Foxman



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science study (TIMSS)**

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INVESTOR IN PEOPLE



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1 The Third International Mathematics and Science Study (TIMSS)

1.1 TIMSS data sources on textbooks

The Third International Mathematics and Science Study (TIMSS) was the largest of several cross-national surveys of the two subjects conducted over the past two decades, in terms of both the number of participating educational systems and the amount and range of the data gathered. The study was organised by the International Association for the Evaluation of Educational Achievement (IEA), an international cooperative of national research institutions and government research agencies, and took place in about 50 countries in the Northern and Southern hemispheres. Its principal aim was to measure student attainment in participating countries and to assess some of the curricular and classroom factors that would be likely to influence student learning in the two subjects. Three populations of pupils were studied:

- **Population 1**

Nine-year-olds in primary schools (international Grades 3 and 4, equivalent in England to National Curriculum Years 4 and 5).

- **Population 2**

Thirteen-year-olds in middle and secondary schools (international Grades 7 and 8, equivalent in England to National Curriculum Years 8 and 9).

- **Population 3**

Students in their final year of secondary education.

In England, and also in Scotland, the populations of pupils involved were the nine- and 13-year-olds, Populations 1 and 2, neither country participating in the Population 3 survey.

The purpose of this report is to focus on the data obtained by TIMSS on the role of textbooks in the teaching and learning of mathematics in schools in a number of different countries. The textbook data for these countries is compared and discussed in relation to the performance of students in the countries and some aspects of the mathematics curriculum they experienced. In nearly all cases, the comparisons relate to the higher of the two grades in each population – Grade 4 (Year 5) in Population 1, and Grade 8 (Year 9) in Population 2.

The main data-gathering exercises for TIMSS took place in the school year 1994–5, in 1994 for schools in the Southern hemisphere and in 1995 for countries in the Northern hemisphere. The instruments used were written and practical (performance) tests of mathematics and science attainment of the pupils, and three separate questionnaires: for the participating schools, the pupils who took the tests, and the teachers who taught them mathematics or science. The results of the tests and the responses given to the questionnaires have been described in international reports published by Boston College in the United States, where the TIMSS International Centre was located. Reports of the study in England have been published by the NFER, where the National Centre was based, and the Scottish Office Education and Industry Department published national reports of the study in Scotland. The questionnaires for both pupils and teachers included several items about textbook use. Some details of the responses to these are recorded in the international reports (Beaton *et al.* 1996; Mullis *et al.* 1997) and the England national reports (Keys *et al.* 1997a, 1997b).

Other data about aspects of curriculum, including textbooks and their use, comes from supplementary TIMSS studies which began before the main surveys in 1995:

- An investigation of the curricula of 48 of the participating countries, including Scotland, but not England (Schmidt *et al.* 1997). This was conducted in two ways: by a mapping of the coverage of content topics of the TIMSS mathematics curriculum framework by grade (Robitaille *et al.* 1993; Schmidt *et al.* 1997) and a document analysis of curriculum guides and textbooks within countries. In this article, some of the document analysis data will be described; the methods used are elaborated later when the content of textbooks is discussed in Section 3.

- Descriptions of the characteristic features of education in each of the participating countries, including sections on curriculum and textbooks in the TIMSS Encyclopaedia (Robitaille, 1997).
- A classroom observation project in six countries (Schmidt, 1996). This was part of the Survey of Mathematics and Science Opportunities (SMSO), a TIMSS supplementary study of teaching and learning in mathematics and science classrooms that began in 1991. The ultimate aim was to develop a theoretical model of student experiences and a comprehensive battery of survey instruments addressing student, teacher, school and curriculum factors. The questionnaires addressed to teachers and students who participated in TIMSS were developed from this work. The classroom observation project was a collaborative effort by researchers from six countries: France, Japan, Norway, Spain, Switzerland and the United States. The report of this project includes some details of the use of textbooks in the classrooms in the six countries.

1.2 The role of textbooks in the context of the TIMSS curriculum model

In an analysis of Grade 8 textbooks from eight countries, Howson (1993) distinguishes between their roles in the classroom and in the educational system of a country. In the classroom, he notes the following uses a textbook may provide:

- a source of problems and exercises;
- a reference book setting out ‘kernels’: theorems, rules, definitions, procedures, notations and conventions which have to be learned as knowledge;
- ‘explanations’ – not themselves kernels – which prepare the students for the kernels.

Textbook series were seen by Howson as attempting to meet one or more of the goals listed below. Which ones would depend on the nature of the system; for example whether or not the curriculum was centralised.

1. Fleshing out a centrally prescribed curriculum.
2. Attempting to update pedagogy within a centrally prescribed curriculum.

3. Responding to new, non-statutory proposals on pedagogy, for example National Council of Teachers of Mathematics (NCTM) *Standards* in the United States or the *Cockcroft Report* in Britain.
4. Helping to define a new curriculum.

He suggested that the aims of a country's texts are determined by the nature of the country's educational system. Japan's texts can only aim at 1 and 2. All of its series attempt to put flesh on the new skeletal national curriculum, but, in addition, can attempt to increase pupils' motivation, to proceed from the concrete to the abstract, to make greater use of contextualised examples and problems. The French text he analysed contained innovations directed at 2, that is, a greater use of technological aids. The US text aimed primarily at 3 but also at 4. In England, where School Mathematics Project (SMP) texts were used by over 40 per cent of the Population 2 pupils in the year of the TIMSS surveys, Howson proposed that a planned total rewrite of SMP 11–16 materials (Cambridge University Press, 1983, 1992) should seek to satisfy 1 and 2, whilst still hoping to achieve some success with 4.

Howson, 1999, considered that primary texts differ from secondary texts in their approach, some countries providing only teachers' guides in the early primary years (e.g. The Netherlands and England schemes Howson studied), while others provide pupils' texts from the beginning of Grade 1 (e.g. the Japan and Ireland texts he studied), usually in the form of workbooks. Kernels and explanatory material may appear at Grades 2 or 3.

Howson's distinction between the role of textbooks in the classroom and in the system as a whole reflects two of the three levels of the model of the curriculum adopted by TIMSS – originally used in the IEA's previous mathematics study, the Second International Mathematics Study (SIMS: Travers and Westbury, 1989). The three levels, outlined below, focus respectively on the educational system, the school and its classrooms, and the individual student.

- The *intended* curriculum is that laid down in official documents such as the National Curriculum of England. Such curricula may be statutory, as in England, or not, as in the Länder of Germany. The level of the intended curriculum is the

educational system in a country (or systems in countries like Canada where each province, or each linguistic community within a province, has its own educational system).

Evidence of the intended curriculum is obtained from official documents or analyses of them, and from textbooks which, as Howson (op. cit.) noted, can have a role in interpreting what is intended. Thus, in this article, the main evidence of the intended curriculum comes from the TIMSS curriculum analyses of curriculum guides and, in part, from the textbook analyses.

- The *implemented* curriculum is that which schools and their teachers actually put in place in classrooms. Schools may go beyond what is intended in some respects, and ignore other aspects, depending on the flexibility allowed by the system and the interpretations of individual schools and teachers.

Evidence of the implemented curriculum can be obtained from systematic observations of lessons, and from questionnaire surveys about practice, completed by headteachers, classroom teachers and pupils. Textbooks supply exercises and activities which can be carried out in the classroom; those selected for use in particular classrooms provide some indication of the content and teaching approach adopted. The responses to the teacher and student questionnaires supply the main evidence of the implemented curriculum; the classroom observation project provides further data at the school level for those countries that participated in it.

- The *attained* curriculum is concerned with the knowledge, skills, understanding and attitudes exhibited by pupils, whether acquired in the classroom or outside it. Evidence of the attained curriculum is obtained from the results of the TIMSS written and performance achievement tests.

Textbooks have a role in both the intended and the implemented curricula, and thus serve as intermediaries in turning intentions into implementations. They help make possible one or more potential implementations of mathematics curricular intentions. Schmidt *et al.* (1997) link the intended and implemented curricular levels of the

TIMSS curriculum model with a 'potentially implemented' curriculum which consists of textbooks and other organised resource materials.

It should be noted that 'textbooks' in this report normally refers to pupil texts and/or teachers' guides associated with them, unless otherwise stated. In addition, the reference is to the particular text or texts studied, which, although used with a high proportion of pupils, may not be entirely typical. This is especially so in countries that allow the commercial production of schemes and where schools have freedom of choice from among those schemes.

2 The Comparison Countries and their Attained Curricula

2.1 The country groupings

Schmidt, McKnight *et al.* (1997) considered ways of grouping countries for comparison and analysis: by geographic region, economic category, market group membership and statistically. In this article, countries selected for comparison are grouped geographically. As Schmidt *et al.* point out:

Neighbouring or nearby countries often share traditions, cultural similarities, and historical interactions. They may have a history of – or an interest in – mutual comparisons, or may have a more direct economic competitiveness. They might also share common curricular traditions.

Sixteen countries were selected for comparison here from five geographical groups. The Pacific Rim countries are often cited together for their high performance, as are some continental West European and also some East European countries such as the ones selected here. The other countries selected are all English-speaking. Two of the Western European countries, France and Switzerland, did not participate in the survey of nine-year-olds.

Offshore Europe: England, Scotland, the Republic of Ireland.

Continental Europe: France, The Netherlands, Switzerland, Hungary, Czech Republic.

Pacific Rim: Singapore, Korea, Hong Kong, Japan.

North America: United States, Canada.

Australasia: Australia, New Zealand.

2.2 The mathematics performance of the comparison countries

The following tables provide the contrasts in performance of these countries for the higher grades in each population only. These are the only grades reported on for

responses to questionnaires in the international reports, the response patterns for the two grades in each population are, anyway, generally very similar. This section relates to performance in the written tests only which was reported by mathematics content in both national and international reports. The performance assessment reports include some reporting by mathematical skills. They will be referred to in a later section dealing with this aspect of mathematical performance.

There were two separate measures of performance in the written tests:

1. An overall score scaled using an item response theory (IRT) method (Beaton *et al.* 1996, Appendix A)
2. Mean percentages of items correct overall and in various subcategories of the TIMSS mathematics content framework.

The overall scores, both measures of which are presented in Table 1, give a guide to the selected countries' standing relative to each other. The comparison countries form distinctive blocs with respect to performance, the four Pacific Rim countries having the highest overall scores at both age groups, followed by the Continental European countries, and then the three groupings of English-speaking countries. (See Table 1 on page 39.)

Table 2 has been constructed from the countries' mean topic category percentages correct, by first calculating their deviation from the international mean percentage correct for the topic, and then placing the deviations within country in order of size, largest first. Thus Table 2 represents, for each country, a profile of better/worse performance with respect to the topic areas, and relative to the international topic means for all TIMSS-participating countries. The structure of the TIMSS Curriculum Framework is outlined in Section 4.1. (See Table 2 on page 40.)

At age 9, for example, relative to the international mean scores in each content category, England did best in *Geometry*, then *Data Representation, Analysis, and Probability* (hereinafter *Data Representation*), and least well in *Whole Numbers*. This profile, which is almost the same as that of Scotland, is entirely consistent with previous international study results (Foxman, 1992), and, in respect of *Numbers*, also with OFSTED reports on mathematics in England during this decade (e.g. OFSTED, 1993). All the English-speaking countries did well in *Geometry* relative to other

topics at Population 1, while the reverse was true for the Pacific Rim countries, although the absolute score levels of the latter countries were ahead of those of England and Scotland at both ages and in all subcategories.

These profiles are more distinctive for Population 1 pupils than for the older group, although England and Scotland at Population 2 are still strong in *Data Representation* at this age and weak in the *Number* subcategory, *Fractions* and *Number Sense*, relative to the other topics. *Geometry* is not an outstanding feature of performance in England and Scotland at Population 2. Another aspect of the profiles at Population 2 is that all the English-speaking countries and those in Western Europe have *Data Representation* as a strong topic, while it is a weaker area for the Pacific Rim countries in contrast to their performance in other topics.

3 Textbooks: the Potentially Implemented Curricula

3.1 Some general features of the textbooks

Production and choice

Table 3 lists information about the centralisation of the curricula of these countries and their textbook production and choice. There is contrast here, sometimes within groups. For example, in The Netherlands, there are national core objectives, but not a national curriculum; textbooks are produced commercially and schools are free to select from those on offer. By contrast, curricula in Switzerland are produced individually by the cantons and published by the Ministry of Education; official texts must be used at primary and lower secondary phases. The Eastern European countries have tended to relax their former rigid centralisation and there is now choice for schools. The Pacific Rim countries have national curricula and centralisation of textbook production in that the texts are subject to ministry approval. (See Table 3 on page 41.)

The textbook as a classroom resource

Schmidt *et al.* (1997) note that the official status, design and use of textbooks varied greatly among the TIMSS countries, but 'they were an instantly recognisable resource in classrooms in every country'. Howson (1993), in his study of primary texts in five countries, comments that 'perhaps the most obvious distinguishing feature of the texts studied is their relative size, for the Canadian texts are larger, heavier and more strongly bound than those from other countries'. In contrast to, say, Switzerland, where textbooks often contain only exercises, Howson found many cross-curricular examples in the Canadian text he studied and space for poems and illustrations, which, he points out, although not needed for doing the mathematics, offer more general educational opportunities to children.

Schmidt *et al.* (1997) also comment on the various sizes of texts. They suggest that the extensive variation may imply different uses. Slim volumes might only contain

exercises or exposition (as in Switzerland), but are probably not meant to be used independently of the teacher. Larger books probably have a greater range of materials (both exposition and exercises) and may play a larger role in the classroom, as Howson suggested.

In the TIMSS Encyclopaedia (Robitaille, 1997), the sections on textbooks provide pointers to varying usage between countries. In general, the Pacific Rim and Continental European countries indicate a close, but not necessarily rigid, reliance on textbooks in their classrooms, while several of the English-speaking countries are keener to indicate that textbooks constitute one among several possible kinds of resource. Thus, the writer on Switzerland states that textbooks 'are a principal resource for teachers', and in France, 'textbooks are designed for students to read and learn on their own'. In Singapore, textbooks 'follow the intended curriculum very closely...students are encouraged to read them, but do not generally learn from them on their own'. Students in Hong Kong are hindered from reading textbooks as most of them are written in English although over 98 per cent of the students are Chinese. In Japan, 'teachers at all levels are expected to use textbooks in implementing the intended curriculum...students use textbooks for reading, highlighting important information, and doing exercises'. Among the English-speaking countries, the United States indicated in their section of the Encyclopaedia that 'texts are now one of several media used in mathematics instruction', and in Canada, 'currently, there is a trend away from a single textbook...towards a variety of materials from which to choose'. In Australia, there is 'a reduction in emphasis placed on textbooks, particularly in primary schools', while New Zealand teachers use 'textbooks as a resource rather than a major determinant of what should be learned'. However, variation within New Zealand is also indicated in that 'choice of textbook for a class depends on whether the teacher wishes it to be used largely as a source of exercises or activities, or whether a major part of what students learn is to result from their studying the textbook and using it as a reference'.

The influence of curriculum change

A number of countries reported in the TIMSS Encyclopaedia that their recent textbooks make more use of colour, graphs and illustrations than formerly. In several instances, these changes accompanied more freedom for schools and teachers to decide what to teach (e.g. the Czech Republic), and/or a greater emphasis on 'real world' applications (e.g. Canada, Czech Republic, The Netherlands, Korea, Japan). Some of the colour and illustrations may be used decoratively, but Singapore emphasised that these elements and graphs are used 'where necessary'. In The Netherlands, 'about 80 per cent of primary schools use a mathematics textbook based on the realistic approach to mathematics education'. The realistic approach was founded by Freudenthal (1991) and took hold in The Netherlands at the end of the 1980s: Treffers (1991) reported that the distribution of textbooks in primary schools changed from a ratio of 95 per cent 'mechanistic' to five per cent 'realistic' in 1980 to a ratio of 25 per cent mechanistic to 75 per cent realistic in 1990.

Korea reported that change in its country is slow in practice, and the writer of the United States section of the TIMSS Encyclopaedia said that 'the degree to which the actual approach to mathematics in texts has changed is debatable'. In some other countries, change does not appear to have begun: Hungary stated that mathematics is taught in a rather traditional fashion, while Hong Kong blamed examination pressure for causing 'a standard definition-theorem-proof-example-exercise format. Projects, historical highlights, and applications are rare. There is not much emphasis on the cultivation of interest, the understanding of concepts, or the development of problem solving ability.'

Primary school texts

Harries and Sutherland (forthcoming) comment on the 'complexity' of the primary school schemes they studied (from England, USA, Singapore, Hungary and France), that is, the variety of parts into which a scheme was organised. In England, these could include pupil texts, pupil workbooks, assessment material, a resource pack containing games, a teachers' guide and extension material. By contrast, the schemes they selected from Hungary and Singapore consisted of pupil texts, pupil workbooks

and a teachers' guide which elaborates the text and guides the teacher through sets of lessons.

In respect of primary texts, Bierhoff (1996) stated that there are about three times as many exercises in Continental textbooks as in the English schemes, and that they provide greater choice for teachers according to pupils' needs, as well as placing greater emphasis on consolidation. Both Bierhoff (op. cit.) and Howson (1993) noted that topics are changed more frequently in English schemes than in the other texts they studied.

Secondary school texts

Howson (1993) in the TIMSS Monograph analysed international Grade 8 texts from countries participating in SMSO (France, Japan, Norway, Spain, Switzerland, United States) plus texts from England and The Netherlands. In addition to teachers' guides, many of the texts he reviewed also offered supplementary work or activity books for students. Some also provided stencils or copying masters, overhead transparencies, apparatus, and, in a few cases, software. The teachers' guides varied from little more than collections of answers to reproductions of reduced student texts together with notes on the aims of particular passages of text and on the problems set. Despite variations in presentation, Howson considered that the texts he studied, with one exception, followed the same basic pattern. The exception was the text from the canton of Berne in Switzerland, which consisted of a collection of 387 questions with no narratives and only the occasional kernel.

3.2 The TIMSS document analysis methods

As indicated in the introduction, curriculum and textbook content were analysed in TIMSS by two main methods: by obtaining topic coverage from a country's curriculum experts and by analysing curricular documents, curriculum guides and selected textbooks. The topic coverage was named *Topic Trace Mapping*. It was carried out in each participating country by a panel of experts designated by the country. They were asked to provide two types of information, to indicate: (1) all grades in which aspects of that topic were covered, and (2) in which grade the topic

was the focus of more extensive or intensive curricular attention. The Topic Trace Mapping is not considered here; some details can be found in Schmidt *et al.* (1997).

The documents analysed were curriculum guides and textbooks that represented those used for at least half of the students in the targeted grades in a country. A method of analysis was developed to divide documents into smaller segments: *units* to represent larger structures which were then subdivided into *blocks*. These are defined and described in some detail in Schmidt *et al.* (1997). *Units* in curriculum guides are defined as ‘the smallest functional segments of the document – for instance, there were introduction units, units stating policies, units stating educational objectives...’; the units were mainly composed of objective, content and pedagogical suggestion blocks. In textbooks, the most fundamental unit type was the *lesson*, itself defined as ‘a text material segment devoted to a single main mathematical topic and intended to correspond to a teacher’s classroom lesson on that topic taught over one to three instructional periods’. *Block* types in lessons included ‘narrative’ prose, ‘graphic’, ‘exercise/question’, ‘activity’, ‘worked example’.

Country representatives were trained at international meetings to use a system to code the units and blocks which obviated the need for translating documents. The country representatives selected the documents to be analysed according to the criteria laid down by the TIMSS International Centre and, in turn, trained personnel in their own countries who carried out the analyses.

While Scotland participated in this aspect of TIMSS, England did not. However, there is a good deal of resemblance between the mathematics curricula in the two countries. The documents analysed were curriculum guides, usually an official national document (for example, in the case of Scotland, the Scottish Office Education Department’s Mathematics 5–14), and textbooks which were used with the majority of pupils in a country at the age groups studied. In Scotland, the textbooks analysed were also used by a large proportion of the pupils in England: the primary scheme, Heinemann Educational, and the secondary SMP series. Furthermore, in the results of both IAEP2 and TIMSS achievement tests, the topic profiles of the two countries at both ages were almost identical – in IAEP2, this was so almost item by item (Foxman, unpublished analysis).

With the data obtained from countries, a variety of analyses were carried out which are reported in Schmidt *et al.* (1997). These analyses attempted to address questions about countries' coverage and emphases in the various aspects and topics of mathematics. A selection of these is considered here in order to illustrate the variation in the structure and other features of textbooks in the selected countries. Most of the reported analyses include all of the selected comparison countries except England, although, for some, data is available only for Population 2, usually Grade 8.

4 Emphases in Textbooks in Relation to the TIMSS Curriculum Framework Dimensions

4.1 The TIMSS Mathematics Curriculum Framework

The TIMSS document analyses of curriculum guides and textbooks were carried out with regard to the TIMSS Mathematics Curriculum Framework. The Framework was used for planning the construction of the tests and interpreting the results. It consists of three dimensions or aspects. The main categories of these are subdivided into several levels. Some examples are given below, and the full list is in Robitaille *et al.* (1993).

- ◆ Content

The content dimension consists of five main categories (e.g. *Numbers, Measurement, Proportionality*, etc). Each of these is organised hierarchically, by subdividing the main category (e.g. Numbers into *Whole Numbers, Fractions and Decimals*, etc.), and each subdivision is further divided (e.g. *Whole Numbers* into *Meaning, Operations ...*) and each of these into a fourth level of subcategories.

- ◆ Performance expectations

This is the cognitive or process aspect, consisting of five main categories (e.g. *Knowing, Using Routine Procedures, Investigating and Problem Solving...*), each subdivided (e.g. *Knowing* into *Representing, Recognising Equivalents, Recalling Mathematical Objects and Properties*) and so on to a further subdivision. According to Schmidt *et al.* (1997), 'Expectations were considered less culturally determined than postulating the cognitive processes of performing specific mathematical tasks.'

- Perspectives

This aspect focused on the development of students' attitudes, interests and motivations in the teaching of the subject.

4.2 The Framework content categories in textbooks

Several indicators of emphasis were developed by TIMSS, some from textbook analysis:

- topics covered in both curriculum guides and textbooks;
- the percentage of textbook blocks devoted to specific topics.

The data for topics covered in both curriculum guides and textbooks is available for Grade 8 only. This analysis was carried out as it was considered that topics present in both documents probably received more emphasis than those not present in both. However, there is no indication of the type of presentation appearing in either of the documents, nor of how the documents are used in classrooms. Table 4 presents some comparisons between the selected countries and selected topics in the main TIMSS Framework categories. The topics are from three main categories: *Numbers*, *Geometry* and *Data Representation, Probability and Statistics*. They were selected because they represent the relatively weakest (*Numbers*) and the strongest (*Data Representation, Probability and Statistics*) performance areas for England and Scotland in TIMSS and the earlier IAEP 2 study. *Geometry* was a strong area in IAEP 2 for both age groups in both countries, but principally for Population 1 pupils in TIMSS. (See Table 4 on page 42.)

The most extensive representation of the TIMSS Framework topics in both curriculum guides and textbooks was in Switzerland and the two North American countries. Scotland represented all the selected topics in both documents except for two *Numbers* topics, which were in the country's curriculum guide only. The topic most frequently absent from both documents was *Uncertainty and Probability*, which is a relatively new topic for many countries. The data from Korea was regarded as inconsistent by the compilers of the table in Schmidt *et al.* (1997) and must be

considered suspect, with apparently no representation of *Numbers* topics in either their curriculum guide or textbooks. The data from Japan also looks very odd, with no representation at all of the *Number* topics in the texts analysed.

Another indicator derived from textbook analysis is the amount of space (textbook blocks) devoted to some broad content categories. Schmidt *et al.* (1997) note that this measure would be especially meaningful for countries that make consistent and extensive use of textbooks in their instructional and learning activities. Again the focus here is on the *Numbers*, *Geometry* and *Data Representation* categories. The data in Table 5 again relates only to Grade 8. The *Numbers* and *Geometry* categories in the table both cover more content categories than Table 4. (See Table 5 on page 43.)

In respect of the *Numbers* category, the text for Scotland, a relatively low-scoring country in this topic, provided more blocks than for any other comparison country. In fact, looking at the complete list of TIMSS countries, only the analysed texts in two others equalled (Slovenia) or surpassed (Iceland) the amount of space devoted to *Numbers* in the Scotland text. The second highest number of blocks devoted to *Numbers* among the comparison countries was provided by the text for high-scoring Switzerland.

The two eastern countries of Continental Europe devoted more textbook space than the other comparison countries to *Geometry*, especially the traditional aspects of the area. *Data Representation*, *Probability* and *Statistics* generally received less textbook space than the other two categories.

Some similar data for Grade 4 was illustrated in Schmidt *et al.* (1997) but for only three mathematics topics, including two of the Whole Numbers topics. These are reproduced in Table 6. (See Table 6 on page 44.)

Despite their high performance in *Number* in Grade 4, the Pacific Rim countries do not appear to devote a great deal of textbook space to these topics, but, since information about only one other topic is included, it is not possible to say what topics are dealt with extensively in their textbooks. One high-scoring country, Switzerland,

had the largest amount of space of the comparison countries devoted to *Whole Number* operations, and it has already been noted that textbooks in Switzerland may consist only of exercises. The other Continental European countries that performed well in *Numbers* did not differ to any marked degree from Scotland in their coverage of that category of mathematics.

In general, at both age groups, the limited data presented here does not suggest there is an association between the amount of coverage of a mathematics category during the year of testing and performance in that category. Other variables relating to textbooks may have a bigger impact on attainment, such as the way concepts and operations are presented, and how a textbook is used. For example, in respect of primary texts it was noted earlier that British texts have fewer exercises than those in Continental Europe, and also changed topic more frequently (Bierhoff op. cit.; Howson, personal communication). Both these features could make consolidation of learning more difficult.

4.3 The Framework performance expectation categories

In addition to analyses of the mathematics content, textbook blocks were also coded in terms of the cognitive aspect of mathematical performance which is represented by the dimension of performance expectations in the TIMSS Curriculum Framework. The main categories on this dimension are *Knowing, Using Routine Procedures, Investigating and Problem Solving, Mathematical Reasoning and Communicating*. In relation to the performance of countries in these categories, the TIMSS performance assessment tasks are more relevant than the written tests because they assessed the higher-order skills of problem solving and investigating as well as mathematical procedures. Only five of the 16 comparison countries participated in the performance assessment at Grade 4, and reference will be made below only to Grade 8 performance in these tests where 19 countries participated, ten of them from the comparison countries. The absentees from the 16 comparison countries, apart from England, were the Pacific Rim countries (except Singapore), France and Hungary. In overall performance on the tasks, Singapore was again the leading country, but England had the next highest average score, while Scotland also had an above-

average score. However, when the overall scores were separated into two subcategories, *Performing Mathematical Procedures* and *Problem Solving and Mathematical Reasoning*, it appeared that England's and Scotland's high relative overall performance was due more to the former than the latter category.

There was little variation between countries in the percentages of textbook blocks that covered the performance expectation categories and most of the percentages were low – up to ten per cent. The subcategories presented in Table 7 are those which showed a little more variation between the comparison countries than others. Their titles have been abbreviated in the table and the full ones are listed below. No subcategories of the main category, *Communicating*, are represented in Table 7. Subcategories of performance expectations not listed can be found in Robitaille *et al.* (op. cit.)

Knowing: Recalling Mathematical Objects and Properties

Using Routines: Performing Routine Procedures

Investigating and Problem Solving: Formulating and Clarifying Problems (Grade 4 table); *Solving* (Grade 8 table)

Mathematical Reasoning: Developing Algorithms (Grade 4 table), *Justifying and Proving* (Grade 8 table)

(See Table 7 on page 45.)

In Grade 4, with respect to *Recalling*, the North American, Australasian and Continental European countries tended to have lower textbook coverage than Scotland, Ireland and the Pacific Rim countries. However, Hungary among the Continental countries and Korea among the Pacific Rim countries were exceptions within their groupings. Scotland and Ireland had average coverage of *Performing Routine Procedures*, the highest proportions being found among the Continental European (Netherlands, Switzerland and Czech Republic) and Pacific Rim countries (Hong Kong). Apart from Korea, the Pacific Rim countries had relatively extensive coverage of both these subcategories at Grade 4, and were closely followed by Scotland in this respect.

In Grade 8 also, Scotland was among the countries with higher proportions of *Recalling* and *Performing Routine Procedures* than other selected countries. There

was some tendency for the two subcategories to have higher coverage in secondary than in primary textbooks. Of the ten comparison countries that took part in the performance assessment at Grade 8, Scotland had the second highest average score in the *Performing Mathematical Procedures* category to Singapore, which also had high relative coverage of routine procedures in its texts. Singapore also obtained the highest *Problem Solving and Mathematical Reasoning* score in the performance assessment from among the comparison countries, but had low coverage of both the *Investigating and Problem Solving* and *Mathematical Reasoning* subcategories in its textbooks.

While the other subcategories presented in Table 7 tend to take up low proportions of textbook space in the different countries, there are a few unusually high proportions – primary textbooks in France apparently include a much larger proportion of *Developing Algorithms* than the other comparison countries, and secondary Czech Republic texts have *Solving Problems* more highly represented than texts in the other countries. While the Czech Republic scored above average in the performance assessment in *Problem Solving and Mathematical Reasoning*, so did Singapore, Switzerland, Australia and New Zealand, all of which had a much lower coverage of these skills in their textbooks.

These results do not provide any evidence of a relationship between performance in mathematical skills and the amount of textbook coverage in the comparison countries that participated in the TIMSS performance assessment.

4.4 The Framework perspectives categories

The perspectives dimension is concerned with pupils' attitudes to, and career interests in, mathematics. There are five main subcategories: *Attitudes towards Science, Mathematics and Technology*; *Careers Involving Science, Mathematics and Technology* (divided into *Promoting Careers in these Subjects* and *Promoting the Importance of these Subjects in Non-technical Careers*); *Participation in Science and Mathematics by Under-represented groups*; *Science, Mathematics and Technology to Increase Interest*; *Scientific and Mathematical Habits of Mind*. Schmidt *et al.* (1997) provide information on the representation of the subcategories in both Grade 4 and

Grade 8 texts. The picture of the representation of the Perspectives dimension was very patchy, with some countries having no coverage – for example, Scotland and the Czech Republic at both ages, and Hungary, and Korea in Population 1 textbooks. Others have representation in just one of the subcategories. The most extensive use of the subcategory *Science, Mathematics and Technology to Increase Interest* was largely confined to the West European Continental comparison countries and Australasia, at both ages.

5 The Use of Textbooks: the Teacher and Student Questionnaires

5.1 The amount of use of textbooks by teachers

In most countries, the teachers of all or nearly all pupils in Grade 4, and particularly Grade 8 classes, indicated that they used textbooks in their teaching of mathematics. Presumably these uses included teacher planning, pupil use in the classroom and for homework, and, possibly, assessment. The only exceptions among the selected countries here were in Australia, where the teachers of 35 per cent of Grade 4 pupils claimed never to use textbooks, and in New Zealand where the teachers of 25 per cent of the Grade 4 pupils indicated that they did not use them. The percentages of use in Australia and New Zealand were also lower than the other countries at Grade 8: 94 per cent in Australia and 86 per cent in New Zealand. Teachers in all the other countries stated a degree of use with over 96 per cent of the pupils – 100 per cent in the Pacific Rim countries.

Further information on the extent of use of textbooks in the comparison countries is provided in Table 8, which contains teachers' estimates of the amount of mathematics teaching time based on this resource. For Population 1, this data confirms that teachers in Australia and New Zealand relied least on textbooks compared with others in the table, over 40 per cent of their pupils basing a quarter or less of their mathematics lessons on them. In Continental Europe, teachers in the Czech Republic were also low users of textbooks. The most frequent users were in The Netherlands, the teachers of 84 per cent of pupils in that country indicating that over three-quarters of mathematics teaching time was based on textbooks or textbook schemes. As a group, the Pacific Rim countries also made extensive use of textbooks, although Singapore was a moderate user, compared with other countries in the table, as were England and Scotland. (See Table 8 on page 46.)

In all the comparison countries, teachers of the older pupils generally based more teaching time on textbooks than did teachers of the nine-year-olds, but the pattern of higher and lower use of textbooks was very similar to that found at Population 1. The most frequent users were in The Netherlands, followed by the Pacific Rim group of countries and also Scotland. Teachers in France, Australia and New Zealand were the least dependent on textbooks, while those in England were relatively moderate users.

In relation to textbook use in the classroom, R.A. Garden (personal communication) states that teachers in New Zealand, especially at primary level, have been historically discouraged from extensive use of textbooks, and that teacher-produced material is common in both primary and secondary classes. Some regionally produced resources for primary school teachers provide programmes for a substantial number of teachers. Garden also points out, in explanation of the similarity of some of the Australian and New Zealand data, that

the cultures of Australia and New Zealand have many similarities, and the original shapers of educational theory and practice in the two countries had similar cultural and educational backgrounds. There is also a lot of interaction, both formal and informal, between Australian and New Zealand educators and educational policy makers.

The responses for England show that 66 per cent of Year 5 pupils were taught by teachers who based over 50 per cent of their mathematics teaching on textbook schemes, and that the corresponding proportion of pupils in Year 9 was 84 per cent. These figures are similar to those obtained in the King's College evaluation of the implementation of the National Curriculum in the early 1990s (Askew *et al.* 1993). The question asked differed from the one in the TIMSS questionnaire in that it was specifically about classroom use (the proportion of mathematics work done in class from a commercial scheme, Table 9), and the unit of analysis was the teacher, not the pupil as in the TIMSS work. (See Table 9 on page 25.)

Table 9

The proportion of mathematics work done in class from a commercial scheme (Askew *et al.*, 1993)

	0-20%	21-50%	51-100%
	%	%	%
KS 1	45	23	33
KS 2	17	24	59
KS 3	13	8	79

These figures show that teachers' classroom use of textbook schemes increases considerably through the key stages, and, in particular, demonstrates that secondary school teachers are much more reliant on them than their counterparts in primary schools. In part this is likely to be due to the increase in pupils' reading skills as they get older. Bierhoff (1996), contrasting English and Continental practice, suggests that English primary textbooks need to have high readability because 'English teachers spend most of their time in class dealing with pupils individually; each pupil consequently has very limited contact-time with the teacher'. The evidence from TIMSS (Table 10) is that Grade 4 pupils in the selected countries in Continental Europe said they worked on their own from workcards or textbooks as much as pupils in England and Scotland claimed to do. In this respect, Grade 4 pupils in England and Scotland were on a par with their counterparts in North America and Australasia, while those in the Pacific Rim countries were less likely to work on their own from workcards or textbooks. At Grade 8, however, students in the Continental Europe countries (except The Netherlands), like those in the Pacific Rim, said they were less likely to work on their own from workcards or textbooks than did their peers in England and Scotland, and also in the other English-speaking countries. (See Table 10 on page 47.)

Primary school teachers, rather more than those in secondary schools, have frequently been criticised for over-reliance on commercial schemes, although, unlike secondary school practitioners, they are not mathematics specialists. For example, OFSTED (1993b) reports:

In over a third of classes there was an over-reliance upon a particular published scheme which usually led to pupils spending prolonged periods of time in which they worked at a slow pace, often on repetitive undemanding exercises, which did little to advance their skills or understanding of number, much less their interest and enthusiasm for mathematics.

The Cockcroft Report (1982), while emphasising that ‘...textbooks provide valuable support for (primary school) teachers in the day-to-day work of the classroom...’, added the qualification: ‘However, it is always necessary to use any textbook with discrimination, and selections should be made to suit the varying needs of different children’ – one of the reasons Garden (above) gives for the relatively lower use of textbooks by New Zealand teachers than by those in comparison countries.

The Assessment of Performance Unit (APU) data reported in Foxman *et al.* (1985, 1991) showed that primary school teachers of Year 6 pupils of the pre-National Curriculum era in Britain (Scotland not included) used textbooks to an even greater extent than reported in the Askew *et al.* study and in TIMSS. In 1982, the year of the publication of the Cockcroft Report, APU questionnaire responses showed that 86 per cent of pupils in the sample were taught mathematics based on a textbook scheme for 50 per cent or more of mathematics teaching time; in 1987, this figure had risen to 91 per cent of Year 6 pupils. When the National Curriculum was inaugurated, there was insufficient time for textbook authors and publishers to produce up-to-date books, and few schools were likely to have had funds to buy completely new schemes anyway. Subsequent revisions to the National Curriculum did not improve this situation. Whether simply due to the circumstances of the introduction of the National Curriculum, or, additionally, because, as the OFSTED report implied, primary textbooks were considered to be inherently deficient, teachers had to adapt existing resources. But other criticisms of primary teachers’ over-dependence on textbook schemes relate to the issue of professionalism. Thus Burton (1994) suggests that the over-use of published schemes forces teachers into the subservient role of a ‘helper’ and invokes negative learning experiences. Harries and Sutherland (forthcoming) suggest that this is a dominant view in England but that ‘in practice many primary teachers do not have the time or the resources to decide independently how to present

and sequence mathematics for particular learning aims. Thus teachers inevitably become dependent on the very textbook schemes which the experts dismiss.'

Schmidt (1996) noted in their account of the TIMSS observation study, SMSO, in France, where 'content was relatively more complex formally than for other SMSO countries' that

the frequency with which teachers departed from strict reliance on the textbook was evidence of classrooms centred on teacher expertise. In those instances, teachers either provided their own content examples or embellishments or made selective use of the student text material. The teachers' handling of content and the kinds of activities used left little doubt that teachers were the subject matter discipline experts in the classroom.

That is the kind of confidence and training required to be free of over-reliance on textbooks. However, it is not clear how representative the teachers and classes observed in the SMSO project were (Keitel and Kilpatrick, 1999).

5.2 Amount of textbook use in relation to mathematics performance

TIMSS provided data on the relationship between the degree of teacher use of textbooks and pupil performance, from the questionnaire responses of teachers of the pupils' who took tests. The data is displayed here in Table 11. Since the relationship appears to be different in the two grades surveyed in each age group, the data for Grades 3 and 7 is included in the table as well as that for Grades 4 and 8. (See Table 11 on page 48.)

In the upper grade of each age level, the greater the teachers' reliance on textbooks, the higher the performance, but there is no clear relationship for the lower grades. A further analysis by the NFER based on classes in England suggested that textbooks are used slightly more often with high-scoring classes and in classes with wider ranges of attainment (W. Keys, personal communication). It would appear that teachers' greater reliance on textbooks at both age groups is not associated with lower

performance and may even be associated with higher attainment. This conclusion also holds for some countries among the international comparisons: teachers in primary schools in three Pacific Rim countries selected here (but not Singapore), and in The Netherlands in Continental Europe, all place greater reliance on textbooks and have a higher mathematics performance than their counterparts in England and Scotland. However, such relationships in TIMSS are correlational and not necessarily causal, and are not universal.

5.3 Teachers' use of textbooks in planning lessons

In addition to the general question of amount of use of textbooks for teaching, TIMSS teachers were asked to indicate how much they relied on different parts of a textbook scheme for planning their mathematics lessons. For each of the pupils' edition of a textbook, the teachers' guide, and other resource books they were asked whether these resources were used 'not at all', 'a little', 'quite a lot' or 'a great deal'. Table 12 shows the percentages of pupils in Grade 4 (Year 5) and Grade 8 (Year 9) classes whose teachers indicated a resource was used either 'quite a lot' or 'a great deal'. Some variation in the questions asked by countries in the questionnaires was allowed, and teachers in Scotland were not asked these particular questions. (See Table 12 on page 49.)

Teachers of the older pupils in most of the selected countries used pupils' texts for their planning rather more than did teachers of Population 1 pupils. There were exceptions among the Pacific Rim countries, where teachers of the older age groups in Korea, Singapore and Japan made about the same or a little less use of pupils' texts for planning than their Population 1 teachers. In fact, in both Korea and Singapore, teachers of the younger age group indicated 'a great deal' of use more than did their counterparts in secondary schools. By contrast, teachers of younger pupils tended to make more use of teachers' guides than the teachers of Population 2 pupils. The guides are anyway usually more extensive for secondary than for primary teachers. Hong Kong and North American countries differed from this general pattern. There were no clear differences in the patterns of use of other resource books by the teachers of primary and secondary pupils.

Comparing countries within age groups, Korea and Singapore teachers made heaviest use of all three types of resource for planning at both ages. In addition, in Grade 4 classes, The Netherlands, North America and Australasia made greatest use of pupil texts and teacher guides. In Grade 8 classes, all countries used pupil texts extensively to plan for teaching topics, and, to some extent, other books were also employed. The North American countries relied more than the others on teachers' guides. The extent of use of textbooks for planning lessons by Australian and New Zealand teachers seems somewhat odd in relation to their low estimates of teaching time based on the texts, although they were also among the comparison countries making greatest use of material other than pupil texts or teacher guides for planning.

Teachers were also asked to indicate their main source of written information when planning each of four aspects of their mathematics lessons. In Table 13 they are abbreviated as follows:

1. deciding what topics to teach (**topics**);
2. deciding how to present a topic (**presenting**);
3. selecting problems and exercises for work in class and/or homework (**exercises**);
4. selecting problems and tasks for assessment and evaluation (**assessment**).

The choice of response in each case is also abbreviated:

- pupil/student edition of textbook (**P**);
- teachers' edition of textbook (**T**);
- school curriculum guide (**S**);
- national curriculum guide (**N**);
- other books (**O**).

The data on each aspect of planning was given, as for other items in the teachers' questionnaire, in terms of the percentage of pupils whose teachers had selected a particular response. In Table 13, the separate responses to these questions have been combined into a single table by indicating only responses greater than 20 per cent – in order of size, for each aspect.

- The responses are indicated by the letters P, T, S or O, the abbreviations for the choices of response given above.

- Where more than one letter is given, there was more than one selection with above 20 per cent of students in the classes of the teachers' making these responses.
- Letters in bold indicate that teachers who selected that response taught more than 50 per cent of the pupils; roman letters indicate that between 20 and 49 per cent of the pupils were in the classes of teachers who selected the response.
- A ' / ' between two letters indicates that there was little difference between the two.

Thus, in England, for planning what topics to teach, the National Curriculum (N) was selected by the teachers of more pupils as their main source of written information than the given alternatives. The school's own curriculum guide (S) was selected by the teachers of the next largest percentage of pupils. In both cases the percentage of pupils whose teachers made the selection was between 20 and 49 per cent. (See Table 13 on page 50.)

The main sources of information indicated for the planning of each aspect are first compared across grades. The predominant resource used for planning each of the four aspects considered is indicated below both descriptively and in brackets using the code letters for each resource as in Table 13 on page 50.

The main source for planning:	In Grade 4	In Grade 8
♦ what topic to teach	Mainly the N; the teachers' guide in some countries, especially Japan, and the School guide in two other Pacific Rim countries. (N)	Also mainly the N; the School guide also more prominent in Australasia for Population 2. (N)
♦ how to present topics	The teachers' guide used in all countries. Other books used most in Australasia. (T)	The student text is the most important for most countries, but other books are prominent in English-speaking countries and the teachers' guide in the Pacific Rim and two of the Continental European countries. (T)
♦ selecting exercises	The pupil text used most in all countries, with some also using other books (Australasia, Singapore, Japan, England and Scotland) (P)	The student text is a very strong first choice in all but the USA, where the teachers' guide is also an important source. (P)
♦ assessment	Pupil and then other books indicated mostly. (P)	Other books are predominant, presumably test papers. (O)

The importance of specific resources for planning the four aspects is fairly consistent within geographical group, particularly in Grade 8 classes. The Pacific Rim countries were less homogeneous at Grade 4. Except for setting exercises for the older pupils, teachers in many countries, including England, tended not to have one overriding source for each aspect. A notable exception was in The Netherlands, whose teachers made use of either a teachers' guide in their primary classes or a pupil text, particularly with the older pupils.

In relation to teachers presenting topics, students in Population 2 classes were asked whether they looked at a textbook when their teacher introduced a new topic. Table 14 shows that students in the English-speaking and British-influenced Pacific Rim countries indicated that they were more likely to do so than their counterparts in Continental European countries. (See Table 14 on page 51.)

5.4 Grade 8 (Year 9) teachers' use of textbooks in setting homework

In England, questions on the setting of homework were addressed to secondary school teachers only. They asked how often teachers set workbook tasks, questions or problems in textbooks and reading textbooks. The proportion of pupils whose teachers set these tasks with particular frequencies is given in Table 15. (See Table 15 on page 52.)

The selected countries were much more likely to set **questions or problems from textbooks** than either of the other two types of task, most frequently in Continental Europe (especially in The Netherlands, Hungary and the Czech Republic), and in the Pacific Rim (particularly in Korea, Hong Kong and Singapore). Japan's practice was different in this respect from the other selected countries in that region, as it has been in some other features already noted above: it used textbooks for setting questions or problems less than all the other selected countries.

Worksheets or books were never used by high proportions of teachers in the Czech Republic and Hungary, while high proportions of teachers in England, Switzerland, Korea, Singapore, and the North American and Australasian countries used them at least sometimes. In The Netherlands, little use was made of worksheets as compared with their extensive employment of textbooks for homework, as well as planning aspects of their teaching, as noted in the previous section. A fairly large proportion of teachers in Japan also did not often use worksheets or books for setting homework – another feature of their practice which was different from the other selected Pacific Rim countries.

The Netherlands and Pacific Rim countries (but again, not Japan) set **textbook reading** tasks to pupils, presumably because their textbooks are written particularly for the student reader. The lowest users of this task were teachers in France, England,

Ireland, the Czech Republic, Japan, Canada and the Australasian countries. Students were asked whether they thought that they needed to memorise textbooks or notes to do well in mathematics (Table 16). Ninety-five per cent of the French Population 2 students indicated they agreed with the need to memorise to a much greater degree than their peers from the other comparison countries. As their teachers did not set them many reading tasks for homework, it must be assumed that they were required to memorise notes rather than textbook passages, or memorising in class. A case study of observations in a French Grade 8 class (Schmidt, 1996), which, of course, is not necessarily typical, indicates that the students took notes throughout the lesson. Students in the other Continental countries contrasted with those in France, around 50 per cent or more indicating disagreement with the need to memorise textbooks or notes. Another feature of the responses to this question was the contrast between the two age groups, younger pupils from all the comparison countries indicating the need to memorise to a greater extent than the older group. Neither England nor Scotland asked the question of their Population 1 pupils and so there is no information about the contrast between age groups from these countries. The perception of the younger pupils of the need to memorise may be due to their teachers' requirements for number bonds and multiplication tables to be learned. (See Table 16 on page 53.)

6. Conclusions

Data from the Third International Mathematics and Science Study (TIMSS) has been used here to compare some features of textbook schemes in distinctive blocs of countries. These blocs were distinctive both geographically (Western Offshore Europe, Continental Europe, North America, Australasia and the Pacific Rim) and in their performance in the TIMSS tests: the Pacific Rim countries were the leading bloc, followed by Continental Europe and then the other three regions in Europe, North America and Australasia respectively. Culturally and historically there are some inter relations between the blocs which could have some influence on educational perspectives in the countries concerned, including the approach in, and the use of, textbook schemes. For example, the Offshore European, North American and Australasian countries are all English-speaking, and two of the Pacific Rim countries, Hong Kong and Singapore, are former British colonies.

The data described here comes from two main sources: the document analyses carried out prior to the testing in 1994–5, some results of which have been published in Schmidt *et al.* (1997); and the printouts of the responses to the TIMSS teacher and student questionnaires that were completed by schools at the time of the testing. There are a few references to textbook use also in the TIMSS six country classroom observation project, published in Schmidt (1996).

The aim of the comparisons was to identify the differing roles textbooks played in the countries compared and consider whether TIMSS data on features of textbook schemes and their use was associated with differences in performance within and between the selected countries and country blocs. In this respect, there are a number of aspects of the role of a scheme to take into account and not all of these are provided by the TIMSS data:

1. The features of schemes

- a) the resources provided (pupil texts, teachers' guides, workbooks, etc);
- b) curriculum emphases in the resources;
- c) the type and amount of material provided (explanation, exercises, etc)
- d) the approach to mathematical concepts and pedagogy in the resources.

2. The use of schemes

- a) the degree of teacher reliance on a scheme;
- b) what the scheme's resources are used for (planning, introducing topics, classroom exercises, homework);
- c) how the students' texts are used in class.

TIMSS provided limited data on 1a, and no direct evidence concerning 1d. Evidence for 1d in the TIMSS data has to be inferred from the balance of block and unit types used to analyse texts. More direct evidence for 1d has to be sought in other work, such as the mainly qualitative comparative analyses of primary texts by Bierhoff (1996), Harries and Sutherland (forthcoming) and Howson (1998), and some secondary texts by Howson (1993). Various statistical data from the TIMSS document analyses of textbooks are available in Schmidt *et al.* (1997) and Schmidt (1996) relating to 1b and 1c. The textbooks analysed in each country were those that were used by a majority of pupils in the country, but may limit the generality of the data in countries where teachers have a range of choice because books are produced commercially.

On the use of schemes, TIMSS provided statistical data on 2a and 2b, mainly from the teachers' questionnaires and a little from the student questionnaires. The responses given represent the perceptions of the respondents both of the way questions are put and their interpretation of their own behaviour in their teaching. The data does not always appear to be consistent and in many cases is difficult to interpret. Questionnaire evidence needs to be complemented by more detail, for example by interviews with teachers like those which were undertaken by Askew *et al.* (1993) in their evaluation of the implementation of the National Curriculum. How textbooks are used in the classroom (2c) requires observation. Although TIMSS undertook a classroom observational study, it was confined to six countries and the report on it (Schmidt, 1996) contains only snippets of information on this issue in its accounts of classroom activities in the SMSO countries. In addition, the representativeness of the classes observed is unclear.

The TIMSS Encyclopaedia (Robitaille, 1997) provided some descriptive evidence about changes in the features of schemes in the participating countries over the past

five or ten years. This indicated that many countries had moved or were moving towards a broader curriculum, which included data-handling and 'real-world' problems. Their textbooks reflected this trend and the intention to make mathematics more attractive to students (and their teachers) by the use of colour, pictures, diagrams and graphs. There is an issue about the use of colour and pictures as purely decorative as contrasted with their use for mathematical purposes. Harries and Sutherland (forthcoming) indicate that the texts they studied from England and the United States made more use of these devices for decoration than texts from France, Hungary and Singapore, where they supported the learning of mathematics.

Despite movements towards certain similarities in curriculum breadth, there appears to be much diversity in aspects of the curriculum, teaching approaches and the resources used, including textbook schemes. Textbook schemes vary in their size, curriculum emphases, structure and complexity, which indicates variation in their role in the classroom. This variation occurs not only between disparate countries in different regions, in different economic circumstances, but also within regional blocs such as those contrasted here. There is also variation within countries, most particularly in those which have commercially produced schemes. For example, Millett and Johnson (1996) have listed some features of the variation in Britain:

Published schemes in Britain vary considerably in the way in which the mathematics content is organised, the provision made for progression and differentiation, the integration of Attainment Target 1 (Using and Applying Mathematics) with the rest of the curriculum, and the suitability of the work for a variety of teaching styles.

There was some indication from the country descriptions in the TIMSS Encyclopaedia that the English-speaking countries from among those compared here were tending to regard textbooks as only one of several possible resources available to teachers. This suggests there could be lower reliance on textbooks in these countries than in countries which regard them as the main teacher resource, and this was confirmed at least in the teacher questionnaire data of Australia and New Zealand. In general, teachers in the Pacific Rim countries said they relied more on textbooks than the other countries compared. By contrast, teachers in The Netherlands had a higher

rating of reliance on textbooks than their counterparts in the other countries at both ages. In all the comparison countries except Japan, teachers of older pupils placed greater reliance on textbooks for their teaching than their primary school counterparts. This could mean that books are more focused on specific teaching objectives for the final years of secondary schooling than for the earlier years of education. This might be particularly true of countries which have certificated examinations, like those in Britain. There may be other explanations, but it does seem strange that mathematics specialists should adhere more firmly to a scheme than their generalist primary counterparts, especially when such practice is not highly regarded by many leading mathematics educators in a country, like those in the English-speaking countries here. Furthermore, the questionnaire data within England indicates that, at least in Years 5 and 9, the pupils of those teachers with a higher reliance on textbooks have a higher attainment than those with lower test scores in the TIMSS content tests.

The 16 countries compared in this report were selected from geographical regions, and represented three levels of achievement in the TIMSS tests of mathematics topics: the Pacific Rim bloc at the top, followed by the Continental European countries and then by the English-speaking countries. The diversity in the features of the data gathered by TIMSS, between and within country blocs, is not easily correlated with performance in a country. The TIMSS framework classified performance with respect to mathematical processes (performance expectations) as well as content, and this dimension was more appropriately tested in the performance assessment, which had fewer participating countries than the content tests, especially at age nine. There were differences in relative performance in the two kinds of assessment. However, relating this to the textbook coverage of process is arguably less easy than in the case of content, especially as the process dimension is more difficult to define.

The data on the features of texts is largely quantitative, obtained by defining particular categories of text and then counting the frequency of each category in a segment of text. Howson (1999) says of this approach by TIMSS:

So far as textbook analysis is concerned, I can think of no practicable way in which textbooks, used in over 40 different educational systems and written in over 30 languages, could usefully and reliably be compared – either

quantitatively or qualitatively – and their influences on the teaching and learning in the classroom to be assessed.

Outside TIMSS, Bierhoff (op. cit.), Harries and Sutherland (op. cit.) and Howson (1998) imply that certain differences in the approach and structure of primary texts in different countries could be related to student learning. Neither quantitative nor qualitative research methodologies, however, provide a complete picture of the role played by textbooks in classrooms in different countries. Together they need to be supplemented by studies of their actual use in a range of classrooms which is sufficiently adequate to provide a representative picture within a country as well as a range of variation within a country.

Table 1 Scaled scores and percentage correct items: rank of selected countries

Country	Grade 4 (Year 5)			Grade 8 (Year 9)		
	Scaled Score	Rank	% Correct	Scaled Score	Rank	% Correct
England	513	13	57	506	14	53
Scotland	520	12	58	498	16	52
Ireland	550	7	63	527	11=	59
United States	545	10	63	500	15	53
Canada	532	11	60	527	11=	59
Australia	546	9	63	530	10	58
New Zealand	499	14	53	508	13	54
Korea	611	2	76	607	2	72
Japan	597	3	74	605	3	73
Singapore	625	1	76	643	1	79
Hong Kong	587	4	73	588	4	70
Czech Republic	567	6	66	564	5	66
Hungary	548	8	64	537	9	62
Netherlands	577	5	69	541	7	60
France	-	-	-	538	8	61
Switzerland	-	-	-	545	6	62
Mean for all TIMSS countries	529		59	513		55

Source: Beaton *et al.* (1996) Tables 1.1 and 2.1, and Mullis *et al.* (1997) Tables 1.1 and 2.1

Table 2 Profile of countries' performance in topic areas

Key to topic areas:

Grade 4: WN=Whole Numbers; FP=Fractions & Proportionality;

MENS=Measurement, Estimation & Number Sense;

DRAP=Data Representation, Analysis & Probability;

GEO=Geometry; PRF= Patterns, Relations & Functions

Grade 8: FNS= Fractions & Number Sense; GEO= Geometry;

ALG= Algebra; DRAP= Data Representation, Analysis &

Probability; MEAS= Measurement; PROP= Proportionality

(No. items) Country	WN (25)	FP (21)	MENS (20)	DRAP (12)	GEO (14)	PRF (10)	FNS (51)	GEO (23)	ALG (27)	DRAP (21)	MEAS (18)	PROP (11)
England	6	3=	3=	2	1	5	5=	3	4	1	2	5=
Scotland	6	3=	3=	2	1	3=	4=	3	6	1	2	4=
Ireland	4	1	6	2	5	3	1=	6	5	1=	4	3
United States	4	5	6	1	2	3	2	5	3	1	6	4
Canada	4	5	6	2	1	3	2	5	4	1	6	3
Australia	6	5	3=	2	1	3=	2=	6	2=	1	2=	5
New Zealand	5	4	6	3	2	1	3	4	5	1	2	6
Korea	2	4=	4	3	6	1	4=	1	2=	4=	6	2=
Japan	5	2=	2=	1	6	2=	3	1	2	4=	4=	4=
Singapore	3=	1	5	2	6	3=	2=	5	4	6	2=	1
Hong Kong	5	1	3=	2	6	3=	4=	2=	1	6	4=	2=
Czech Republic	2	6	1	5	3=	3=	2=	4	1	6	2=	5
Hungary	1=	5	3	6	4	1=	2	4=	1	4=	3	6
Netherlands	3	2	6	1	4	5	4	5	6	1	2=	2=
France							3=	2	6	1	3=	5
Switzerland							3	5	6	1=	1=	4

Source: derived from Beaton *et al.* (1996) Table 2.1 and Mullis *et al.* (1997) Table 2.1

Table 3 Curriculum and textbook centralisation

Country	Curriculum Centralisation National (NC=National Curriculum) or Regional	Centralisation of Textbook Production and Choice National or Regional	Publication of Textbooks Commercial or Government	Textbook Selection by:
England	NC	None	Commercial. Referenced to NC and examinations at 16+	Schools
Scotland	National guidelines and exam syllabus	None	Commercial	Schools
Ireland	NC	None		
United States	Regional: State	None	Commercial; some State-recommended	Schools, but selection may be from state approved list
Canada	Regional: Province, but some collaborate to produce a common syllabus	Textbooks may have coverage for several provinces	Commercial. Reviewed first at provincial or territorial level	District or school
Australia	No centralisation since 1994. Regional: State from 1994	None	Commercial	Schools
New Zealand	NC	None	Resource agency under contract to Ministry	Class level, depending on how used.
Korea	NC	Centralised	Primary: Ministry-produced Secondary: Commercial but Ministry-approved Commercial, but Ministry-approved.	
Japan	NC	Centralised (Pop 1) Regional (Pop 2)	Ministry-approved government and commercial texts	Local boards of education and teacher representatives
Singapore	NC	Centralised		Schools
Hong Kong	NC	Centralised		
Czech Repub.	NC	None	Commercial	Schools
Hungary	None	None	Ministry-approved	Schools
Netherlands	Core objectives. Schools decide how to reach objectives	None	Commercial, referenced to core objectives	Schools
France	NC	None	Commercial, developed by maths experts	Groups of teachers in a school
Switzerland	Regional: Canton	Varies across Cantons	Government	

Source: derived from TIMSS Encyclopaedia (Robitaille, 1997).

Table 4 Topics present in both curriculum guides and textbooks

Key:

C= present in curriculum guide; T= present in textbook; CT= present in both; O= present in neither

Country	Numbers										Geometry			Data Representation, Probability and Statistics	
	Whole Numbers		Fractions and Decimals				Estimation	Position, Shape		Symmetry	Data Representation & Analysis	Uncertainty & Probability			
	Meaning	Operations	Fractions	Decimals	Relations: Fractions & Decimals	Percentages		Properties Fractions & Decimals	Estimating Computations				2D: Basics	2D: Polygons & Circles	Trans-formations
Scotland	CT	CT	CT	CT	CT	CT	CT	C	CT	CT	CT	CT	CT	CT	
Ireland	CT	CT	CT	CT	CT	CT	CT	T	CT	CT	CT	CT	CT	O	
Czech Republic	CT	T	T	T	T	T	T	T	T	T	CT	CT	C	O	
Hungary	CT	CT	CT	CT	CT	CT	CT	C	CT	CT	CT	CT	CT	CT	
Netherlands	O	CT	T	T	CT	T	O	T	T	T	C	CT	CT	C	
France	CT	CT	T	CT	CT	CT	T	O	CT	CT	CT	CT	CT	O	
Switzerland	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	
Korea	O	O	O	CT	CT	CT	O	O	CT	CT	CT	CT	CT	CT	
Hong Kong	CT	CT	CT	CT	CT	CT	CT	T	CT	CT	C	CT	CT	C	
Singapore	T	T	T	T	T	CT	O	O	CT	CT	CT	C	CT	O	
Japan	O	O	O	O	O	O	O	O	CT	CT	CT	CT	CT	O	
United States	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	
Canada	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	
Australia	CT	CT	CT	CT	T	T	T	C	CT	CT	C	CT	CT	C	
New Zealand	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	C	

Source: adapted from Schmidt *et al.* (1997) Table 7.1

**Table 5 Percentages of textbook blocks devoted to content categories
(Grade 8, Year 9 only)**

The midpoints of the percentage ranges are given in the cells: 0=0%; 5=1-10%; 15=11-20%, etc.

Country	Numbers		Geometry		Data representation, probability & statistics
			Shape, Position, Visualisation & Shape	Symmetry, Congruence & Similarity	
Scotland	65		35	15	15
Ireland	45		35	15	15
Czech Republic	25		55	25	00
Hungary	15		45	35	15
Netherlands	15		35	15	15
France	45		35	15	15
Switzerland	55		25	15	15
Korea	15		35	25	25
Hong Kong	45		25	00	15
Singapore	15		35	25	00
Japan	15		35	35	15
United States	45		25	15	25
Canada	55		25	15	15
Australia	25		35	15	15
New Zealand	45		25	25	15

Source: Adapted from Schmidt *et al.* (1997) Figure 13.2

**Table 6 Percentages of textbook blocks devoted to two number topics
(Grade 4, Year 5 only)**

The percentages are estimates from a bar graph (Figure 7.2 p. 116)

Country	Grade 4 (Year 5)	
	Meaning	Operations
Scotland	8	28
Ireland	12	42
Czech Republic	8	30
Hungary	8	28
Netherlands	10	19
France	8	30
Switzerland	8	50
Korea	10	28
Hong Kong	0	17
Singapore	8	15
Japan	5	25
United States	7	33
Canada	12	30
Australia	19	35
New Zealand	15	43

Source: Adapted from Schmidt *et al.* (1997) Figure 7.2

Table 8 Teachers' questionnaire
Approximately what percentage of your mathematics teaching time is based on the textbooks/schemes indicated in the previous question?

Country	Grade 4 (Year 5)				Grade 8 (Year 9)			
	0-25% %	26-50% %	51-75% %	76-100% %	0-25% %	26-50% %	51-75% %	76-100% %
England	12	22	43	23	06	11	45	39
Scotland	07	16	45	32	07	13	25	55
Ireland	09	26	36	30	13	10	32	46
United States	13	24	35	29	16	17	31	36
Canada	21	33	34	13	09	16	39	36
Australia	49	30	17	04	15	24	37	24
New Zealand	40	35	21	04	29	36	26	09
Korea	07	16	30	48	04	05	41	50
Japan	04	11	23	63	12	13	28	47
Singapore	08	31	37	24	06	08	29	57
Hong Kong	04	12	31	53	03	08	24	66
Czech Republic	30	36	27	08	09	28	53	10
Hungary	11	29	37	23	01	14	50	35
Netherlands	03	03	09	84	<1	01	05	94
France	<1				29	43	21	07
Switzerland	<1				07	13	32	48

Table 10 Students' questionnaire
We work from workcards or textbooks on our own.

Country	Grade 4 (Year 5)			Grade 8 (Year 9)			
	Most Lessons	Some Lessons	Never	Almost Always	Quite Often	Once in a While	Never
	%	%	%	%	%	%	
England	49	34	17	57	32	08	2
Scotland	62	34	04	70	24	04	2
Ireland	41	41	18	43	30	17	10
United States	57	35	07	58	27	12	3
Canada	65	32	03	61	28	09	2
Australia	43	49	07	61	29	08	2
New Zealand	50	44	06	54	34	10	1
Korea	25	56	19	10	16	56	18
Japan	12	74	14	09	28	50	13
Singapore	43	49	08	28	40	28	6
Hong Kong	31	49	21	45	31	20	4
Czech Republic	54	44	03	17	38	38	8
Hungary	59	39	02	21	45	30	4
Netherlands	59	38	03	50	33	14	3
France				18	19	35	28
Switzerland				33	38	25	4

Table 11 Teachers' questionnaire
Proportion of mathematics teaching time based on a textbook in schools in England

Proportion of Teaching Time Based on a Textbook	Grade 3 (Year 4)		Grade 4 (Year 5)		Grade 7 (Year 8)		Grade 8 (Year 9)	
	% Pupils Taught	Mean Score	% Pupils Taught	Mean Score	% Pupils Taught	Mean Score	% Pupils Taught	Mean Score
0-25%	13	437	12	488	6	492	6	472
26-50%	25	464	22	509	15	479	11	507
51-75%	45	450	43	515	45	475	45	514
76-100%	17	465	23	530	34	480	39	524

Table 12 Teachers' questionnaire

In planning mathematics lessons, how much do you rely on

- a) *pupils' edition of textbooks?*
- b) *teachers' guides or teacher edition of textbook?*
- c) *other textbooks or resource books?*

Country	% of Pupils whose Teachers Responded 'Quite a Lot' or 'A Great Deal'					
	Grade 4 (Year 5)			Grade 8 (Year 9)		
	Pupils' Edition	Teachers' Guides	Other Books	Pupils' Edition	Teachers' Guides	Other Books
	%	%	%	%	%	%
England	61	50	36	72	24	38
Ireland	77	35	51	92	18	77
United States	59	72	55	81	85	87
Canada	87	86	87	97	80	75
Australia	72	78	91	92	37	90
New Zealand	71	76	96	86	51	88
Korea	93	98	92	86	96	96
Japan	59	56	07	61	31	11
Singapore	95	97	93	95	72	94
Hong Kong	59	36	31	78	47	52
Czech Republic	75	42	50	80	18	63
Hungary	81	40	81	95	28	65
Netherlands	78	84	19	98	57	39
France	<1	<1	<1	82	38	83
Switzerland	<1	<1	<1	92	67	75

Table 13 Teachers' questionnaire

In planning mathematics lessons, what is your main source of written information when

1. *deciding what topics to teach (topics)?*
2. *deciding how to present a topic (presenting)?*
3. *selecting problems and exercises for work in class and /or homework (exercises)?*
4. *selecting problems and tasks for assessment and evaluation (assessment)?*

Key:

Pupil/student edition of textbook = P; teachers' edition of textbook =T; school curriculum guide=S; national curriculum guide=N; other books=O Not bold= 20-49% Bold= >50%

Country	% Pupils whose Teachers Used as the Main Source of Their Written Information when Planning:			
	Grade 4 (Year 5)		Grade 8 (Year 9)	
	Topics	Presenting	Exercises	Assessment
England	NS	TO	P/O	P/O
Scotland	N	T	PO	PO
Ireland	PN	PT	P	P
United States	NT/S	T	TP	TP
Canada	-	-	-	-
Australia	N/S	O/T/N	OP	OP
New Zealand	N	OT	OP	OP/T
Korea	P/T/N	TN	PT	PT
Japan	T	T	OPT	OPT
Singapore	S	T	PO	PO
Hong Kong	S	T	PT	O
Czech Republic	N	TP	PO	PO
Hungary	N	T	PO	PO
Netherlands	T	T	PT	PT
France	-	-	-	-
Switzerland	-	-	-	-
	Topics	Presenting	Exercises	Assessment
	SN	PO	P	OS
	NS	PO	P	ON
	NP	P	P	ON
	NS/T	TO	TP	O/T
	N*	TO	PT	OT
	SN	OP	P	O
	S/N	S/O	P	OS
	PT	TP	P	O
	T/P	T/P	PO	O/P
	SN	P	P	O
	S	TP	P	OP
	N	P	P	OP
	NS	TPO	PO	O
	P	P	P	P
	N	OP	P	O
	NT	TP	P	OP

Table 14 Students' questionnaire (Grade 8, Year 9)

		Grade 8 (Year 9) only			
		Almost Always	Quite Often	Once in a While	Never
		%	%	%	%
England		37	38	18	08
Scotland		-	-	-	-
Ireland		41	31	16	13
<hr/>					
United States		43	28	19	10
Canada		38	34	20	08
<hr/>					
Australia		32	38	21	10
New Zealand		23	36	26	14
<hr/>					
Korea		13	25	44	18
Japan		26	28	34	13
Singapore		36	40	18	07
Hong Kong		39	35	21	06
<hr/>					
Czech Republic		21	28	30	22
Hungary		15	28	39	18
Netherlands		15	31	36	18
France		17	21	31	31
Switzerland		08	16	35	41

Table 15 Teachers' questionnaire

If you set mathematics homework, how often do you set each of the following kinds of tasks?

	No Homework Set	Worksheets or Workbooks		Problems/Questions Set in Textbook		Reading a Textbook or Supplementary Materials		Worksheets or Workbooks		Problems/Questions Set in Textbook		Reading a Textbook or Supplementary Materials	
		Grade 4 (Year 5)		Grade 8 (Year 9)		Grade 4 (Year 5)		Grade 8 (Year 9)		Grade 4 (Year 5)		Grade 8 (Year 9)	
		Sometimes %	Always %	Sometimes %	Always %	Sometimes %	Always %	Sometimes %	Always %	Sometimes %	Always %	Sometimes %	Always %
England													
Ireland	01	64	10	59	36	25	03	41	01	19	80	21	03
United States	03	62	15	67	14	25	02	69	09	59	31	31	06
Canada	14	53	12	54	15	18	00	69	08	53	40	23	--
Australia	05	53	31	33	02	09	00	76	10	58	30	20	00
New Zealand	04	49	16	06	00	06	00	75	09	67	14	10	01
Korea	02	39	56	59	30	54	10	76	05	32	64	44	17
Japan	02	52	31	52	03	13	02	31	16	43	17	10	02
Singapore	00	31	67	64	32	56	12	61	19	15	84	51	08
Hong Kong	00	20	78	06	94	42	28	42	13	04	95	40	13
Czech Republic	00	74	14	69	17	24	02	17	03	43	53	25	--
Hungary	01	45	49	51	28	23	11	31	15	18	79	32	03
Netherlands	50	26	13	28	19	08	01	12	01	06	93	40	12
France								33	18	52	38	08	-
Switzerland								68	17	50	42	33	01

Table 16 Students' questionnaire

To do well in mathematics, you need to memorise the textbook or notes.

Country	Grade 4 (Year 5)				Grade 8 (Year 9)			
	Strongly Agree	Agree	Disagree	Strongly Disagree	Strongly Agree	Agree	Disagree	Strongly Disagree
	%	%	%	%	%	%	%	%
England					13	35	40	11
Scotland								
Ireland	62	29	06	03	24	45	25	05
United States	72	21	04	03	19	39	32	09
Canada	62	29	07	03	11	31	40	19
Australia	47	38	11	05	21	46	26	06
New Zealand	55	32	08	06	25	47	23	05
Korea	65	30	04	01	22	52	23	04
Japan	49	42	07	02	39	53	07	01
Singapore	71	23	04	02	05	27	48	20
Hong Kong	75	20	03	01	26	43	25	06
Czech Republic	46	42	10	02	10	31	42	17
Hungary	52	36	09	03	11	36	42	11
Netherlands	36	41	16	07	14	39	38	10
France					61	34	04	02
Switzerland					10	26	43	21

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Mathematics Textbooks across the World: Some Evidence from the Third International Mathematics and Science Study

Textbooks are a major resource for teachers in all countries and they are therefore likely to have a significant influence on student learning. Despite this, little research has been conducted on their characteristics and role in the classroom until relatively recently. This booklet summarises the contribution of the Third International Mathematics and Science Study (TIMSS) to this growing area of enquiry into factors affecting teaching and learning.

Data were gathered for TIMSS by utilising two main methods: analysing textbooks used by a majority of students in a country, and administering questionnaires to teachers and pupils who participated in the study. Other supplementary enquiries of TIMSS also provided information.

Sixteen countries were selected for comparison from five geographical blocs:

- Offshore Europe: England, Scotland, the Republic of Ireland;
- Continental Europe: France, The Netherlands, Switzerland, Hungary, Czech Republic;
- Pacific Rim: Singapore, Korea, Hong Kong, Japan
- North America: United States, Canada;
- Australasia: Australia, New Zealand.

These geographical blocs were also associated with three distinct levels of performance in the TIMSS written tests. The Pacific Rim countries had the best performance scores, with the Continental European countries coming next. The remaining three blocs are all English speaking, and they performed at about the same level in TIMSS – below that of the Pacific Rim and Continental European country blocs.

In addition to summarising the TIMSS data on the characteristics and role of textbooks in these countries, the evidence for any relationship with their performance is discussed. The information will be of particular interest to researchers, teacher training institutions and textbook publishers.

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