The 1999 National Assessment of Mathematics Achievement

SUMMARY REPORT

A study carried out by the Educational Research Centre in co-operation with the Inspectorate of the Department of Education and Science

Gerry Shiel
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Preface

In November 1998, the Department of Education and Science commissioned the Educational Research Centre to conduct a national assessment of the mathematics achievement of pupils in fourth class in primary schools. The following terms of reference were provided by the Department:

1. To conduct a study of the mathematics achievements of a representative national sample of pupils in fourth class in primary schools;
2. To generate baseline data that can be used to monitor achievement in mathematics over time;
3. To establish links between the current study and the Third International Mathematics and Science Study (TIMSS);
4. To identify factors related to the mathematics achievement of pupils; and
5. To make recommendations with regard to the teaching and assessment of mathematics.

Project Advisory Committee

A project advisory committee, broadly representative of the partners in education, was appointed by the Minster for Education and Science to assist the Educational Research Centre in its work. The members of the committee were: Seán Ó Cearbhaill (Chair) (Department of Education and Science), Shirley Brook (Church of Ireland Board of Education), Seán Close (Education Dept., St Patrick's College, Dublin), Austin Corcoran (Irish National Teachers' Organisation), Sr. Anne Dempsey (Association of Primary Teaching Sisters/Teaching Brothers' Association), Oliver Gaughran (National Parents' Council – Primary), Matt Hume (Catholic Primary School Manager's Association), Valerie O'Dowd (National Council for Curriculum and Assessment/Primary Curriculum Support Programme) and Tadhg Ó Gláimhín (Department of Education and Science). The Educational Research Centre was represented by Donal Kelly, Rhona Larney (until June 1999) and Gerry Shiel. The advisory committee met regularly throughout the study.

Scope of the Study

The 1999 National Assessment of Mathematics Achievement involved the development of the following instruments:

- A *Test of Mathematics Achievement (TMA99),* based on an agreed assessment framework;
- *A School Questionnaire,* addressing school-level issues related to the teaching and learning of mathematics, including the development and implementation of whole-school policy on the teaching and assessment of mathematics;
- *A Teacher Questionnaire,* addressing the teaching of mathematics by teachers of pupils in fourth class, including preparation for teaching, use of resources during instruction, involvement in assessment activities, and engagement in incareer professional development activities;
- *A Parent Questionnaire,* addressing the involvement of parents in developing their children's mathematics knowledge;
- *A Pupil Questionnaire,* addressing the involvement of pupils in a range of activities associated with mathematics achievement, and examining their attitudes towards mathematics learning;
- *A Pupil Rating Form*, seeking information from teachers about the learning characteristics of individual pupils; and
- *A Questionnaire for Inspectors*, seeking the views of inspectors about the teaching and learning of mathematics in schools.

The content of the questionnaires was based on the policy issues implied by the terms of reference for the study, and by issues arising in previous national and international studies of mathematics achievement.

An important purpose of the study was to provide baseline data on pupils' mathematics achievement. Hence, considerable attention is given to describing the outcomes of the assessment of achievement for the population of pupils in fourth class, and for subgroups within that population. In addition, relationships are established between the main variables represented in the questionnaires/rating forms and pupils' mathematics achievement.

Organisation of This Report

This summary report is being published in conjunction with a full report on the study (see Shiel & Kelly, 2001). The summary consists of seven chapters. Chapter 1 establishes a context for assessment by describing the performance of Irish pupils in earlier national and international assessments of mathematics achievement, and examining research on variables associated with achievement. Chapter 2 describes the procedures and instruments used in the current study. In Chapter 3, the mathematics achievement of pupils in fourth class is described in terms of their performance on the Test of Mathematics Achievement (TMA99), and teacher ratings of their achievement. Chapters 4 and 5 examine school and teacher variables associated with mathematics achievement, respectively. In Chapter 6, links between pupil home background, learning characteristics and achievement are explored. Chapter 7 provides a summary of inspectors' views about the teaching of mathematics in schools. In Chapter 8, recommendations that arise from the study are presented.

Acknowledgements

We would like to acknowledge the assistance of the following in conducting the 1999 National Assessment of Mathematics Achievement: Dr Thomas Kellaghan, Director of the Educational Research Centre, who advised on the design of the study, and responded to earlier drafts of the main report; Members of the Project Advisory Committee, who offered advice and support throughout the study; Dr Seán Close, St Patrick's College, Dublin who assisted in the identification of a framework for the Test of Mathematics Achievement, and developed many of the items for the test; Dr Michael O'Leary, St. Patrick's College, Dublin, who used item response theory procedures in scaling the test; members of the inspectorate, who oversaw administration of the assessment in schools during the pilot and main studies, and who responded to the Questionnaire for Inspectors; the principal teachers, class teachers and pupils in fourth class in the 12 schools that participated in the pilot study in March 1999, and in the 120 schools that participated in the main study in May 1999. Particular thanks are due to class teachers who administered the Test of Mathematics Achievement and Pupil Questionnaires to their classes during the main study, and who completed the Teacher Questionnaire, and a Pupil Rating Form in respect of each pupil in their fourth classes; the parents of pupils who participated in the National Assessment, who completed the Parent Questionnaire; John Coyle, Educational Research Centre, who provided computer support for the project; Seamus Ó hUallacháin, Educational Research Centre, and Ursula Ní Dhálaigh, who provided assistance with translation of items into Irish; Dr David Millar, Educational Research Centre, who advised on sampling issues, and assisted with the selection of a sample for the study; Mary Rohan, Educational Research Centre, who provided administrative support throughout the study; and Hilary Walshe, Educational Research Centre, who typeset the test booklets and questionnaires. Thanks are also due to Eoin Ryan and Jude Cosgrove of the Centre for their help in preparing this Summary Report.

Key Findings

Background

- A national assessment of Mathematics Achievement was conducted in May 1999. Participants included almost 5,000 pupils in fourth class in a nationally representative sample of primary schools, their principal teachers and class teachers, and their parents/guardians.
- A new test of mathematics achievement, based on the *Revised Primary School Mathematics Curriculum*, but also taking into account the content of *Curaclam na Bunscoile*, was developed and administered to participating pupils.
- Context information with which to interpret the performance of pupils on the test, was obtained by administering questionnaires to inspectors, principal teachers, class teachers, pupils and their parents. Teachers also completed a pupil rating form in respect of each pupil . Response rates exceeded 90% in all cases.

Mathematics Achievement

- Pupils performed best on items dealing with Data and Chance, Number, and Algebra, and poorest on items dealing with Measures and Shape and Space.
- Performance on mathematics processes was strongest on Understanding and Recalling Terminology, Facts and Definitions and Implementing Mathematical Procedures and Strategies, and weakest on Engaging in Mathematical Reasoning, Analysing and Solving Problems and Evaluating Solutions, and Understanding and Making Connections between Mathematical Processes and Concepts.
- The overall mean achievement scores of boys and girls were not statistically significantly different, though more boys than girls achieved scores at or below the 10th percentile, and at or above the 90th percentile.
- Pupils in the 1999 National Assessment achieved a significantly higher mean score than Irish pupils who took part in the Third International Mathematics and Science Study in 1995 on a subset of 20 items that were common to the two assessments.
- The mean mathematics achievement score of pupils attending schools designated as disadvantaged was significantly lower, by about one half of a standard deviation, than that of pupils attending non-designated schools.
- According to teachers, while three-quarters of pupils were achieving at a fourth class level or higher in mathematics, 18% were achieving at a third class level, and 6% at a second-class level or lower.

School Variables and Mathematics Achievement

- Three-quarters of pupils attended a school with a written school plan on the teaching and learning of mathematics. School management and parents had relatively little involvement in the preparation of school plans.
- Whereas most pupils attended schools with policies on the teaching of computation (e.g., subtraction), fewer pupils attended schools with policies on procurement of equipment and materials for teaching mathematics, provision for pupils with learning difficulties in mathematics, engagement of pupils in practical activities, development of strategies for teaching problem solving, and provision of enrichment activities for higher-achieving pupils.
- Fewer than 10% of pupils attended schools in which programmes designed to support parents in helping their children with mathematics were organised.
- Lack of learning support teaching in mathematics, inadequate incareer development for teachers and multiigrade class arrangements were identified by school principals as impeding the teaching and learning of mathematics.

Teacher Variables and Mathematics Achievement

- The vast majority of pupils were taught by teachers who prepared plans for teaching mathematics on an annual and/or a weekly/fortnightly basis.
- Just under 30% of pupils were taught by teachers who had attended an incareer professional development course on the teaching of mathematics since the completion of preservice teacher education.
- More than half of fourth class pupils in single-grade classes were grouped for mathematics teaching according to their ability. In multigrade classes, almost 7 in 10 pupils in fourth class were grouped, mainly by class level.
- Teachers reported placing considerable emphasis on the teaching of Number in mathematics lessons, and comparatively less emphasis on Graphs, Measurement and Shape and Space (Geometry).

Pupils' Home Backgrounds, Learning Characteristics and Mathematics Achievement

- Moderately strong associations were obtained between measures of parents' educational attainment and their children's mathematics achievement.
- Parents' expectations for their children's education were also positively associated with mathematics achievement.
- Parents of lower-achieving children reported spending more time providing help with homework than parents of higher-achieving children.
- More boys (24%) than girls (14%) indicated that they disliked mathematics.

Inspectors' Perspectives on Teaching and Learning Mathematics

- Inspectors were very satisfied with the teaching of Number, and with the teaching of mathematics processes involving Understanding and Recalling Terminology, Facts and Definitions, and Implementing Mathematical Procedures and Strategies.
- Inspectors were generally satisfied with the amount of mathematics homework assigned to pupils, but indicated some dissatisfaction with nature of the feedback about homework provided to students.
- Seventy-five percent of inspectors were less than satisfied with teachers' interpretations of standardised tests, and their use and interpretation of criterion-referenced tests accompanying mathematics textbooks.
- One half of inspectors expressed dissatisfaction with arrangements for grouping for mathematics in single-grade fourth classes, while almost 3 in 10 expressed dissatisfaction with such arrangements in multigrade fourth classes.

Learning Support and Learning Difficulties

- Forty-five percent of pupils in fourth class attended schools in which learning support in mathematics was provided by an officially-sanctioned learning support teacher, though in some schools, such support was provided by other teachers.
- According to class teachers, 16% of pupils in fourth class were in receipt of learning support in English from a sanctioned learning support teacher, while just 7% were in receipt of such support in mathematics. Twenty percent of pupils in each subject area were deemed to be in need of learning support by their teachers.

Assessment of Mathematics

- Teacher-made tests were used more often than other types of tests to assess pupils' mathematics achievement.
- According to their teachers, two-thirds of pupils had been assessed using a test that accompanied their mathematics textbook during the 1998-99 school year, while 57% had been assessed using a standardised test.

1. The Context of the 1999 National Assessment of Mathematics Achievement

In this chapter, a context for the 1999 National Assessment of Mathematics Achievement involving pupils in fourth class is established. First, the performance of pupils in earlier national assessments of mathematics achievement is examined. Second, the performance of Irish pupils in international studies of mathematics achievement is considered. Third, research on correlates of mathematics achievement is summarised.

National Assessments of Mathematics Achievement

In 1977, the Curriculum Unit of the Department of Education began a programme of assessment of mathematics achievement in primary schools. The purpose of the programme was to 'assess the level of achievement of pupils in the areas of mathematics specified in the primary school curriculum' (Martin, 1990, p. 27). As part of the programme, mathematics tests were developed and administered to national samples of pupils in second and fourth classes in 1977, and in sixth class in 1979 and 1984. Reports summarising the results of the assessments were published in 1980 and 1985 (Department of Education, 1980, 1985). No national surveys took place between 1984 and 1999, though Ireland participated in a number of international surveys during that time.

The content of the 1977 mathematics tests for pupils in second and fourth classes was based on the 1971 mathematics curriculum (*Curaclam an Bunscoile*, Department of Education, 1971). Criterion-reference tests, based on sets of objectives that reflected the content of *Curaclam na Bunscoile* (see Department of Education, 1978) were constructed and administered to nationally representative samples of pupils. In analysing the outcomes, objectives were grouped by content category, and an average percent correct score was reported for each category.

At second class level, the highest overall degree of mastery was achieved on Operations with Whole Numbers (85%). Performance was somewhat weaker on Whole Number Structure (65%), Problems (63%), Spatial Experience (Geometry) (61%), Graphs (60%), and Measurement (56%). Specific objectives on which students did poorly included problems involving subtraction (52%), use of the commutative property of addition (40%), and use of the distributive property of addition (35%).

Overall mastery of specific mathematics content areas was noticeably lower in fourth class than in second class. Performance was strongest in the areas of Operations with Whole Numbers (75%), Whole Number Structure (59%), Measurement (58%), and Fractions and Decimals (58%). Performance was poorer in Graphs (53%), Spatial Experience (Geometry) (40%) and Problems (41%). The specific objectives on which students did least well included problems involving unitary method, symmetry, perimeter, interpretation of timetables, positioning of numbers on the number line, addition and subtraction of decimals, interpretation of barline graphs, problems involving fractions, conversion of fractions to decimals, problems involving money, and long division.

There are links between the assessments involving pupils in sixth class in 1979 and 1984, and the assessment involving pupils in fourth class in 1977. First, some objectives dealing with Operations with Whole Numbers that had been assessed in the fourth class test in 1977 and presented difficulties for pupils, were also assessed in sixth class in 1979 and 1984. Of these operations, only long-division continued to present difficulties for pupils in sixth class with 68% achieving mastery in 1979, but just 61% in 1984 (a statistically significant decline). Second, performance on Whole Number Structure was relatively low in both 1979 (50.3% mastery) and 1984 (51.5%) – an outcome also observed in the 1977 assessment in fourth class. Third, performance on objectives in Geometry was relatively low, although an increase in achievement of some objectives was observed between 1979 and 1984. Fourth, performance on Problem Solving objectives did not change substantially between 1979 (52.5%) and 1984 (50.8%), and was low relative to performance of pupils in the second and fourth classes in 1977 in the same content area.

International Assessments of Mathematics Achievement

From the late 1980s onwards, Irish students participated in a number of international assessments that included mathematics. The most recent of these are the Third International Mathematics and Science Study (TIMSS) (Beaton et al., 1996; Mullis et al., 1997), and the OECD[1] Programme for International Student Assessment (PISA) (OECD, 2001; Shiel, Cosgrove, Sofroniou & Kelly, 2001).

The TIMSS Study

The target populations in TIMSS, which was administered in 1995 under the auspices of the International Association for the Evaluation of Educational Achievement (IEA), were the two class levels with the majority of 9-year olds, and the two class levels with the majority of 13-year olds. In Ireland, these were third and fourth classes (primary level) and first and second years (post-primary level). In all, 45 countries participated, though not all countries were represented at all class levels. The performances of pupils in fourth class and second year are reviewed here.

An analysis of TIMSS mathematics data for fourth class and second year (the fourth and eighth grades) by the Organisation for Economic Co-operation and Development (OECD) indicated that, whereas Irish pupils in fourth class achieved a mean score that was significantly above the average for OECD countries, by second year, the mean score for Irish pupils was not significantly different from the OECD average (OECD, 2000). In contrast, countries such as Iceland, New Zealand and Norway, which had mean scores that were not significantly different from the OECD average in fourth class, had scores that were significantly higher in second year.

TIMSS also estimated students' progress in mathematics between the fourth class and second year, using items that were administered at both class levels. Ireland ranked 19th of 25 countries, with an expected difference of 116 points between the estimated mean for fourth class on the second-year scale, and the actual mean for second year (Mullis et al., 1997), indicating relatively disappointing progress between the two class levels. Most progress was made by students in Singapore (186 points) and least by students in the United Sates (93).[2]

Irish pupils in fourth class in TIMSS performed significantly better than the corresponding international country averages in four mathematics content areas (Whole Numbers; Fractions and Proportionality; Data Representation, Analysis and Probability; and Patterns, Relations and Functions), and at about same level in the two remaining areas (Measurement, Estimation and Number Sense; and Geometry) (Mullis et al., 1997). Irish students in second year performed significantly better than the international country average in three areas (Fractions and Number Sense, Data Representation, Analysis and Probability, and Probability), at about the same levels in two areas (Algebra and Measurement), and below the international average in one area (Geometry) (Beaton et al., 1996). The comparatively lower performance of Irish pupils in Measurement and Geometry is consistent with the low achievement observed in these areas in earlier national and international studies.

[1] OECD: The Organisation for Economic Co-operation and Development, based in Paris.
[2] The standard deviation associated with the TIMSS average international mean score for second years was 100 points.

The OECD PISA Study

In 2000, Irish 15-year olds participated in OECD Programme of International Assessment, in which reading literacy was the main assessment domain, and mathematical literacy and scientific literacy were minor domains (i.e., only limited aspects of these domains were assessed). On the test of mathematical literacy, which purported to assess skills and knowledge deemed necessary for future life rather than the content of school curricula, Irish students achieved a mean score that was not significantly different from the OECD country average (OECD, 2001; Shiel et al., 2001b). Thirteen OECD countries, including Japan, the Republic of Korea, New Zealand and the United Kingdom achieved significantly higher mean scores than Ireland; 5 countries, including the USA achieved scores that were not significantly different from Ireland's; and 8 countries, including Italy and Portugal, achieved significantly lower mean scores. The result is noteworthy to the extent that Irish students achieved mean scores in reading and scientific literacy that were above the OECD country averages in those areas. Related to this is the observation that several countries with mean scores that were not significantly different from Ireland's in reading and scientific literacy, achieved significantly higher mean scores than Ireland in mathematical literacy. Another noteworthy finding is that, while Irish students scoring at the 10th percentile achieved a score that was significantly higher than the corresponding OECD country average, Irish students scoring at the 90th percentile achieved a score that was significantly lower. A more comprehensive account of the performance of Irish students on PISA mathematical literacy will become available in 2003, when mathematical literacy becomes a major assessment domain in PISA and students are assessed over a broader range of knowledge and skills. The OECD did not report performance in mathematics content areas in 2000.

The broad picture that emerges across the international studies is that Irish students typically achieve in the average range, at about the same level or better than some European countries, and lower than such countries as Singapore, Korea and Japan. The finding that other countries do consistently better than Ireland suggests that there is scope for Irish pupils to improve. Furthermore, the relatively poor growth in achievement in TIMSS between fourth class (primary) and second year (post-primary) points to further room for development. Across studies, Irish pupils (both primary and post-primary) do relatively well on items dealing with Number and Operations, fairly well on items dealing with Data Representation and Analysis, and least well on items in Algebra, Measurement and Geometry.

Correlates of Achievement in Mathematics

In this section, research on correlates of mathematics achievement is reviewed. Four broad sets of correlates are considered: those associated with gender, home background, pupil self-concept, and school and teacher factors.

Gender

Girls outperformed boys on most content areas in the 1977 national assessment of mathematics in second class. In fourth class, girls still did better than boys, but the gap was narrower (Department of Education, 1980). Boys significantly outperformed girls in both the 1979 and 1984 assessments at sixth class level, but the size of the advantage in favour of boys declined between the two assessments (Department of Education, 1984).

No significant differences were found between boys and girls on overall TIMSS scores, or on any of the TIMSS content areas at either the fourth class or second year levels. Only two countries with approved sampling procedures or response rates showed a statistically significant difference in overall achievement in favour of boys at fourth grade (Japan and Korea), while 5 showed such differences in second year (Japan, Korea, Spain, Portugal, and Iran) (Beaton et al., 1996; Mullis et al., 1997). No countries showed statistically significant differences in favour of girls.

On the OECD PISA assessment of mathematical literacy, Irish boys achieved a significantly higher mean score than Irish girls (OECD, 2001). The difference was one sixth of a standard deviation, which was close the OECD average difference. There were statistically significant differences in mathematical literacy in about one half of OECD countries in PISA, all in favour of boys.

Home Background

Research on the factors associated with achievement in mathematics consistently points to the influence of socioeconomic status. In a study of fifth-class pupils, Greaney and Hegarty found that socioeconomic background (based on father's occupation) correlated significantly (r = .18) with scores on a test of mathematics computation. In PISA, home background variables that correlated moderately strongly with students' mathematical literacy were parents' socioeconomic status (r = .29) and parents' educational attainment (r = .24).

An important distinction that is sometimes made is that between home background variables, such as indices of socioeconomic status or parents' education on the one hand, and home process variables, such as the level of emphasis on achievement in the home, on the other (e.g., Bloom, 1976; Kellaghan, 1977; Kellaghan et al., 1993). Kellaghan (1977) found significant correlations (r = .49 to .55) between six home-environment variables (achievement press, language model, academic guidance, family activeness, intellectuality and work habits) and performance on a test of mental arithmetic for 8- and 9-year olds children living in a disadvantaged area of Dublin.

Pupils' Attitudes Towards Mathematics and Academic Self-Concept

There is some evidence of a relationship between how pupils feel about mathematics and their mathematics achievement. In TIMSS, Irish pupils in fourth class who were 'strongly positive' in their attitudes[3] towards mathematics (41% of students) had significantly higher achievement than pupils who reported negative or strongly negative attitudes (20%) (Mullis et al., 1997). Academic self-concept has also been shown to be related to mathematics achievement. In a study by Kellaghan and Fontes (1988), boys in sixth class rated themselves more highly than girls on their mathematical ability, although a tendency for pupils in general to rate themselves highly was also observed.

School and Teacher Variables

An important purpose of recent international studies has been to examine relationships between a range of school- and teacher-related variables and achievement. In PISA, such variables as school type (i.e., whether a school was secondary, vocational or community/comprehensive) and disadvantaged status were associated with the achievement of 15-year olds in mathematical literacy.

A major focus of TIMSS was on teacher and instructional factors related to achievement in mathematics (and science). These included teacher perceptions about the nature of mathematics and mathematics teaching, class size, classroom organisation during mathematics lessons and frequency of use of computers and calculators during mathematics classes. In relation to class size, for example, Irish pupils in fourth class who were taught in small classes (1-20 students) achieved a higher mean score (555 points) than their counterparts in medium-sized classes (21-30 students) (541 points) (Mullis et al., 1997). However, the difference between these mean scores was not statistically significant.

[3] Based on a composite variable consisting of average responses to the statements, 'I like mathematics', 'I enjoy learning mathematics', and 'Mathematics is boring' (reversed scale).

2. Assessment Procedures and Survey Instruments

Given that the last national assessment of mathematics achievement in fourth class was carried out in 1977, it was decided to develop a new test for the 1999 assessment. A further consideration was the necessity to develop a test that could be used in future national assessments based on the revised *Primary School Mathematics Curriculum* (NCCA, 1999a, 1999b). Hence, the new Test of Mathematics Achievement (TMA99) was based on the framework underpinning the revised curriculum, while also taking into account the content of *Curaclam na Bunscoile*. One consequence of this was the inclusion of a small number of items in TMA99 that are based on new content in the revised curriculum (for example, extending and describing sequences, using the vocabulary of uncertainty and chance, ordering events in terms of likelihood of occurrence, and identifying and recording outcomes of simple random processes), and the exclusion of content in *Curaclam na Bunscoile* but not in the revised curriculum (for example, long division). A second consequence was that certain curricular areas, including Shape and Space, Measures, and Data were given greater emphasis in TMA 99, in line with their increased importance in the revised curriculum (see Table 2.1). To allow for a link with the Third International Mathematics and Science Study, it was decided to include 20 TIMSS items in TMA99. In line with recent international assessments of mathematics achievement, it was decided to include a balance of multiple-choice and short-answer questions on the test.

Following a pilot study in 12 schools in March, 1999, a final version of the test – 125 items spread over two test booklets was assembled (see Table 2.1). The distribution of items by content area indicates the weighting attributed to each content area.

Table 2.1 Distribution of Items on TMA99, by Mathematics Content Area – TMA99

Content Area	No. of Items	Percentage of All Items
Number	46	36.8
Algebra	6	4.8
Shape/Space	18	14.4
Measures	44	35.2
Data	11	8.8
Total	125	100.0

Development of Questionnaires

Five questionnaires and were developed in conjunction with the national assessment. These were: a School Questionnaire; a Teacher Questionnaire; a Parent Questionnaire; a Pupil Questionnaire; and a Questionnaire for Inspectors. In addition, a Pupil Rating Form that would elicit information about certain pupil characteristics deemed to be linked to mathematics achievement, was developed. The development of these measures was influenced by work in other assessments, including the Third International Mathematics and Science Study and the 1998 National Assessment of English Reading (Cosgrove et al., 2000), by the policy needs of the Department of Education and Science, and by issues raised by members of the Project Advisory Committee.

Sampling Schools and Students

A representative national sample of pupils was selected to participate in the assessment. In the first stage of sampling, 120 schools were selected in three size categories – large schools (60), medium schools (30) and small schools (30). Special schools and private schools were not included in the sampling frame.

In the second stage of sampling, all pupils in fourth class in each participating school were selected to complete the Test of Mathematics Achievement (TMA99) and associated questionnaires. Pupils in special classes, pupils with disabilities that would prevent them from attempting the test, and non-national pupils with limited proficiency in English were exempted.

All selected schools agreed to participate in the assessment. Altogether, 4747 pupils (91.7% of the selected sample) completed the Test of Mathematics Achievement on a designated day during a two-week test administration period (May 17-28, 1999). The pupils ranged in age from 8 years, 2 months to 13 years, 3 months, with an average age of 10 years, 6 months (SD = 5.5 months[4], n = 4722). The selected and achieved samples are compared in Table 2.2. The discrepancy between the numbers in the two samples can mainly be attributed to changes in the numbers of pupils in some classes since data for the primary schools database had been submitted by schools on September 30, 1998 and absenteeism on the day on which the test was administered. Thirty-five pupils in 22 of the selected schools were exempted from taking the test because principal teachers indicated that the pupils' limited proficiency in English or their learning difficulties made it impossible for them to attempt it. Tables 2.2 gives a breakdown of the achieved sample by school size, designated disadvantaged status, and language.

Table 2.2. Number of Schools, Percentages of Schools, Numbers of Pupils and Percentages of Pupils in the Sample, by School Type (Unweighted Data)

Characteristic	Number of Schools	Percent of Schools	Number of Pupils	Percent of Pupils
Size				
Large Schools	60	50.00	3626	76.39
Medium Schools	30	25.00	751	15.82
Small Schools	30	25.00	370	7.79
Disadvantaged Status				
Disadvantaged	21	17.50	909	19.15
Non-designated	99	82.50	3838	80.85
Language				
English-medium	115	95.83	4575	96.38
Lán-Ghaeilge	4	3.33	141	2.97
Gaeltacht	1	0.83	31	0.65
Total	120	100.0	4747	100.00

Administration of Tests and Questionnaires

An inspector of the Department of Education and Science was assigned to each school in the sample. Following a training day in which procedures relating to the administration of the survey were outlined, the inspector made initial visits to the schools during the week of May 10-14, 1999 to make arrangements for administering the Test of Mathematics Achievement and associated questionnaires. On a second visit (between May 17 and 28, 1999), the inspector oversaw administration of TMA99 by pupils' class teachers and collected completed questionnaires. Following the second visit, all completed materials were sent to the Educational Research Centre for processing.

[4] Based on 4722 pupils for whom valid ages were available

Implementation of the study in schools was generally successful and reflected the strong commitment to it by inspectors, principal teachers, class teachers, pupils and parents. Completion rates for the questionnaires were uniformly high, exceeding 90% in all cases.

Scaling the Test of Mathematics Achievement

Following the main study, TMA99 was scaled using Item Response Theory methodology. A three-parameter IRT model was chosen for scaling the test, and was implemented using the BILOG programme (Mislevy and Brock, 1990). For multiple choice items, three parameters – item difficulty, item discrimination and guessing – were estimated. For short answer items, strong prior distributions were set on the guessing parameter. The likelihood-ratio chi-square statistics generated by BILOG flagged 9 of the 125 items as potentially poor-fitting to the underlying IRT model. However, an examination of the item response curves for these items indicated no substantial deviations from the theoretical curves. Since the classical item statistics for those items were satisfactory, and other reasons for eliminating them such as a large percentage of missing responses were discounted, it was decided not to omit any of the 9 items. A regression of the derived IRT scale scores on the number of items answered correctly (raw scores) resulted in an R^2 of 88%, indicating that the IRT scale provided a satisfactory representation of pupils' achievement on the test. A complete description of the scaling process may be found in O'Leary (1999). Following scaling, a scaled score was available for each pupil who completed TMA99. The scale had a mean of 250 and a standard deviation of 50.

Analysis of the Data

In order to draw more accurate inferences about the characteristics of the population of pupils in fourth class, all achievement and questionnaire data were weighted in the course of analysing the data. Jackknifed standard errors of measurement were computed for all achievement data (mean scores and percentages) and for most questionnaire data in order to take into account the stratified and clustered nature of the sample. The standard error indicates the extent to which a sample statistic (such as the mean mathematics achievement of boys) may be expected to vary about the true (but unknown) population value. There is a 95% chance that a true population statistic such as a mean score lies in an interval that extends to two standard errors on either side of the estimated value.

In analysing the data, a number of statistical techniques were also employed to take into account the stratified and clustered nature of the sample and the need to make multiple comparisons between groups. The values of chi-square statistic and associated significance levels were adjusted using a procedure by Rao and Scott (1981), which was implemented using the WesVar statistical package (Westat, 1998). The statistical significance levels associated with correlation coefficients were obtained using regression procedures in WesVar. The Dunn-Bonferroni procedure (Dunn, 1961) was used to adjust the critical values in making multiple comparisons between groups.

In analysing the data, responses to the School and Teacher Questionnaires were disaggregated to the pupil level. For example, responses of teachers to the Teacher Questionnaire are reported in terms of the proportions of pupils whose teachers provided particular responses, rather than the proportions of teachers.

3. The Mathematics Achievement of Pupils in Fourth Class

This chapter describes aspects of pupils' mathematics achievement based on (i) the performance of pupils on the Test of Mathematics Achievement (TMA99) and (ii) teachers' judgements about pupils' mathematics achievements.

Range of Mathematics Achievement

The mean score for the population of pupils in fourth class was set at 250, and the standard deviation at 50 (see Chapter 2). In future national assessments at this class level, it will be possible to compare the mean of the population with the 1999 mean of 250. Table 3.1 illustrates the range of achievement on the TMA99. The table indicates the scores achieved by pupils at five common markers – the 10th, 25th, 50th, 75th and 90th percentiles. Pupils who scored at the 10th percentile achieved a score of 181. The corresponding score for pupils at the 90th percentile was 309. The median score (50th percentile) was 256, indicating that the distribution of scores was slightly negatively skewed. Again, in future assessments, it will possible to use these scores as benchmarks against which to compare the performance of higher- and lower-achieving readers.

Table 3.1. Scores Achieved by Pupils at Five Critical Markers on TMA99

	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
Scale Score	180.96	217.30	256.34	284.41	308.70
Standard Error	3.01	2.73	2.39	1.81	1.75

Gender and Mathematics Achievement

The achievement of boys and girls was examined in relation to their overall performance on TMA99 (Table 4.2). The slight difference in favour of boys is not statistically significant (R^2 = 0.00, F (1,58) = 0.08). This outcome is consistent with the finding that there was no overall significant difference between Irish boys and girls in fourth class in TIMSS in 1995 (Mullis et al., 1997) (see Chapter 1).

Table 3.2. Mean Scale Scores and Standard Errors for Overall Mathematics Achievement, by Gender

Gender	Mean *(SE)*
Boys	250.44 *(2.89)*
Girls	249.55 *(2.20)*
Total	250.00 *(2.20)*

Whereas boys scoring at or below the 10th percentile achieved a mean score (150.00, *SE* = 2.00) that was significantly lower than that of girls (158.57, *SE* = 1.64),[5] the difference between the mean scores of boys (329.41, *SE* = 1.41) and girls (326.46, *SE* = 2.26) scoring at the 90th percentile was not statistically significant.

The performance of boys and girls on selected individual items on TMA is compared in Appendix 1. Performance is reported in terms of percent correct scores for each item.

[5] See Table 4.4, Main Report

School Designated Disadvantaged Status and Mathematics Achievement

Mean scale scores for overall mathematics achievement were computed for pupils in schools designated as disadvantaged (designated disadvantaged schools) and in non-designated schools. The overall mean score of pupils in designated schools (227.75) was about one half of a standard deviation below the mean for pupils in non-designated schools (254.27). The difference was statistically significant (R^2 = 0.038, F(1,60) = 22.09, p. <0.00).[6]

Using the 10th and 90th percentiles of the whole population on the Test of Mathematics Achievement (TMA99) as cut-off points for very low and very high achievement (see Table 3.1), the performance of fourth class pupils was examined in the context of the disadvantaged status of their schools. More than twice as many pupils in designated disadvantaged schools (20%) as in non-designated schools (8%) performed at or below the 10th percentile for the population. At the other end of the scale, fewer than half as many pupils in designated disadvantaged schools (4%) as in non-designated schools (11%) scored at or above the 90th percentile

This analysis leads to the conclusion that designated schools had higher proportions of lower-achieving pupils than non-designated schools, while proportionally fewer pupils with very high achievement were found in designated than in non-designated schools.

Performance In Mathematics Content Areas

As indicated in Chapter 1, items on the TMA99 were drawn from the five mathematical content areas represented in the revised *Primary School Mathematics Curriculum* – Number (37% of items), Algebra (5%), Shape and Space (14%), Measures (35%) and Data (9%). The distribution of items by content area was arrived at after examining the emphasis placed by the revised mathematics curriculum on each content area, and consulting with persons involved in the development of the curriculum.

It was not possible to scale individual content areas using item response theory methodology as there was an insufficient number of items in some content areas (e.g., Algebra). Therefore, outcomes for each content area are reported in terms of the average percent correct scores achieved by pupils (see Table 3.3). No significant differences were found between boys and girls on any of the mathematical content areas. [7]

Table 3.3. Mean Percent Correct Scores for Each of Five Mathematics Content Areas, by Pupil Gender

	Mean Percent Correct *(Standard Error)*		
Content Area	All Pupils	Boys	Girls
Data	68.57 *(0.87)*	67.49 *(1.19)*	69.70 *(0.99)*
Number	59.59 *(0.95)*	59.48 *(1.20)*	59.71 *(1.09)*
Algebra	58.35 *(0.94)*	58.43 *(1.17)*	58.26 *(1.21)*
Measures	54.09 *(0.86)*	55.10 *(1.12)*	53.04 *(1.10)*
Shape/Space	45.31 *(0.80)*	45.15 *(0.99)*	45.48 *(1.02)*

Performance on Mathematics Processes

The 125 TMA99 items assess five broad mathematical process areas: Understanding and recalling terminology, facts and definitions (14% of items); Using mathematical strategies and implementing mathematical procedures (30%); Engaging in mathematical reasoning (e.g., exploring mathematical patterns and relationships) (22%);

[6] See Table 4.6, Main Report
[7] See Table 4.10, Main Report

Integrating and making connections between mathematical procedures and concepts (6%); and Analysing and solving problems and evaluating solutions (29%). A sixth mathematical process – Communicating and Expressing – was not assessed in TMA99.

Percent correct were computed to describe performance in each assessed content category (Table 3.4). Pupils performed best on items dealing with Understanding and Recall (63% correct) and Using Strategies/Implementing Procedures (58%), and least well on items dealing with Analysing and Solving Problems and Evaluating Solutions (54%) and Integrating and Connecting (53%). The ordering of the mathematical processes in terms of their relative difficulty suggests that lower-level processes such as Understanding and Recalling and Using Strategies/Implementing Mathematical Procedures were somewhat easier for pupils than higher-order processes such as Analysing and Solving Problems and Evaluating Solutions.

Table 3.4. *Mean Percent Correct Scores for Each of Five Mathematics Content Areas, by Pupil Gender*

	Mean Percent Correct *(Standard Error)*		
Process Areas	All Pupils	Boys	Girls
Understanding and Recalling	62.96 *(0.88)*	66.28 *(1.12)*	63.26 *(1.05)*
Using Strategies/ Implementing Procedures	58.05 *(0.88)*	58.16 *(1.22)*	5792 *(0.96)*
Reasoning	55.40 *(0.83)*	55.04 *(0.98)*	55.77 *(1.03)*
Integrating and Connecting	53.22 *(0.98)*	53.28 *(1.21)*	53.15 *(1.29)*
Analysing and Solving Problems, and Evaluating Solutions	53.98 *(0.92)*	54.66 *(1.13)*	53.26 *(1.13)*

Mean percent correct scores for boys and girls for each mathematics process were also computed and compared. Again, no significant differences were found between the mean scores of boys and girls on any of the five processes.[8]

Performance on TIMSS Items in 1995 and 1999

The inclusion in TMA99 of 20 items that had been used in the Third International Mathematics and Science Study (TIMSS) was designed to serve two purposes: (i) to provide a link between the two forms of TMA99 used in the 1999 National Assessment (the 20 TIMSS items featured as a block of items in the two forms), and (ii) to provide a basis for comparing achievement outcomes in TIMSS and the 1999 National Assessment. In the case of 14 of the 20 items, there was an increase in the percentage of pupils responding correctly between 1995 and 1999. Statistically significant differences were found for four of these items.[9] None of the six negative differences was statistically significant. Across all 20 items, the average percent score increased from 65.87% (*SE* = 0.81) in 1995 to 69.23% (*SE* = 0.77) in 1999 – a statistically significant increase.[10] While welcome, these findings must be qualified by an acknowledgement that, whereas in 1995, the 20 TIMSS items were interspersed among science items and other items assessing mathematics achievement, they were presented in a single block in 1999. Furthermore, while all pupils in 1999 were asked to attempt all 20 TIMSS items, no student in the 1995 study was asked to attempt more than 11 of these items and some were asked to try as few as five.

[8] See Table 4.18, Main Report
[9] See Table 4.21, Main Report
[10] See Table 4.24, Main Report

Teacher Judgements About Pupils' Mathematics Achievement

Teachers were asked to specify, for each pupil in their classes, the pupil's level of mathematics achievement, on a 4-point proficiency scale – advanced, proficient, basic, or weak/inadequate. Table 3.5 provides a breakdown the outcomes for boys, girls, and all pupils.

Table 3.5. Percentages of Pupils at Each of Four Levels of Mathematics Proficiency (Based on Teacher Judgements) and Associated Mean Mathematics Achievement Scores and Score Ranges, by Gender

Proficiency Level		Percent of Pupils *(SE)*	Mean *(SE)* on TMA99	Range on TMA99
Advanced	Boys	11.54 *(1.28)*	312.12 *(2.88)*	230.55 - 385.78
	Girls	11.26 *(1.45)*	293.75 *(2.26)*	202.74 - 399.96
	All	11.40 *(1.25)*	303.23 *(3.12)*	202.74 - 399.96
Proficient	Boys	44.00 *(2.11)*	274.04 *(2.26)*	116.05 - 366.56
	Girls	50.05 *(1.93)*	264.55 *(2.43)*	149.80 - 374.87
	All	46.97 *(1.48)*	269.08 *(2.04)*	116.05 - 374.87
Basic	Boys	26.19 *(1.30)*	230.36 *(2.85)*	109.13 - 333.86
	Girls	26.59 *(1.58)*	230.41 *(3.96)*	107.52 - 321.61
	All	26.39 *(1.03)*	230.38 *(2.61)*	107.52 - 333.86
Weak/Inadequate	Boys	18.26 *(1.74)*	183.55 *(3.61)*	90.56 - 314.57
	Girls	12.10 *(1.22)*	188.27 *(3.73)*	88.35 - 302.18
	All	15.24 *(0.93)*	185.39 *(2.47)*	88.35 - 314.57

Just over 11% of pupils were judged to be at an advanced level of achievement. On the other hand, just over 15% were judged to have a level of achievement that could be described as weak or inadequate. While the same proportions of boys and girls were judged to fall into the 'advanced' category, proportionately more boys than girls were regarded by their teachers as being in the 'weak/inadequate' category. A statistical comparison of the percentages of boys and girls in each category indicates that the differences in category percentages are associated with gender ($\chi^2 = 38.22$; $df = 3$; $p < .001$).

A consideration of the scores achieved by pupils in each of the four proficiency categories indicates the broad range of achievement represented by each category. For example, pupils judged by their teachers to be 'advanced' in mathematics achieved scores that ranged from 202 (i.e., almost one standard deviation below the mean of 250) to 400 (three standard deviations above the mean). Similarly, scores achieved by pupils in the 'weak/inadequate' category ranged from 88 to 315. However, the overall correlation between teacher judgements of pupils' proficiency and the pupils' scores on TMA99 is strong and significant ($r = 0.77$, $p < .001$).

Teachers were also asked to indicate the class level at which each pupil in their fourth class was functioning with respect to mathematics achievement. Seven options were given: post-primary, sixth class, fifth class, fourth class, third class, second class, and first class or lower. A majority of pupils in fourth class (68%) were deemed to be achieving at a fourth class level. Almost one quarter were considered to be achieving at second- or third-class levels, while 1% were judged to be achieving at first class level or lower. Eight percent were judged to be functioning at fifth-class level or higher.[11]

[11] See Table 4.26, Main Report

4. School Variables and Mathematics Achievement

This chapter addresses school-level variables related to the teaching and learning of mathematics. The data are based on the responses of school principals to the School Questionnaire. First, the views of school principals regarding difficulties affecting the teaching of mathematics and the resource requirements of schools are considered. Second, school-level planning for the teaching of mathematics is examined. Third, school-wide policies on such issues as the assessment of mathematics and the selection of mathematics texts are discussed. Fourth, the implementation of parent programmes in mathematics is described. Fifth, the comments offered by school principals on the teaching/learning of mathematics are summarised.

Resources for Teaching and Learning Mathematics

Principal teachers were asked to identify, from a list of possible problems, up to three significant problems that most affected their school in providing for the teaching and learning of mathematics. All pupils attended schools whose principal teachers identified at least one problem. The problems that affected the largest proportions of pupils were a lack of learning support (remedial teaching) in mathematics (65%)[12] and inadequate inservice training for teachers on the teaching of mathematics (53%). Multigrade class arrangements were identified as a particular problem in the case of almost two-thirds of pupils attending small schools (62%) and just over one-third attending medium-sized schools (34%). Insufficient equipment for the teaching and learning of mathematics was a significant problem for almost 3 in 10 pupils. Among the ‘other’ problems identified by principal teachers were the breadth of the mathematics programme at some class levels, large class sizes, textbooks that did not provide enough examples, a lack of textbooks and computer materials in Irish, difficulties in teaching mixed ability pupils within large classes, and difficulties using equipment in large classes.

Principal teachers were asked to select, from a list, up to three categories of equipment/materials that their school lacked for the teaching of mathematics. Their responses indicate that almost half of all pupils attended schools in which materials for teaching Number (e.g., fraction walls, notation boards) were needed. Other resources for teaching that were needed included software for developing mathematics concepts (47%), software for teaching Number facts and skills (42%), devices for teaching Measurement (41%), and equipment for teaching Shape and Space (36%). Significantly, over one quarter of pupils (28%) attended schools in which additional resource materials for teachers, such as books and manuals, were required. In general, the proportions of pupils in schools in different size categories that required particular resources were similar. Among the ‘other’ resources that principal teachers indicated as lacking were Irish language materials for the teaching of mathematics.

According to principal teachers, fewer than 2% of pupils in fourth class had used computers to learn mathematics in the week prior to the survey. Where computers had been used, the emphasis was on practicing mathematic facts rather than on learning concepts or developing higher-level mathematical thinking skills.

Learning Support in Mathematics

According to school principals, over one half of pupils in fourth class (56%) attended schools in which no learning support in mathematics was provided by an officially-sanctioned learning support teacher (Table 4.1). Pupils attending medium and small

[12] See Table 8.1, Main Report

schools were less likely than their counterparts attending large schools to have access to learning support classes in mathematics.

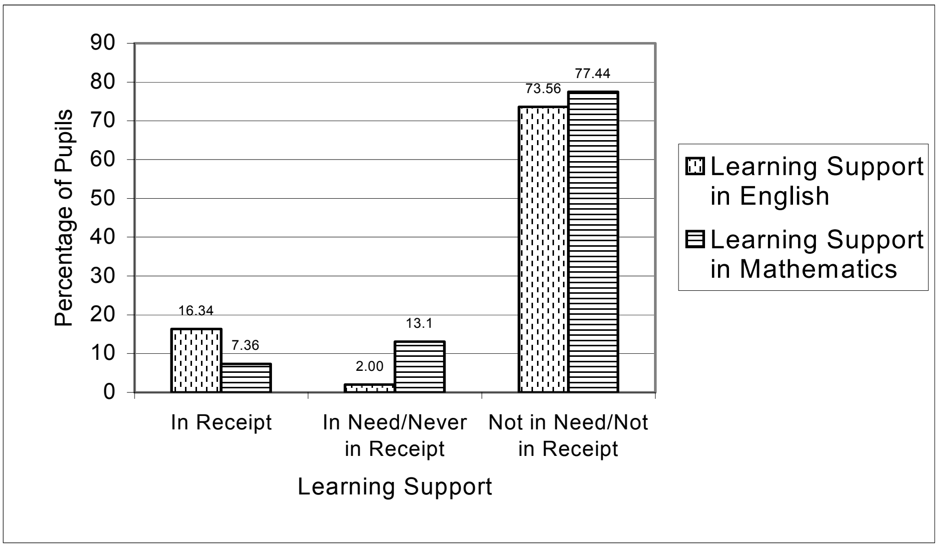
Just under one fifth of pupils attended schools in which learning support in mathematics was provided by an ‘unofficial’ learning support teacher – for example, a teacher on the school staff who was assigned learning support duties for part or all of the school day, but was not the officially sanctioned learning support teacher. Medium-sized and large schools were more likely than small schools to provide learning support from a non-sanctioned learning support teacher.

Table 4.1. Percentages of Pupils Attending Schools with a Learning Support Service, in which Learning Support in Mathematics Was Not Provided by an Officially-Sanctioned Learning Support Teacher, by School Size.

School Category/Status	Percentages of Pupils *(SE)* – No Learning Support in Mathematics Provided by an Officially-Sanctioned LS Teacher
Large	48.08 *(6.21)*
Medium	55.56 *(10.30)*
Small	64.29 *(8.38)*
All Schools	55.59 *(4.60)*

According to class teachers, almost twice as many pupils (16.34%) were receiving learning support in English from a learning support teacher as were receiving learning support in mathematics (7.36%). Further, whereas 13% of pupils were felt to be in need of learning support in mathematics, but had never received it, just 2% were in the same situation for English.

Figure 4.1. Learning Support: Provision and Need Among Pupils in Fourth Class – English and Mathematics



School Planning for Teaching and Learning Mathematics

Given the importance attached to school planning in recent years (e.g., Department of Education, 1999), several questions on the topic were included on the School Questionnaire. According to school principals, almost three quarters of pupils in fourth class attended schools in which there was a plan for the teaching and learning of mathematics. Among the reasons offered by school principals for not developing a school plan were: insufficient time available for collaborative planning; a view that a school plan was not necessary; and the imminent publication of the revised Primary School Mathematics Curriculum, which could be used as a basis for developing or revising plans.

Principal teachers were asked to indicate if their school had a policy statement on each of several topics relating to the teaching and learning of mathematics in schools.[13]

The vast majority of pupils attended schools that had a policy statement on the assessment of mathematics achievement, communicating pupils' progress in mathematics to parents, and maintaining records on pupils' achievement in mathematics. Whereas almost three quarters of pupils attended schools in which there was an agreed methodology for teaching computation across classes, just over 30% attended schools in which there was an agreed approach to teaching strategies for problem solving. Between one half and two thirds of pupils attended schools in which there were documented procedures relating to the acquisition and storage of mathematics equipment and materials, including distribution of materials across classes, procurement of equipment and materials, maintenance of an inventory of equipment and materials, and replacement of defective equipment. Over one half of pupils attended schools with policies on the organisation of teaching for mathematics (for example, grouping pupils for instruction), and on provision for pupils with learning difficulties in mathematics. Just under 1 in 4 pupils attended a school in which there was a documented policy on the provision of enrichment activities for advanced pupils in mathematics.

Just over one fifth of pupils attended schools in which no time was allocated to the teaching and assessment of mathematics at staff meetings during the 1998-99 school year (Table 4.2). On the other hand, just under one third of pupils attended schools in which between 6 and 10% of the time was allocated to discussion on this topic during staff meetings. Overall, the data in Table 4.2 indicate that relatively little time was devoted to discussing mathematics at staff meetings.

Table 4.2. Percentages of Pupils Attending Schools with Varying Proportions of Time at Staff Meetings Allocated to the Teaching and Assessment of Mathematics (1998-99 School Year)

	Percentage of Pupils *(Standard Error)*			
Percent of Time	Small Schools	Medium Schools	Large Schools	All Schools
None	30.77 *(8.66)*	25.00 *(8.09)*	15.79 *(5.28)*	22.78 (4.16)
1 to 5 pct	11.54 *(6.72)*	21.43 *(7.23)*	35.09 *(6.78)*	24.29 (4.14)
6 to 10 pct	34.62 *(10.89)*	28.57 *(8.48)*	28.07 *(6.14)*	30.33 *(4.91)*
11 to 20 pct	11.54 *(6.72)*	10.71 *(6.21)*	12.28 (4.57)	11.68 *(3.32)*
More than 20 pct	11.54 *(6.72)*	14.29 *(6.98)*	8.77 (3.93)	10.92 *(3.23)*

School Policy on Assessment of Mathematics

According to school principals, just over four-fifths of pupils attended schools with a policy on the regular administration of standardised, norm-referenced tests of mathematics. Small schools were somewhat less likely than large or medium schools to have a policy on the administration of standardised tests in mathematics.

[13] All pupils whose schools returned valid data were included in the analyses reported here, regardless of whether or not the schools had written a School Development Plan for teaching and learning Mathematics.

Over one half of pupils (53%) attended schools in which the progress tests that accompany mathematics textbooks were administered as a matter of policy. Such tests might be described as criterion-referenced in that test content relates specifically to what was covered during instruction, though administration and scoring procedures are less specific than in the case of standardised criterion-referenced measures such as the Department of Education tests developed in the late 1970's, and the outcomes cannot be compared with national standards.

Implementation of Parent Programmes

Principal teachers were asked to indicate whether or not their school offered a programme that supported parents in helping their children with mathematics at home. Just under 10% of pupils attended schools in which such a programme was provided, with large schools being more likely to offer a programme than either small or medium schools. The parents of 31% of pupils attending designated disadvantaged schools had access to such a programme. The corresponding percentage for pupils attending non-designated schools was 6%. The higher percentage in the case of designated schools may be accounted for by the activities of Home-School Community Liaison (HSCL) teachers who may be involved in the delivery of parent programmes in mathematics. Among the specific programmes offered by schools were:

- A class for parents on decomposition method of multiplication/division
- A programme for parents of pupils in the Junior classes
- A presentation on the mathematics curriculum and materials for parents each September
- A basic mathematics skills programme for parents

Comments Made by School Principals

School principals were asked to comment on issues relevant to the National Assessment of Mathematics Achievement in fourth class, including the teaching and learning of mathematics in schools. In all, 66 comments were made by 35 principal teachers. The comments of principals on the 1971 curriculum in mathematics related to the breadth of the curriculum (including a perceived overemphasis on computations involving fractions), the irrelevance of some content (e.g., long division), the need for more emphasis on Measurement and Shape and Space, the need for more emphasis on practical work in classes, and the difficulty of the curriculum for less able pupils.

Comments on teacher education mainly focused on the need for whole-school incareer development for teachers, while those relating to learning support called for the appointment of additional learning support teachers to deal with pupils' learning difficulties in the area of mathematics. Some principals indicated that adequate funding was available for equipment and resources; others called for additional direct funding. There were calls for improved materials for bridging the gap between conceptual understanding and independent problem solving. In relation to parent involvement in mathematics programmes, it was pointed out that some parents did not have adequate skills to become involved, whereas others did not demonstrate an interest. There were also calls for the Department of Education and Science to promote the implementation of parent involvement programmes in mathematics.

5. Teacher Variables and Mathematics Achievement

This chapter summarises findings based on teachers' views about the teaching of mathematics in schools. There are sections on the teachers' views of the adequacy of professional development, planning by teachers for mathematics lessons, classroom organisation, and curriculum coverage.

It is estimated that 27% of pupils in fourth class were taught by male teachers, while 73% are taught by female teachers. The average number of years of teaching experience of male teachers involved in teaching mathematics to pupils in fourth class was 20.72 (*SE* = 2.25). The average experience of female teachers was 17.74 years (*SE* = 2.38).

Preservice Teacher Education and Incareer Professional Development

While teachers were generally satisfied with the coverage of topics related to Number in their preservice teacher education courses, there was less satisfaction with Measures and Shape and Space, and least satisfaction with Algebra and Data and Chance. However, it must be acknowledged that Chance is a new area in the revised *Primary School Mathematics Curriculum*. Just 10% of pupils were taught by teachers who believed that the identification of learning difficulties in mathematics, classroom-based assessment of mathematics, and the interpretation of standardised test scores had been covered 'very well' or 'well' in preservice training.

Just under 30% of pupils were taught by teachers who had attended an incareer professional development course on the teaching of mathematics since the completion of preservice teacher education (Table 5.1). Pupils in designated schools (37%) were more likely than those in non-designated schools (28%) to be taught by a teacher who had attended an incareer development course. The perceived quality of incareer development courses in mathematics varied. Among teachers who had attended such courses, those working with 46% of pupils indicated dissatisfaction. Teachers' comments on incareer development highlighted a need for advice on working with multigrade classes and classes in schools designated disadvantaged.

Table 5.1. Percentages of Pupils whose Teachers Attended Incareer Professional Development Courses in the Teaching of Mathematics

Incareer Professional Development	Percent of Pupils *(SE)* Whose Teachers Attended
Since Completion of Initial Teacher Training	29.44 *(3.61)*
In the Previous Five Years	16.40 *(2.97)*
In Previous 12 Months*	3.33 *(1.09)*

*The survey took place in May, 1999

Planning for Teaching and Learning Mathematics

The vast majority of pupils were taught by teachers who reported that they prepared plans for teaching mathematics on an annual and/or a weekly/fortnightly basis. Teachers indicated that main sources of information they used in planning were pupils' textbooks and teacher manuals. Relatively few teachers reported drawing on the then current curriculum document (*Curaclam na Bunscoile*) or on school plans for mathematics. Almost one half of pupils were taught by teachers who met just once or twice a year with other teachers to discuss and plan the teaching and learning of mathematics, while one in four pupils was taught by a teacher who had never met with colleagues for these purposes.

Classroom Organisation

It is estimated that pupils in single grade fourth classes received an average of 268 minutes of instruction in mathematics each week, while pupils in fourth class in multigrade classrooms received an average of 229 minutes. The mean mathematics achievement score of pupils in single-grade fourth classes (M = 247.02, SE = 2.56) was somewhat lower than that the mean of pupils in multigrade classes (M = 253.54, SE = 3.68), though not statistically significant.

According to teachers, more than half of fourth class pupils in single-grade classes were grouped for mathematics teaching according to their ability. In multigrade classes, almost 7 in 10 pupils in fourth class were generally grouped by class level, though in some cases, pupils were grouped by achievement level within or across classes. More than half of the instructional time for mathematics across all classes was spent on whole class teaching, over a quarter of time on individual work, and less than 20% on small-group work.

Curriculum Coverage

During mathematics instruction, teachers placed considerable emphasis on teaching Number. Areas that received comparatively less emphasis included Problem Solving, Graphs, and Measurement. Geometry (Shape and Space), the content areas on which pupils did relatively poorly on the Test of Mathematics Achievement, received the least emphasis. It is likely that the relative emphasis that teachers (and indeed textbooks) placed on the various mathematical content areas and processes will change with the implementation of the revised *Primary School Mathematics Curriculum*, where there is less emphasis on Number and more on Measures and Shape and Space (Geometry) than in *Curaclam na Bunscoile*. However, such issues as the availability of appropriate mathematics equipment and the development of appropriate learning environments in which to use such equipment may also affect the allocation of time.

Teachers' Comments on the Teaching and Learning of Mathematics

In all, 47 comments were made by teachers. They commented that the then current (1971) mathematics curriculum was too crowded and that more time was needed to address all the areas adequately. In addition, they highlighted areas of the curriculum that they felt caused particular problems for pupils, such as long division, and areas that they felt should receive more attention, such as mental calculations and tables. Other comments made by teachers referred to limitations of preservice teacher education in such areas as teaching in mult-grade classrooms, working in schools designated as disadvantaged, and teaching children with specific learning needs. A perceived lack of incareer development and a lack of learning support in mathematics also drew some comment, as did high pupil-teacher ratios and a lack of funds to purchase mathematics materials. While some teachers called for the increased use of computers and calculators for the teaching of mathematics, a few urged that calculators not be introduced to primary schools and that computer software not be relied on for teaching mathematics.

6. Pupils' Home Backgrounds, Learning Characteristics, and Mathematics Achievement

This chapter addresses aspects of the home environments of pupils who participated in the 1999 National Assessment of Mathematics Achievement, based on information provided by their parents or guardians, who responded to a Parent Questionnaire. In addition, the chapter describes the learning characteristics of pupils who participated in the assessment, based on data provided by teachers who completed the Pupil Rating Form in respect of each pupil in their classes.

Parents' Educational Attainment

Each parent respondent was asked to indicate the highest level of examination taken by him/her, and by his/her partner, and these were interpreted as indicators of educational attainment.[14] The mean mathematics achievement of children increased in line with the educational attainment of their parents. For example, the mean achievement of pupils whose mothers had taken no examinations at second level (226) is statistically significantly lower than that that of mothers who had completed the Leaving Certificate examination (260) (Table 6.1). However, as the score ranges indicate, there were some children with very high achievement, and some with very low achievement, for each level of parent attainment.

Table 6.1. Pupils' Mean Mathematics Achievement Scores, by Educational Attainment of Female Parents

Educational Attainment	Children's Mathematics Achievement	
Female Parent	Mean* *(SE)*	Range of Scores
Primary Education/No exams taken at 2nd level	226.02 *(4.39)*	97.36 - 383.65
Group Certificate	238.98 *(3.12)*	106.00 - 368.10
Intermediate/Junior Certificate	242.05 *(2.62)*	93.62 - 366.52
Leaving Certificate	260.18 *(3.67)*	97.97 - 384.19
Diploma/Certificate	265.08 *(4.27)*	119.25 - 385.78
Degree	281.29 *(2.13)*	88.35 - 399.96
Parent's Education Missing	227.61 *(**)*	90.56 - 364.83

*Mean mathematics achievement score on TMA99
**Standard Errors were not calculated for pupils whose parents' education could not be specified (these include missing and 'other' responses to the parent education item).

There is a moderately strong correlation ($r = 0.32$, p. < .01) between female parents' educational attainment and their children's mathematics achievement, while the correlation between male parents' attainment and their children's achievement is 0.26 ($p < .01$). The correlation between the highest level of education attained by either parent/guardian and their child's mathematics achievement is 0.34 ($p. < .01$).

[14] The percentages of male and female parents in each category of educational attainment, and their standard errors, are reported in Tables 6.1 and 6.2 in the main report.

Economic Circumstances

Possession of a medical card may be taken as an indicator of economic circumstances. Over one quarter of parents of children in fourth class (26.89%; *SE* = 1.54) indicated that they held a medical card. There were statistically significant differences between the mean mathematics achievement scores of children whose parents held a medical card (*M* = 232.01, *SE* = 3.14) and those who did not (*M* = 259.53, *SE* = 2.25).[15] A similar finding emerged in the 1998 National Assessment of Reading, where pupils in fifth class whose parents held a medical card achieved a significantly lower mean reading achievement score than those who did not.

Access to Home Educational Resources

Less than half of parents (47.75%, *SE* = 2.54) indicated that a computer was available in the home for their child's use, while almost three-quarters (73.50%, *SE* = 1.18) indicated that a calculator was available. There are significant differences between the mean mathematics achievement scores of children who had access to computers and/or calculators and those who did not (Table 6.2). However, it is unlikely that these resources by themselves had an impact on mathematics achievement outside of their relationship with other factors such as economic circumstances and parent educational attainment, which also correlate strongly with mathematics achievement.

Table 6.2. Mean Mathematics Achievement Scores and Score Ranges of Children with Access to Computers and Calculators at Home

Resource Availability*		Test of Mathematics Achievement (TMA99)	
		Mean (SE)	Range of Scores
Computer	Yes	260.97 *(2.14)*	100.14 - 399.96
	No	239.98 *(2.47)*	88.35 - 377.01
Calculator	Yes	253.24 *(2.39)*	88.35 - 399.96
	No	241.01 *(2.89)*	90.56 - 366.56

Support with Homework

The vast majority of parents indicated that their children were assigned mathematics homework every day (61.23%, *SE* = 2.47) or three or four times a week (29.31%, *SE* = 1.66). Smaller percentages were assigned homework once or twice a week (7.78%, *SE* = 1.96), a few times a month (M = 1.28, *SE* = 0.54), or 'hardly ever or never'. There is no obvious relationship between the frequency assignment of mathematics homework and pupils' mathematics achievement, and indeed the correlation coefficient between the two is just .02, which is not statistically significant (p = .16).[16]

Almost 3 in 5 parents (58.67%, *SE* = 1.08) indicated that their children spent between 15 and 30 minutes doing homework when it was assigned. About one fifth (20.20%, *SE* = 1.45) said their children spent less time than 15 minutes; 18.29% (*SE* = 1.28) said that their child spent between 30 and 60 minutes, and 2.85% (*SE* = 0.47) indicated that their child spent more than an hour. Children who spent longer on mathematics homework had significantly lower mathematics achievement than children who spend shorter periods of time.[17] The correlation between time spent on homework and mathematics achievement is negative ($r = -.27$, $p < .01$).

15 See Table 6.9, Main Report
16 See Table 6.12, Main Report
17 See Table 6.11, Main Report

The child's mother (or female guardian) was the person most likely to provide help with mathematics homework (77.26%, *SE* = 0.09), followed by the father (or male guardian) (42.12, 1.22%) and either a brother or sister (19.36%, *SE* = 1.05). The majority of parents spent fewer than 15 minutes helping with their child's mathematics homework (Table 6.3). Fewer than one-fifth spent between a half and one hour, while a small proportion spent more than an hour. Parents of children in schools designated disadvantaged schools spent more time more time helping their children with mathematics homework than parents of children in non-designated schools.

There is a significant, though moderate, negative correlation ($r = -.45$; $p < .01$) between the amount of time that parents spend helping their child with mathematics homework and children's mean scores on the Test of Mathematics Achievement. This is the same type of relationship that exists between the amount of time that children spend on their mathematics homework and their mathematics achievement (see above). It appears that longer periods of time are spent on providing help with mathematics homework by the parents of children with lower mathematics achievement.

Table 6.3. Percentages of Pupils Receiving Help with Homework from Parents/Others with Varying Degrees of Frequency, and Associated Mean Mathematics Achievement Scores and Score Ranges

		Mathematics Achievement (TMA99)	
Amount of time	Percent of Pupils (SE)	Mean (SE)	Range of Scores
More than one hour	1.68 *(0.30)*	194.03 *(6.79)*	107.23 - 366.52
Between half and one hour	18.74 *(0.93)*	219.19 *(3.00)*	88.35 - 335.07
About quarter of an hour	30.68 *(0.89)*	242.25 *(2.76)*	99.42 - 352.70
A few minutes	41.79 *(1.07)*	268.62 *(2.14)*	132.29 - 399.96
None	7.11 *(0.57)*	289.28 *(4.48)*	135.60 - 385.78

More than three-fifths of parents (61.47%, *SE* = 1.56) indicated that their child's school had a policy on homework, while more than 1 in 10 (11.20%, *SE* = 0.93) indicated that their child's school did not. Over one quarter of parents (27.33%, *SE* = 1.06) indicated that they did not know if the school had a homework policy.

A review of international research on homework (Cowan and Hallam, 1999; Hallam and Cowan, 1998) leads to a number of observations. First, it is pointed out that, as in the case of the current study, much of the research has focused on the amount of time spent at homework, which, it is claimed, is 'at best a crude predictor of learning outcomes' (Hallam & Cowan, 1998, p. 20). Second, it is argued that while the case for the benefits of homework at second level has been established, the case at primary level has not. Third, it is pointed out that typically there is a low positive or negative correlation between the amount of time spent at homework at primary level and pupil achievement, but that, at second-level the correlation is stronger, because pupils may be assigned homework that is more commensurate with their ability.

7. Inspectors' Views on the Teaching of Mathematics

Inspectors involved in overseeing the administration of the National Assessment of Mathematics Achievement in fourth class were also asked to complete a short questionnaire about the teaching of mathematics in schools. In all, 47 inspectors responded to the questionnaire.

Approaches to Teaching Mathematics

Inspectors were asked about their views on a range of issues related to the teaching of mathematics (Table 7.1). Grouping of pupils by achievement level was seen by 70% of respondents as being an 'effective' or 'very effective' approach to developing pupils' competence in mathematics. Other approaches that were regarded as being at least as effective were using activity-based approaches for teaching mathematics concepts, discussing problems with the class before asking pupils to solve them, and teaching problem-solving strategies to pupils. Only one of the listed approaches, the daily use of workbooks, was viewed as not being a particularly effective strategy for developing pupils' mathematics competence. Indeed, 43% of respondents indicated it to be an ineffective strategy.

Table 7.1. Percentages of Inspectors Assigning Varying Ratings to the Effectiveness of Specified Instructional Approaches in Developing Pupils' Competence in Mathematics

Approach		Percent of Respondents			
	N	Very Effective	Effective	Somewhat Effective	Ineffective
Grouping pupils by achievement level	47	29.79	40.43	25.53	4.26
Activity-based approaches for teaching concepts	47	78.72	19.15	0.00	2.13
Daily use of maths workbooks	46	2.17	2.17	52.17	43.48
Daily review of number facts	47	27.66	57.45	14.89	0.00
Class discussion on word problems before pupils solve them independently	47	57.45	31.91	8.51	2.13
Teaching pupils problem-solving strategies	47	76.60	19.15	0.00	4.26

Teaching Mathematics Content Areas and Processes

A majority of inspectors indicated that the quality of teaching was either 'very satisfactory' or 'satisfactory' for one mathematics content area, Number, and for two mathematics processes, Understanding and Recalling Terminology, Facts and Definitions, and Implementing Mathematical Procedures and Strategies. On the other hand, teaching in such content areas as Shape and Space/Geometry, Measures, Algebra and Data Handling and Graphs was regarded as being less than satisfactory by a majority of inspectors. Teaching of some 'higher-order' mathematics processes such as Engaging in Mathematical Reasoning, Understanding and Making Connections between Mathematical Procedures and Concepts, and Analysing and Solving Problems and Evaluating Solutions was also viewed by a majority of inspectors as being in need of development.

Satisfaction with pupils' achievement was highest in the area of Number, with almost 87% of inspectors indicating that they were either 'very satisfied' or 'satisfied', and lowest in the area of Algebra, with 82% of inspectors indicating that they were 'somewhat satisfied' or 'dissatisfied'. Inspectors were more dissatisfied than satisfied with achievement in Shape and Space/Geometry and Data Handling and Graphs (though pupils did well in the latter area on TMA99). Four-fifths of inspectors were either 'very satisfied' or 'satisfied' with pupils' achievement on Understanding and Recalling while a slightly higher proportion (85%) expressed equivalent levels of satisfaction with achievement in the area of Implementing Mathematical Procedures and Strategies. On the other hand, inspectors were quite dissatisfied with pupils' performance in relation to higher-level mathematics processes. For example, over 90% indicated that they were 'somewhat satisfied' or 'dissatisfied' with pupils' performance in Engaging in Mathematical Reasoning. Inspectors were least satisfied with the achievement of pupils on Analysing and Solving Problems and Evaluating Solutions (51% 'dissatisfied') and Communicating and Expressing Mathematics Processes (39% 'dissatisfied').

Classroom Organisation for Teaching Mathematics

Inspectors were asked about the balance achieved between whole-class instruction, group work and individual work in the teaching of mathematics to pupils in fourth class in (a) single-grade classes and (b) multigrade classes. Exactly 50% of respondents indicated that they were 'dissatisfied' with the balance achieved between the different modes of organising learning in single-grade classes (Table 7.2). Respondents were somewhat more satisfied with the situation in multigrade classes, where grouping for instruction was, in any case, more common.

Table 7.2. Percentages of Inspectors' Indicating Varying Levels of Satisfaction with the Use of Whole Class Work, Group Work and Individual Work in Single Grade and Multigrade Classes

		Percent of Respondents			
Balance between Whole Class Work, Group Work and Individual Work in. .	N	Very Satisfied	Satisfied	Somewhat Satisfied	Dissatisfied
Single-grade Classes	46	0.00	17.39	32.61	50.00
Multigrade Classes	44	0.00	29.55	45.45	29.00

Use of Resources to Teach Mathematics

According to inspectors, the use of teaching resources/equipment was not extensive across mathematics content areas in general. However, it was observed to be particularly low in Shape and Space/Geometry and Measures – areas where use of an appropriate range of resources could serve to increase pupils' conceptual understanding and problem solving skills.

Two resources that are likely to be used more widely in the years ahead are calculators and computers. According to 94% of inspectors, the use of calculators in the teaching of mathematics was not extensive in fourth class. On the other hand, there is some evidence that computers were being used in the teaching of mathematics, with one quarter of respondents indicating that their use was either 'extensive' or 'somewhat extensive'.

Homework and Feedback on Work Completed

Inspectors were asked for their views on two aspects of homework – the amount of homework assigned to pupils in fourth class, and the level of feedback provided to pupils on their homework. Over 85% of respondents were 'very satisfied' or 'satisfied' with the amount of homework assigned to pupils. However, there was somewhat less satisfaction with the amount of feedback on homework given by teachers to pupils, with just over a quarter of inspectors indicating that they were either 'very satisfied' or 'satisfied'.

Assessment of Pupils' Mathematics Knowledge

Inspectors were asked about their satisfaction with the implementation of various strategies related to the assessment of mathematics in fourth class, including the provision of feedback on work completed in class. Whereas 45% of respondents were 'very satisfied' or 'satisfied' with the administration of standardised tests, just under a quarter expressed similar levels of satisfaction with the interpretation of standardised test results (Table 7.3). Respondents were also more dissatisfied than satisfied with the use of informal procedures for assessing mathematics, and with the use and interpretation of criterion-referenced mathematics tests, including the 'mastery' tests that accompany textbooks. Just over one quarter of respondents expressed themselves to be either 'very satisfied' or 'satisfied' with the level and quality of feedback given to pupils during classwork. Just one-fifth of respondents expressed similar levels of satisfaction with the amount and quality of feedback given to pupils in relation to work completed independently in class.

Table 7.3. Percentages of Inspectors' Indicating Varying Levels of Satisfaction with the Implementation of Specified Assessment Strategies in Mathematics

Assessment Strategy	Very Satisfied	Satisfied	Somewhat Satisfied	Dissatisfied
Administration of standardised tests	6.52	39.13	45.65	8.70
Interpretation of standardised test results	2.17	21.74	36.96	39.13
Use of informal assessment procedures (e.g., records of children's work kept on an ongoing basis; use of checklists, etc.)	2.13	21.28	36.17	40.43
Use and interpretation of criterion-referenced tests (including 'mastery' tests)	0.00	10.87	52.17	36.96
Quality of feedback given to pupils during classwork	2.17	23.91	60.87	13.04
Quality of feedback given to pupils on work completed independently during class	0.00	20.93	55.81	23.26

Planning for Teaching and Learning Mathematics

Inspectors were more dissatisfied than satisfied with aspects of whole-school plans dealing with the teaching of mathematics. On the positive side, the vast majority of inspectors were either 'satisfied' or 'somewhat satisfied' with the quality of individual teachers' annual or yearly plans for teaching mathematics.

Among the topics which inspectors felt should be covered incareer professional development courses for teachers were Algebra, Shape and Space, Data Handling and Graphs, Analysing and Solving Problems and Evaluating Solutions, assessing children's mathematics achievement, learning difficulties in mathematics, and effective use of computers/information technology in mathematics lessons. The content areas of Number and Measures, and processes involving Recalling Mathematical Terminology, Facts and Definitions, and Implementing Mathematical Procedures and Strategies were identified as requiring less attention.

8. Conclusions and Recommendations

In this chapter, conclusions and recommendations arising from the outcomes of the 1999 National Assessment of Mathematics Achievement are presented.

Conclusions

Pupils' Mathematics Achievement

As in earlier national and international assessments of mathematics achievement involving pupils in primary school, pupils performed better on items dealing with Number and Data Analysis than on items dealing with Measures and Shape and Space (Geometry), suggesting that these areas need to be strongly emphasised during implementation of the revised *Primary School Mathematics Curriculum*. Similarly, higher-level mathematical processes such as Engaging in Mathematical Reasoning and Analysising and Solving Problems and Evaluating Solutions need to receive particular attention.

The disparities in performance between pupils attending designated disadvantaged schools and those attending non-designated schools are quite striking, and indicate a need to address the low achievement of pupils in designated schools as a matter of urgency.

School Variables and Mathematics Achievement

Principal teachers considered a lack of learning support teaching to be a significant factor impeding the development of effective programmes in mathematics. This concern needs to be viewed in the context of principal teachers' dissatisfaction with the incareer training of teachers in mathematics education, and with a perceived shortage of instructional resources for teaching mathematics. The recently published *Learning Support Guidelines* (Department of Education and Science, 2000) offers suggestions for organising support services in schools so that the needs of pupils scoring at or below the 10th percentile on nationally-normed tests of achievement in English (or Irish) and mathematics are given priority, and an improved balance is achieved between provision of learning support in these curricular areas.

In many schools, the development and review of the school plan for mathematics needs to involve a broader range of persons in the school community, including management and parents (see *Developing a School Plan: Guidelines for Primary Schools*, Department of Education, 1999). In addition, the range of topics under discussion could be extended in some schools to include provision for pupils with learning difficulties, the development of problem solving strategies (across classes), and the provision of enrichment activities to higher-achieving pupils. Opportunities to incorporate these elements into school plans are likely to arise in the context of implementing the revised *Primary School Mathematics Curriculum.* It might also be expected that teachers would draw more often on the school plan in preparing their own teaching plans.

Finally, the provision of programmes for parents on aspects of the mathematics curriculum or of school policy on the teaching and learning of mathematics (including homework policy) could be increased, and would be beneficial to parents of children in all types of schools.

Teacher Variables and Mathematics Achievement

It is clear that many pupils are taught by teachers who have not participated in incareer professional development in the teaching of mathematics in the recent past; moreover, even when such courses have been accessed, their quality has been viewed by teachers as being uneven. There will be an increased emphasis on incareer development in mathematics in the context of the implementation of the revised *Primary School*

Mathematics Curriculum. It is likely that the mathematics content areas of Algebra, Shape and Space, and Data and Chance will receive considerable attention, and that the teaching of higher-level processes, including Reasoning and Analysing and Solving Problems, will be more strongly emphasised. Incareer development will also need to be informed by the needs identified by principal teachers, class teachers and inspectors. Areas of need identified in the current study include classroom-based assessment, the interpretation of standardised test results, the identification of learning difficulties in mathematics, the selection and use of computer software for teaching mathematics, and the teaching of mathematics in multigrade classes and classes in designated disadvantaged schools.

The matter of grouping pupils for mathematics continues to challenge schools and teachers. Indeed, inspectors in the current study expressed dissatisfaction with the balance achieved by teachers between whole-class teaching, group work and individual work in mathematics lessons. Yet, according to teachers themselves, just over one half of pupils in single-grade fourth classes were grouped for instruction. Clearly, this is an area in which some teachers may need additional support, particularly in the context of providing differentiated instruction to pupils with learning difficulties, and in implementing interactive problem-solving strategies outlined in the revised *Primary School Mathematics Curriculum.*

Home Background, Pupil Characteristics and Mathematics Achievement

Correlations between parents' educational attainment and children's mathematics achievement are, at best, only moderately strong, indicating that a range of other variables may play a role in developing children's mathematics achievement.

Although the amount of time spend by children doing mathematics homework, and the amount of time spent by parents providing help with mathematics homework, are negatively correlated with mathematics achievement, homework confers several benefits that are relevant to a child's progress in school, including development of home-school links, review and reinforcement of work carried out in class, parental involvement, enrichment and extension work, and the development of good study habits. It is important that parents are aware of the purpose of homework, and of strategies they can implement to support the schools' goals with regard to homework. The apparent willingness of parents of lower-achieving students to provide additional support with homework is noteworthy and is worth building on.

Learning Support and Learning Difficulties

There is a need for schools to extend the provision of learning support to pupils with very low achievement in mathematics, in line with the recent *Learning Support Guidelines* (Department of Education and Science, 2000). It is unclear whether this can be achieved by improving the balance between the provision in English (or Irish) and mathematics in schools by giving greater priority initially to those achieving at or below the 10th percentile on nationally-normed tests of achievement in either subject, or whether some other solution or combination of solutions is needed. It is likely, for example, that the provision of incareer development opportunities in such areas as the implementation of classroom assessments, and the identification of learning difficulties, will enable teachers to address the needs of at least some lower-achieving pupils.

Assessment of Mathematics

Many of the concerns about assessment that were expressed by principal teachers, class teachers and inspectors could be addressed through the provision of appropriate incareer development for teachers, while schools themselves can also play a role by encouraging the use a broad range of assessment tools, and enabling teachers to work collaboratively on identifying pupils' learning needs and providing appropriate instruction.

Research on Mathematics Achievement

Future assessments might include more qualitative approaches to studying how schools and teachers plan instruction in mathematics, and deliver instruction to pupils. Future assessments might also include some performance assessments tasks that involve the use of concrete materials and facilitate the assessment of a broader range of abilities including the communication of mathematical processes and outcomes.

Recommendations

The following recommendations are made with a view to increasing overall mathematics achievement, and improving the performance of lower-achieving pupils. These recommendations follow from a consideration of the outcomes of the current survey, and the findings of earlier international studies.

1. Schools and teachers should place a greater emphasis on the mathematical content areas of Measures and Shape and Space, in planning for and teaching mathematics.

2. Schools and teachers should place a greater emphasis on developing higher-order mathematics processes including Integrating and Connecting, Reasoning, and Analysing Problems and Evaluating Solutions, in planning for and teaching mathematics.

3. Schools and teachers should ensure that all pupils have access to and use a broad range of materials and equipment during mathematics lessons. Where necessary, teachers should be provided with support in the effective use of materials and equipment.

4. Schools should involve parents in meaningful communication on matters related to homework in mathematics by providing information on such matters as the purposes of homework, strategies for dealing with children's difficulties in mathematics in the context of homework, and the application of mathematics in everyday activities.

5. Schools should organise programmes to familiarise parents with the content and processes underlying the mathematics curriculum and the school development plan in mathematics, and suggest ways in which parents can help in the development of children's mathematical knowledge.

6. Teachers in schools and in clusters of schools should work cooperatively to plan learning experiences and assessment activities in mathematics, in the context of preparing school development plans, and implementing the revised *Primary School Mathematics Curriculum*.

7. In addition to addressing matters related to the implementation of the strands and skills in the revised *Primary School Mathematics Curriculum*, incareer development courses for teachers should address needs in a range of areas including:
    - classroom-based assessment;
    - the interpretation of standardised test results;
    - the identification of learning difficulties in mathematics;
    - the use of calculators in the teaching of mathematics;
    - the selection and use of computer software for teaching mathematics;

- teaching mathematics in multigrade classes; and
- teaching mathematics in classes in designated disadvantaged schools.

8. Incareer development courses on planning for and teaching mathematics should be provided to all teachers on an ongoing basis after initial in-service courses related to the implementation of the revised *Primary School Mathematics Curriculum* have been delivered.

9. Software selected to promote the teaching and learning of mathematics should include a variety of activities designed to develop pupils' conceptual knowledge and problem solving skills, in addition to 'drill and practice' activities.

10. The development and review of a school's plan for mathematics should be a collaborative activity involving all teachers in the school, the Board of Management, parents, and the wider school community. School plans for mathematics should include:
    - strategies for meeting the needs of pupils with learning difficulties
    - the systematic development of computation and problem solving skills across classes
    - the grouping of pupils for mathematics instruction
    - the procurement and purchase of materials and equipment, and
    - the provision of enrichment activities to higher-achieving pupils.

11. The Department of Education and Science should support schools in developing and implementing strategies to meet the needs of pupils with learning difficulties in mathematics, and in providing supplementary teaching (learning support) to pupils with very low achievement in mathematics, in line with current Department policy.

12. The apparent decline in mathematics achievement among Irish pupils' between fourth class (primary level) and second-year (post-primary level), revealed in a recent international study, should be investigated, and, if possible, addressed.

13. In planning for future national assessments of mathematics achievement, the availability and use of calculators in classrooms, as suggested in the revised *Primary School Mathematics Curriculum*, should be taken into account.

14. Future national assessments of mathematics achievement should include:
    - qualitative analyses of the processes underlying the planning for, teaching and learning of mathematics in schools;
    - the administration of a performance-based assessment that measures pupils' ability to communicate mathematical ideas, processes, and solutions to problems.

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Appendix 1: Performance of Pupils on Selected Items

In this appendix, descriptions of selected items are given for each of the five mathematics content areas assessed. The percentages of boys, girls and all pupils getting each item correct are also given, along with their standard errors.

Table A1. Mean Percent Correct Scores on Selected 'Number' Items, by Gender of Pupils

			Mean Percent Correct *(Std. Error)*		
Level	Description of Item	Format*	Boys	Girls	Total
Relatively Easy	Divide a two-digit number by a single-digit number (e.g., 56 ÷ 8)	SA	86.28 *(1.69)*	88.87 *(1.31)*	87.06 *(1.15)*
	Subtract a three-digit number from a four-digit number (e.g., 2273 – 294)	MC	82.64 *(1.68)*	81.91 *(1.57)*	82.29 *(1.16)*
	Solve a single step word problem that involves multiplying a three-digit number by a single-digit number	MC	75.36 *(1.61)*	84.06 *(1.37)*	79.62 *(1.18)*
More Difficult	Identify the fraction represented by the shaded area of a triangle	MC	63.82 *(2.56)*	58.87 *(2.42)*	61.41 *(1.81)*
	Indicate the best estimate when a three-digit number is divided by a two-digit number (e.g., 407 ÷ 19)	MC	55.81 *(3.05)*	55.95 *(2.67)*	55.88 *(2.15)*
Most Difficult	Estimate the answer to a one-step problem involving repeated addition/ division	SA	36.57 *(2.07)*	27.86 *(1.71)*	32.29 *(1.47)*
	Round a four-digit number to the nearest hundred	MC	32.80 *(2.00)*	24.33 *(1.90)*	28.67 *(1.51)*

*SA = Short Answer; MC = Multiple Choice

Table A2. Mean Percent Correct Scores on Selected 'Measure' Items, by Gender of Pupils

			Mean Percent Correct *(Std. Error)*		
Level	Description of Item	Format*	Boys	Girls	Total
Relatively Easy	Identify the greatest distance among four choices	MC	85.41 *(1.84)*	84.80 *(1.63)*	85.11 *(1.27)*
	Identify the appropriate unit for measuring the quantity of liquid in a bucket	MC	78.72 *(1.99)*	82.41 *(1.64)*	80.51 *(1.11)*
	Measure the length of an object in *cms* using a ruler	MC	77.69 *(1.77)*	71.60 *(2.10)*	74.69 *(1.39)*
More Difficult	Compute the change from £20 after purchasing three items at a cinema	SA	63.86 (2.96)	68.88 (2.64)	66.31 (2.10)
	Compute perimeter of a rectangle, given the length and width (diagram provided)	MC	64.51 (2.30)	61.52 (2.57)	63.04 (1.19)
	Solve a word problem involving the difference between two quantities of liquid	SA	56.71 (2.84)	57.54 (2.73)	57.11 (2.26)
Most Difficult	Compute length of time away from home, given departure and return times	MC	35.14 *(2.30)*	35.20 *(1.81)*	35.17 *(1.50)*
	Identify the shortest route (distance) between two towns on a map	SA	38.05 *(2.56)*	31.69 *(2.70)*	34.92 *(1.96)*
	Solve a word problem involving the distance around a rectangular playground, where length and width are given	SA	31.80 *(2.39)*	33.74 *(2.53)*	32.74 *(1.68)*

*SA = Short Answer; MC = Multiple Choice

Table A.3. Mean Percent Correct Scores on Selected 'Algebra' Items, by Gender of Pupils

			Mean Percent Correct *(Std. Error)*		
Level	Description of Item	Format*	Boys	Girls	Total
Relatively Easy	Identify the next three numbers in a sequence of natural numbers	MC	80.74 *(1.62)*	84.19 *(1.31)*	82.43 *(1.24)*
More Difficult	Identify the number sentence corresponding to a word problem	MC	65.38 *(1.68)*	65.59 *(2.20)*	65.48 *(1.35)*
Most Difficult	Define a mathematical symbol (>)	SA	30.95 *(2.21)*	32.07 *(2.24)*	31.50 *(1.68)*

*SA = Short Answer; MC = Multiple Choice

Table A4. Mean Percent Correct Scores on Selected 'Data/Chance' Items, by Gender of Pupils

			Mean Percent Correct *(Std. Error)*		
Level	Description of Item	Format*	Boys	Girls	Total
Relatively Easy	Complete a bar-line graph, based on the information provided	SA	80.54 *(2.31)*	86.07 *(1.65)*	83.26 *(1.60)*
	Identify the everyday event among four that was most likely to happen	MC	69.47 *(2.22)*	73.96 *(2.47)*	71.66 *(1.82)*
More Difficult	Identify, on a bar-line chart, the months on which the same number of children were born	SA	58.57 *(2.29)*	57.76 *(2.08)*	58.18 *(1.52)*
Most Difficult	Identify the number of different routes that can be taken when travelling between two towns on a map	MC	29.44 *(2.61)*	31.81 *(2.53)*	30.59 *(1.91)*

*SA = Short Answer; MC = Multiple Choice

Table A5. Mean Percent Correct Scores on Selected 'Shape and Space' Items, by Gender of Pupils

			Mean Percent Correct *(Std. Error)*		
Level	Description of Item	Format*	Boys	Girls	Total
Relatively Easy	Identify which of four cut outs folds to make an open box	MC	76.43 *(2.10)*	78.00 *(2.23)*	77.20 *(1.63)*
	Discriminate between the essential and non-essential properties of a triangle	MC	69.21 *(1.62)*	75.10 *(1.37)*	72.10 *(0.99)*
More Difficult	Identify whether a given angle is straight, right, obtuse or acute	MC	65.87 *(2.88)*	60.34 *(2.86)*	63.15 *(2.46)*
	Identify the number of faces on a given three-dimensional shape	MC	57.75 *(3.02)*	61.13 *(2.28)*	59.41 *(2.04)*
Most Difficult	Identify the lines of symmetry on a two-dimensional shape	SA	43.25 *(2.97)*	42.22 *(2.63)*	42.75 *(2.21)*
	Identify the number of edges on a given three-dimensional shape	SA	33.90 *(2.30)*	33.87 *(2.90)*	33.89 *(2.06)*

*SA = Short Answer; MC = Multiple Choice

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