Chapter 1. The Second International Assessment of Educational Progress

BACKGROUND TO THE ASSESSMENT

The Second International Assessment of Educational Progress (IAEP II) was an international comparative study of the achievements in mathematics and science of 9- and 13-year old students in 20 countries. IAEP II was a development of the First International Assessment of Educational Progress (IAEP I), which took place in 1988 (Lapointe, Mead, & Phillips, 1989).

In IAEP II, tests in mathematics and science were developed through a process of international consensus and co-operation, and were administered to representative samples of students in participating countries. Testing took place during the month of October 1990 for countries in the southern hemisphere and in March 1991 for northern hemisphere countries. The results of the study were published in two booklets, *Learning mathematics* (Lapointe, Mead, & Askew, 1992) and *Learning science* (Lapointe, Askew, & Mead, 1992), which summarize the results from an international perspective. While the general international perspective is valuable, it omits much that may be of interest to readers in a particular country. In this report, IAEP II results are presented with particular reference to Ireland and to the concerns of Irish readers. The general approach and many of the ideas have been adapted from the international booklets.

THE DESIGN OF THE SURVEY

The IAEP surveys were co-ordinated by the Center for the Assessment of Educational Progress, which is a division of Educational Testing Service, Princeton, New Jersey. Educational Testing Service is a private, not-for-profit corporation devoted to measurement and research in education. Funding for project co-ordination was provided by the US National Center for Education Statistics and the US National Science Foundation. Each participating country provided funding for project activities within that country. In Ireland, the IAEP surveys were conducted by the Educational Research Centre, St. Patrick's College, Dublin. Funding was provided by the Department of Education.

Following the success of IAEP I, representatives from 20 countries came together to design a survey that would yield comparative data on the mathematics and science achievements of their pupils, yet which could be implemented in a

timely and economical manner A fundamental prerequisite was that the project adhere to the highest standards of survey research

In addition to the usual requirements of survey research in the areas of sampling, administrative procedures and accuracy in data-processing, the IAEP II design paid particular attention to three issues that have important implications for the quality of international comparisons These were the extent to which the target populations were clearly defined and delimited, the suitability of the instruments used to measure pupil achievement and attitudes, and the impact of cultural and educational factors

Participating Countries

A total of 20 countries participated in some way in IAEP II (Figure 1 1) The core of IAEP II was a survey of the achievements of 13-year olds in mathematics and science A survey of the achievements of 9-year olds in mathematics and science was an option that was taken up by 14 of the participating countries There was also an optional short experimental survey of the geography achievement of 13-year olds (Lazer, 1992) and an optional experimental assessment of the ability of 13-year olds to perform practical tasks in mathematics and science (Semple, 1992) Ireland took part in the mathematics and science assessments at both age levels, and in the geography assessment, but not in the performance assessment

Target populations in participating countries were defined in terms of age to ensure a clearly defined basis for cross-national comparisons The 13-year old population was defined as all pupils born in the 1977 calendar year, and the 9-year old population as all pupils born in 1981 Although the project sampling design required that the target population in a participating country should consist of all pupils born in the appropriate year, in several countries it was necessary to further refine the definition of the population either to restrict it to some geographical areas of the country or to exclude particular sections of the desired population Although this report refers to countries, it should be remembered that in some cases (e g , China, Italy, Brazil) findings relate only to sections of the population

Nineteen countries participated in both mathematics and science at age 13 One additional country, Mozambique, participated in the mathematics assessment, also at age 13 For the purposes of reporting the results of the survey, the countries were divided into two groups, one consisting of comprehensive populations and one consisting of non-comprehensive or special populations

FIGURE 1.1

DESCRIPTIONS OF POPULATIONS

Country	Population in Survey
Brazil	Cities of São Paulo and Fortaleza only, restricted grades, in-school population
Canada	Four provinces at age 9 and 9 provinces at age 13 out of a total of 10 provinces
China	20 out of 29 provinces and independent cities, restricted grades, in-school population
England	All students, low participation at age 9 and age 13
France	All students
Hungary	All students
Ireland	All students
Israel	Hebrew-speaking schools
Italy	Province of Emilia-Romagna, low participation at age 9
Jordan	All students
Korea	All students
Mozambique	Cities of Maputo and Beira, in-school population, low participation
Portugal	Restricted grades, in-school population at age 13
Scotland	All students, low participation at age 9
Slovenia	All students
Soviet Union	14 out of 15 republics, Russian-speaking schools
Spain	All regions except Cataluña, Spanish-speaking schools
Switzerland	15 out of 26 cantons
Taiwan	All students
United States	All students

Countries with comprehensive populations were those that included all age-eligible pupils in the sampling for the study, even if the population was by definition restricted to a specific geographic region or particular language group. Included in this group were eight complete countries (France, Hungary, Ireland, Jordan, Korea, Slovenia, Taiwan, and the United States). For example, Ireland was included in the comprehensive population group because the target population included almost all 13-year olds, and because response rates were high. Also assigned to this group were seven populations that did not represent complete countries but were clearly defined and did represent all age-eligible pupils. These were Canada (all but one province at age 13 but just four provinces at age 9), Israel (pupils in public Hebrew-speaking schools only), Italy (the province of Emilia-Romagna only), Scotland, the Soviet Union (pupils in

Russian-speaking schools only in 14 out of 15 republics), Spain (pupils in Spanish-speaking schools except in Cataluña), and Switzerland (15 out of 26 cantons) The Italian province of Emilia-Romagna was regarded as a comprehensive population Although only 6% of Italian 13-year olds live in this region of Italy, the target population was the entire 13-year-old cohort in Emilia-Romagna

Six of the populations [China, England, Portugal, Brazil (São Paulo), Brazil (Fortaleza), and Mozambique] were considered special populations in IAEP II In these places a significant proportion of age-eligible pupils were systematically excluded from the target population This may have occurred because, for example, either not all grade levels containing 13-year olds were assessed, thereby ruling out some 13-year olds, or because some children were not in school In addition, countries where the participation of sampled schools and students was low (less than 70%) were classified as special populations England was included in this group because of low response rates from the selected schools The combined school and student participation rate in England was 47 percent This response rate was low in comparison with other countries in the study (in Ireland the figure was 90%) and introduces the possibility of bias due to selective non-response In the case of Portugal, 14% of 13-year olds who had dropped out of school were not represented in the study Additionally, 13-year olds were sampled from only some grade levels in the Portuguese school system Brazil included only 13-year olds in Grades 5 through 8 in the cities of Fortaleza and São Paulo In China, 13-year olds below Grade 7 and those not in school were excluded In Mozambique, only 13-year olds in the cities of Maputo and Beira were included

In the study of 9-year-olds, England, Scotland, Portugal, and Italy (Emilia-Romagna) were classified as special populations There was a low response rate from selected schools in England, Scotland, and Italy (Emilia-Romagna), whereas in Portugal, approximately one-fifth of 9-year olds were excluded from participation because they were not enrolled in either grades 3 or 4, the only grades from which 9-year olds were sampled in that country The remaining ten countries in the 9-year old survey provided comprehensive populations

Sampling Procedure

The sampling plan for the IAEP survey called for representative samples of 3,300 students from about 110 schools in each participating country at each age level The survey in Ireland assessed 13-year old and 9-year old students in ordinary classes in post-primary and primary schools Students in private

primary or special schools were not included. Students were selected for inclusion in the survey in two stages.

In the first stage of the sampling procedure, a sample of schools was selected for each age level, using probability-proportional-to-size sampling techniques. A comprehensive list of all schools in the country containing any age-eligible students was obtained and information about gender composition of students in the school, school size, and school type was matched to each school. In keeping with recommendations by the international co-ordinating group, a number of schools containing very small numbers of age-eligible students were deleted from the sampling frame in Ireland (International Assessment of Educational Progress, 1992). This occurred where fewer than six 13-year olds or fewer than five 9-year olds were on roll in a school. Five percent of 13-year old and 3% of 9-year old students were excluded for this reason. A sample of 116 (age 13) and 134 (age 9) schools was drawn in Ireland. Most schools agreed to participate.

In the second stage, principals of schools that were willing to participate supplied the Educational Research Centre with lists of age-eligible students along with information about age and other eligibility requirements necessary for monitoring and verifying the within-school sampling. Between 30 and 34 students in each school were selected in a random systematic manner by the Educational Research Centre and one half of the sampled students were assigned the mathematics test and the remaining half, the science test. These procedures resulted in 3,522 Irish 13-year old students in 110 schools being selected for inclusion in the study of which 3,311 actually took part, giving an overall response rate of 90 percent. The mathematics test was administered to 1,654 students while the remaining 1,657 took the science test. A similar process yielded 2,543 9-year olds located in 126 primary schools giving an overall response rate of 91 percent. Of these, 1,261 took the mathematics test and the remainder the science test. The numbers of schools and pupils assessed in Ireland, along with information on the co-operation rates achieved, are presented in Table 1.1. Table 1.2 provides a breakdown of the grade levels from which the samples were drawn.

Local conditions in some education systems meant that alternative sampling procedures were employed. For example, within each school in England and Switzerland, entire classes were sampled and all age-eligible students in a sampled class were included.

All participating students in a school were tested during one 90-minute session. Teachers in each school were responsible for the administration of the survey instruments (achievement tests and questionnaires) to pupils. At the same time, school principals completed a questionnaire designed to elicit information

about the school, its resources, and curricular provision Information about general educational policies and practices in Ireland was provided by the project co-ordinator for Ireland

TABLE 1 1

NUMBERS OF SCHOOLS AND PUPILS ASSESSED AND RESPONSE RATES

	Number of Schools Assessed	School Response Rate	Number of Pupils Assessed in Mathematics	Number of Pupils Assessed in Science	Pupil Response Rate	Overall Response Rate*
Age 9	126	94%	1 261	1 282	97%	91%
Age 13	110	96%	1 654	1 657	94%	90%

*Combination of the school response rate and the response (completion) rate of pupils sampled for assessment

TABLE 1 2

LOCATION OF SAMPLED PUPILS IN IRISH SCHOOL SYSTEM (PERCENTAGE DISTRIBUTION BY GRADE LEVEL

	Primary School Classes					Post-Primary Years	
	2nd	3rd	4th	5th	6th	1st Year	2nd Year
Age 9 Maths	2	57	40	0	0	0	0
Age 9 Science	3	59	38	0	0	0	0
Age 13 Maths	0	0	0	0	1	62	37
Age 13 Science	0	0	0	0	1	63	35

Note Percentages may not total 100 due to rounding

The Measures of Achievement

There is considerable variation across countries in the degree of emphasis that is placed on different areas of the curriculum If meaningful comparisons of student performance are to be made it is necessary to identify those aspects of the curriculum that are comparable across countries, and to base the assessment on these common areas In IAEP I it was found to be possible to reach consensus among participants on the suitability of a wide range of topics in both

mathematics and science. The experience gained in IAEP I was invaluable in developing the specifications for the IAEP II assessment. The procedure whereby representatives from participating countries developed frameworks for selecting objectives for assessment in each subject, and for developing questions to assess performance on these objectives, is described in detail elsewhere (Center for the Assessment of Educational Progress, 1991). The following is a summary of the procedure.

Taking the frameworks from IAEP I as a starting point, frameworks for objectives were developed by representatives of participating countries at a series of planning meetings. Frameworks were two-dimensional matrices with subject content categories along one dimension and subject skills categories along the other. Country representatives reviewed these frameworks and, after some discussion, adapted them to suit the IAEP II assessment. Curriculum specialists in each country then considered the frameworks and suggested weights for each content-by-skill cell of the matrix that would reflect the degree of emphasis placed on topics in that cell in the curriculum of that country. In mathematics, five content areas that typically form the nucleus of mathematics curricula in all participating countries were identified: Numbers and Operations; Measurement; Geometry; Data Analysis, Statistics, and Probability; and Algebra and Functions. Three cognitive skill levels that representatives of all participating countries agreed were taught in their schools were: Conceptual Understanding; Procedural Knowledge; and Problem Solving (Figure 1.2).

FIGURE 1.2

MATHEMATICS FRAMEWORK FOR 9- AND 13-YEAR OLDS

	Numbers and Operations	Measurement	Geometry	Data Analysis, Statistics, and Probability	Algebra and Functions
Conceptual Uncerstanding					
Procedural Knowledge					
Problem Solving					

The weights from each country were combined and consensus was reached on the weight to assign to each cell in designing the assessment (Tables 1 3 and 1 4) Participants then supplied questions that addressed the topics specified by the cells of the content-by-skills framework. More than 2,000 questions were reviewed and discussed Questions found to be acceptable in most countries were placed in a pool from which a set of questions that met the content-by-skills criteria was then selected

TABLE 1 3

WEIGHTS APPLIED TO MATHEMATICS SKILL CATEGORIES (PERCENTAGES)

Skill	Age 9	Age 13
Conceptual Understanding	35	33
Procedural Knowledge	35	33
Problem Solving	30	33

TABLE 1 4

WEIGHTS APPLIED TO MATHEMATICS CONTENT CATEGORIES (PERCENTAGES)

Content Area	Age 9	Age 13
Number and Operations	50	30
Measurement	15	15
Geometry	15	20
Data Analysis, Statistics and Probability	10	15
Algebra and Functions	10	20

Four content areas were used in designing the science test Life Sciences, Physical Sciences, Earth and Space Sciences, and Nature of Science Cognitive skill levels agreed were Knows Science, Uses Science, and Integrates Science (Figure 1 3) As in the case of mathematics, consensus was reached on the weights to be assigned to each skill and content area (Tables 1 5 and 1 6)

FIGURE 1.3

SCIENCE FRAMEWORK FOR 9- AND 13-YEAR OLDS

	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science
Knows Science				
Uses Science				
Integrates Science				

TABLE 1.5

WEIGHTS APPLIED TO SCIENCE SKILL CATEGORIES (PERCENTAGES)

Skill	Age 9	Age 13
Knows Facts, Concepts, and Principles	45	40
Uses Knowledge to Solve Simple Problems	35	35
Integrates Knowledge to Solve More Complex Problems	20	25

TABLE 1.6

WEIGHTS APPLIED TO SCIENCE CONTENT CATEGORIES (PERCENTAGES)

Content Area	Age 9	Age 13
Life Sciences	35	35
Physical Sciences	30	35
Earth and Space Sciences	20	15
Nature of Science	15	15

Appropriate questions were written and reviewed. Selected questions were then pilot-tested in all participating countries. The results of this testing were used to help select a final set of questions that reflected approximately the specifications of the frameworks, and which appeared to function adequately as test items in each country.

The final test in mathematics for 13-year olds contained 76 questions and the science test 72 questions. The tests for 9-year olds contained fewer questions: 62 in mathematics and 60 in science. About a quarter of the mathematics questions used

an open-ended format where students were required to write in the answer, the rest were multiple-choice All of the science questions were multiple-choice

ANALYSIS OF DATA

Percentage Correct

Results of the mathematics and science tests are presented as the mean percentage of correctly answered items in a country For each country, the percentage of correct answers to each test item was calculated By averaging across the individual item percentages, average percentage scores were obtained over entire tests (e g , mathematics at age 9) and over subsections of tests (e g , Numbers and Operations, Measurement, Conceptual Understanding) for each country Additionally, by restricting analyses to certain categories of students, average percentages correct were obtained for subsections of the sampled populations such as boys, girls, third class pupils, and first year students

Standard Error of the Estimate

Most of the sample statistics presented in this report are accompanied by their standard errors The standard error of a statistic is an indicator of the extent to which the sample statistic may be expected to vary about the true (but unknown) population value Statistics based on samples always contain some sampling error, the standard error is a quantification of this A confidence interval for a statistic (consisting of the region from two standard errors below the statistic to two standard errors above the statistic) may be constructed so that, if the sampling procedure were repeated a large number of times and the sample statistic recomputed on each occasion, the confidence interval would be expected to contain the population value in 19 samples out of 20

A variation on the jack-knife procedure (Mosteller & Tukey, 1977) was used to compute the standard errors presented in this report

Differential Item Functioning

Methods were used to identify test questions that might be particularly susceptible to cultural or linguistic misinterpretations by students and would therefore not provide a true and accurate picture of their mathematical and scientific abilities The main method used to detect such malfunctioning questions was the Mantel-Haenszel procedure Application of this procedure identified a small number of questions which were eliminated from the achievement tests because students of equal ability but from different

populations were found to have different probabilities of answering the questions correctly.

Comparison of Responses from Subpopulations

Because all sample statistics contain some sampling error, comparisons between such statistics must be made with care, since there is always a risk that any observed difference between two or more statistics is merely the result of the sampling procedure. Generally speaking, the use of large samples keeps the risk of sampling error to a minimum. However, even in large surveys such as IAEP II the question of sampling error is not negligible.

The larger a difference between two statistics, the less likely it is to be the result of sampling variation. Hence, the convention has been adopted of treating only differences above a certain magnitude as worthy of consideration, or as being 'statistically significant.' Just how large the difference between statistics should be in order to be considered statistically significant depends on how much sampling error is associated with the statistic (i.e., the magnitude of the sampling errors of the statistics).

A Z-test may be used to test the significance of the difference between two sample statistics. When the statistics are proportions calculated from subgroups of sample respondents the formula for the Z-test is:

$$Z_{ij} = |p_i - p_j| \sqrt{SE^2_i + SE^2_j}$$

where p_i and p_j are the sample properties of the two groups, i and j, and SE^2_i and SE^2_j are their squared standard errors. If the resulting Z_{ij} value is equal to or greater than 1.96, the difference is deemed to be statistically significant at the 5% level. This means that one would expect to find a Z greater than 1.96 because of sampling variation on just one occasion in 20, that is in 5% of samples.

RECOGNIZING CULTURAL DIFFERENCES

The Context of Achievement

The achievement results obtained from the IAEP survey need to be interpreted in light of the contexts in which they were obtained. Comparisons of educational performance across countries are complicated by variations in the cultural, educational, and social contexts in which students learn and achieve. To provide information on these contexts, students taking part in the study were asked to respond to a series of questions related to their experiences in school and at home. School principals also responded to a questionnaire regarding the life of the school. Project co-ordinators in each country provided information on the structure and functioning of their educational system. In addition, information

was obtained on national economic and demographic indicators which might help to provide a more complete picture of the backgrounds and contexts in which students in different countries learn

Although every effort was made to ensure that the assessment frameworks were acceptable to each country, inevitably there were areas where the match between a country's curriculum and the assessment frameworks was less than optimal Thus, use of the principle of consensus to guide item selection may result in certain aspects of the curriculum in a country not appearing in the international tests In the case of the IAEP I survey, topics omitted for 13-year olds included profit and loss, simple interest, VAT, co-ordinates, symmetry, and indices (Greaney & Close, 1989) In the subsequent IAEP II survey, principals of participating schools in each country were asked to indicate the degree of emphasis placed on various topics covered by the questions in the achievement tests The results of these ratings are presented in this report along with indicators of student performance to facilitate comparisons In addition, data such as those gathered concerning the structure and operation of schools can be useful in interpreting achievement results

Instruments Used to Gather Information on Context

The test booklets for 13-year olds were divided into six sections In both the mathematics and science versions, Parts 1 to 4 contained the achievement questions Part 5 consisted of either 24 (for students taking the mathematics test) or 22 (science) questions soliciting information on family background, student activities at home and at school, and opinions about the subject Part 6 of the mathematics booklet contained one half of the geography test, and Part 6 of the science booklet the other half Test booklets for the younger pupils consisted of five parts Parts 1 to 4 (achievement questions) and Part 5 (13 questions regarding pupils' backgrounds and attitudes)

A School Questionnaire was completed by the principal of each school Responses to 72 questions for post-primary school principals and 53 for primary school principals provided information concerning the structure of the school, duration of the school year, number of minutes of instruction per day, class size, the student body, teaching staff, facilities and equipment, and problems faced by the school Specific information was also gathered regarding the teaching of mathematics and science, including the time devoted to each subject per week

Chapter 2. Mathematics Performance of 13-Year Olds

STRUCTURE OF THE TEST

The mathematics test for 13-year olds was made up of 76 questions. One question (measuring students' knowledge of numbers and operations) was eliminated from the international analysis following preliminary analyses which indicated that it did not function in the same way across all populations. Student performance is based on the responses to the remaining 75 questions. The content covered by the test was categorized into five major topic areas as shown in Table 2.1.

TABLE 2.1

NUMBERS AND PERCENTAGES OF QUESTIONS BY TOPIC ON MATHEMATICS TEST (AGE 13)

	Numbers and Operations	Measurement	Geometry	Data analysis Statistics and Probability	Algebra and Functions	Total
Number of Questions	27	13	11	9	15	75
Percentage	36	17	15	12	20	100

OVERALL PERFORMANCE

In this section, the performance of Irish 13-year olds on the mathematics test is compared with that of their peers in the other participating countries. Results are presented in terms of overall performance in Table 2.2 and separately by topic in Table 2.3. Performance is defined in terms of the percentage of questions on the test or subset answered correctly.

The highest average performance on the mathematics test was achieved by 13-year olds in the People's Republic of China[1], who on average, answered 80%

1 The 13-year olds from China who participated in the assessment were selected mainly from urban areas, and are not typical of Chinese 13-year olds in general.

of questions correctly At the other extreme, 13-year olds from Mozambique[2] answered, on average, only 28% of questions correctly The samples of students in both China and Mozambique have been referred to as 'special populations' because the sampling procedures specifically excluded some sections of the target population

Among countries with comprehensive populations, that is, countries that included virtually all 13-year olds, those with the highest average performance are Korea and Taiwan with 73% correct, while the country with the lowest average performance is Jordan, with 40% correct In Ireland, students, on average, responded correctly to 61% of the mathematics questions This is just above the international average of 58 percent Other countries performing close to the international average are Scotland, England[3], and Slovenia.

Although countries may be ranked from highest to lowest in terms of their average scores, the difference between adjacent scores is sometimes so small as to be meaningless This is particularly so when the effects of sampling variability are taken into account. From an Irish perspective, participating countries can be divided into three groups on the basis of their average performance The first group consists of countries for which average mathematics scores significantly exceed the average for Irish students In this case, the magnitude of the difference is such that it is unlikely to be the result of sampling variability This group includes China, Korea, Taiwan, Switzerland, the Soviet Union, and Hungary Irish students perform at approximately the same level as students in France, Italy (Emilia-Romagna), Israel, Canada, England, Scotland, and Slovenia, which form the second group Although six of these countries appear above Ireland in a simple rank ordering of mean percentage correct (see Table 2 2), the differences between them are not statistically significant. Countries in the third group which, on average, performed less well than Irish students are Spain, the United States, Portugal, Jordan, and those parts of Brazil and Mozambique that were included in the survey

2 The target population from Mozambique included only students attending school in the cities of Maputo and Beira.

3 There was an unusually low response rate to the assessment in England, which may have introduced an unknown bias into the results

TABLE 2.2

AVERAGE PERCENTAGES CORRECT ON MATHEMATICS TEST: OVERALL SCORES AND SCORES ATTAINED BY STUDENTS AT 10TH AND 90TH PERCENTILES (AGE 13)

	Average Overall Score	Percentage correct attained by students at: 10th Percentile	90th Percentile
IAEP Average	58 (0.9)		
Comprehensive Populations			
Korea	73 (0.6)	41 (1.5)	96 (0.0)
Taiwan	73 (0.7)	35 (3.0)	97 (1.3)
Switzerland	71 (1.3)	51 (1.9)	93 (1.3)
Soviet Union	70 (1.0)	43 (0.8)	92 (0.0)
Hungary	68 (0.8)	39 (1.3)	93 (0.0)
France	64 (0.8)	37 (1.0)	89 (0.0)
Italy (Emilia-Romagna)	64 (0.9)	37 (1.5)	88 (0.0)
Israel	63 (0.8)	37 (0.2)	88 (2.6)
Canada	62 (0.6)	37 (0.0)	87 (0.0)
Scotland	61 (0.9)	35 (0.0)	87 (0.0)
Ireland	**61 (0.9)**	**33 (2.0)**	**87 (0.0)**
Slovenia	57 (0.8)	32 (0.1)	83 (0.2)
Spain	55 (0.8)	33 (2.0)	78 (0.8)
United States	55 (1.0)	29 (0.0)	83 (1.3)
Jordan	40 (1.0)	21 (1.5)	65 (3.1)
Special Populations			
China	80 (1.0)	57 (3.3)	96 (1.3)
England	61 (2.2)	35 (3.7)	89 (0.5)
Portugal	48 (0.8)	28 (0.5)	75 (0.9)
Brazil (São Paulo)	37 (0.8)	19 (0.9)	63 (0.7)
Brazil (Fortaleza)	32 (0.6)	17 (0.3)	57 (2.1)
Mozambique	28 (0.3)	19 (0.1)	45 (1.4)

Note. Standard errors are presented in parentheses.

In terms of overall mathematics performance then, 13-year olds in Ireland perform at approximately the same level as their peers in most of the other Western countries in the survey. Oriental and Eastern European students have higher average performance levels, while students from developing countries have lower performance levels.

DIFFERENTIAL PERFORMANCE OF HIGH AND LOW ACHIEVERS

An average score provides an indication of the performance of a group as a whole. It is also of interest to consider how much the 'best' Irish students know and can do in relation to the 'best' students in other countries as well as to

compare the weakest Irish students with the weakest groups in other countries To examine these issues, the performance levels corresponding to the 10th and 90th percentiles (i e , the bottom and top 10% of students) in all countries were calculated

The average score for all Irish students in the survey is somewhere in the middle range internationally Similarly, the scores of Irish students at the 10th and 90th percentiles are in the middle range, below countries such as China, Korea, Taiwan, and Switzerland, but above those such as Brazil and Mozambique The 90th percentile for Irish students (the score on the test above which the top 10% of students are to be found) is 87% of the questions answered correctly This is identical to that found in Scotland and Canada The 90th percentile in England and France is 89%, whereas for Swiss students it is 93 percent

The 10th percentile score for Irish students (the score at or below which the bottom 10% of students are to be found) is 33% of items answered correctly The scores corresponding to the 10th percentile in Canada and Scotland are 37% and 35% respectively The 10th percentile for Swiss students, however, is 51%, only 10 percentage points below the average score for all Irish students The figures for Switzerland indicate that in some way the Swiss education system performs well in equipping even its weakest 13-year olds with mathematics knowledge and skills compared to Ireland and all the other comprehensive populations that took part in this study

MATHEMATICS PERFORMANCE OF 13 YEAR OLDS BY GENDER

Boys in Ireland perform at a significantly higher level than girls, responding correctly to 63% of the mathematics questions, compared to 58% for girls This result differs from the 1988 IAEP I study, which showed little difference between boys and girls (Lapointe et al , 1989) This may be due partly to a change in the curriculum coverage of the mathematics test from IAEP I to IAEP II In the first survey, there was relatively more emphasis on computation, which seems to favour girls at this age (Martin, 1990), while in IAEP II, there was an attempt to include more questions on problem solving and fewer questions of a computational or procedural nature Ireland was not the only country to exhibit a gender difference in mathematics performance Significant differences in favour of boys are also found in Switzerland (4% difference), France (3%), Italy (Emilia-Romagna) (4%), Canada (2%), Spain (3%), China (3%), and Brazil (Fortaleza) (4%) However, the superiority of boys is not universal girls in the Canadian province of Newfoundland score significantly better than boys

In reply to a questionnaire item asking whether mathematics is more for boys or for girls in most countries, a high percentage of students said that mathematics is for boys and for girls about equally. Only in Korea, Taiwan, the Soviet Union, Jordan, and Mozambique did the percentage fall below 90. However, even though mathematics is perceived by a relatively large number of students in these countries to be gender-linked (16% to 44%), there was no significant difference in the mathematics performance of boys and girls in any of the five countries. In many countries that reported greater agreement about the appropriateness of mathematics for boys and girls, no achievement differences were found either (e.g., Scotland and the United States), though in some countries, whereas agreement about the suitability of mathematics for both genders was high, achievement differences were evident (e.g., Ireland and Canada)

MATHEMATICS PERFORMANCE OF 13-YEAR OLDS BY TOPIC

The test was composed of questions from five mathematics content areas or topics (see Table 2.1). These topics were Numbers and Operations; Measurement; Geometry; Data Analysis, Statistics, and Probability; and Algebra and Functions. In addition, each question was classified into one of three categories on the basis of the kinds of cognitive processes presumed to be required to answer the question correctly. The three categories were Conceptual Understanding, Procedural Knowledge, and Problem Solving. Although it is impossible to be sure of the nature of the cognitive processes brought to bear by individual students in responding to a question, an attempt was made to devise questions which demanded cognitive skills from each of the three categories. Figures in Table 2.3 show the average percentage of all questions on the test answered correctly by students in each country in the study as well as the average percentage correct in each of the five topic areas.

Table 2.4 provides a more detailed review of the performance of Irish students on the five topics compared to a selection of neighbouring European countries (England, Scotland, France, Spain, and Switzerland). In addition, considering the significant cultural and historical links between Ireland and North America, both the United States and Canada are included, as is Korea, a country where students have consistently performed well in international surveys. The Korean level of achievement provides an indication of the levels of knowledge and skills that are attainable by 13-year old children.

TABLE 2 3

AVERAGE PERCENTAGES CORRECT ON MATHEMATICS TEST OVERALL SCORES AND SCORES BY TOPIC (AGE 13)

	Overall	Numbers and Operations	Measurement	Geometry	Data Analysis Statistics and Probability	Algebra and Functions
IAEP Average	58	61	47	62	69	54
Comprehensive Populations						
Korea	73	77	60	77	81	71
Taiwan	73	75	64	77	81	69
Switzerland	71	74	62	77	82	63
Soviet Union	70	69	60	78	76	72
Hungary	68	69	55	73	76	70
France	64	65	53	73	79	57
Italy (Emilia-Rom)	64	64	63	75	72	53
Israel	63	65	47	66	75	65
Canada	62	66	50	68	76	53
Scotland	61	60	51	70	79	53
Ireland	**61**	**65**	**49**	**60**	**72**	**56**
Slovenia	57	62	43	63	64	52
Spain	55	60	38	60	68	52
United States	55	61	40	54	72	49
Jordan	40	43	32	44	46	38
Special Populations						
China	80	85	71	80	75	82
England	61	59	51	70	80	54
Portugal	48	52	32	49	69	43
Brazil (São Paulo)	37	41	24	34	50	36
Brazil (Fortaleza)	32	36	21	29	44	32
Mozambique	28	34	20	29	35	21

In Table 2 4, the average percentage correct attained by Irish students in each topic is used as a reference point The zero, plus, or minus entries in each cell indicate the relative average topic performance of Irish students compared to each population For example, the figure of zero in the cell corresponding to England and Overall indicates that there is not a statistical difference between the average overall scores of Irish and English 13-year olds The plus sign (+) in the next column indicates that Irish students obtained an average score on Numbers and Operations that is greater than that obtained by English children The minus sign (-) for Data Analysis, Statistics, and Probability for England shows that the average attainment of Irish students is below that of English students on that topic

TABLE 2.4

DIRECTION OF DIFFERENCE BETWEEN AVERAGE PERFORMANCE ON MATHEMATICS TEST OF IRISH STUDENTS AND PERFORMANCE OF STUDENTS IN SELECTED COUNTRIES (AGE 13)

	Overall	Numbers and Operations	Measure-ment	Geometry	Data Analysis Statistics and Probability	Algebra and Functions
England	0	+	0	0	-	0
Scotland	0	+	0	-	-	0
France	0	0	-	-	-	0
Spain	+	+	+	0	+	0
Switzerland	-	-	-	-	-	-
United States	+	+	+	+	0	+
Canada	0	0	0	-	-	0
Korea	-	-	-	-	-	-
IAEP Average	0	+	0	0	0	0

+ The average performance of Irish students is higher than that of other country
0 No statistical difference in average scores
- The average performance of Irish students is below that of other countries
Statistical difference calculations based on Bonferroni procedure (2.79 standard errors).

In the following sections, some sample questions from the test are included for each topic. In all items of the multiple-choice variety presented as part of this report, an asterisk beside an alternative denotes the correct response.

Numbers and Operations

At age 13, over one-third of the mathematics questions assessed pupils' understanding of numerical operations and of the concepts of number lines, place values, negative numbers, multiples, odd and even, fractions, decimals, percentages, and ratios. Students were required to add, subtract, multiply, and divide using whole numbers (including negative numbers), fractions, and decimals. Of the 27 questions used for scoring purposes on this topic, 12 assessed Conceptual Understanding, 8 assessed Procedural Knowledge, and 7 assessed Problem Solving. Both relatively difficult and relatively easy questions were included.

Irish students scored above the international level on Numbers and Operations, as denoted by the + sign in Table 2.4. Table 2.3 indicates that Irish students correctly answered 4% more items than the overall average.

While average overall mathematics performance of Irish students is close to the international average, Irish performance on Numbers and Operations (65%

correct on average) is significantly above the international average (61%, see Table 2 3) Irish students significantly outperform students in England, Scotland, Spain, and the United States on Numbers and Operations Their attainment is similar to that of French and Canadian students but lower than that of Swiss students, the European students with the highest average score on Numbers and Operations Irish students also score below students in the highest scoring comprehensive population, Korea The difference between Irish boys and girls in performance on Numbers and Operations is too small to be statistically significant.

The pattern of correct responses to the question shown in Figure 2 1 is typical for the topic as a whole This question, correctly answered by 57% of all students in the study, requires the translation of a fraction into a decimal There is no difference between the proportion of boys and girls answering the question correctly in Ireland

FIGURE 2 1

TRANSLATE A FRACTION INTO A DECIMAL

Topic Numbers and operations *Skill Procedural Knowledge*

Which of the following numbers is equal to $\frac{5}{8}$?

A 0 375
B * 0 625
C 0 75
D 1 6

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	72	41	41	62	63	77	56	58	85

Another question, requiring division by a mixed number, also shows a somewhat similar ranking of countries (Figure 2 2) Only one other question on the test was answered correctly by fewer students, making this one of the more difficult questions In Ireland, it was answered correctly by a higher proportion of boys than of girls

FIGURE 2.2.

SOLVING A PROBLEM REQUIRING DIVISION BY A MIXED NUMBER

Topic: Numbers and operations *Skill: Procedural Knowledge*

How many rolls of film can be processed in 15 minutes if it takes 1¼ minutes to process one roll?
Answer: _____

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	42	36	36	26	12	48	34	33	47

School principals were asked to indicate the degree of emphasis *(A lot, Some, Not at all)* placed on the various areas of mathematics for 13-year olds in their schools. There were five subtopics under the general rubric of Numbers and Operations. These were: whole number operations; common fractions; decimal fractions; ratio; and proportion and percentages. There was considerable variation both across countries and across subtopics in the degree of emphasis that was reported. A relatively high degree of emphasis was placed on Numbers and Operations in Irish schools. When aggregated across the five subtopics, the average rating of Irish principals was third highest of all the countries, with 63% reporting that such topics were 'emphasized a lot.' Only Spain (68%) and Hungary (65%) had higher ratings.

It may be noted that not all countries with a high level of performance on the overall mathematics test reported a heavy emphasis on Numbers and Operations. China (22% of schools emphasized Number 'a lot'), Korea (22%), and Taiwan (26%) all reported relatively low degrees of emphasis on this topic. On the other hand, Switzerland (62%) and Hungary (65%), countries that also had a good overall level of mathematics performance, reported a high degree of emphasis on Numbers and Operations. It is interesting also that England and Scotland, which had average levels of overall mathematics performance similar to Ireland but did not do as well on Numbers and Operations, both reported less emphasis on Numbers and Operations (39% for England; 49% for Scotland).

Measurement

The questions on Measurement examined students' understanding of and ability to apply basic measurement concepts. This included determining perimeter, area, volume, and surface area, primarily of squares, rectangles, cubes, and rectangular solids. Students were also required to convert from one

measurement unit to another within the same system (e g , metres to centimetres) The ability to read scale drawings was also assessed There were 13 measurement questions, 3 assessed Conceptual Understanding, 3 assessed Procedural Knowledge, and 7 assessed Problem Solving

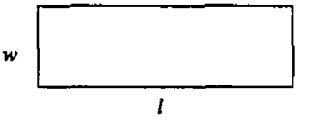
Irish students, on average, responded correctly to 49% of the Measurement questions (see Table 2 3), which was not significantly different from the international average Irish students did just about as well as students in England, Scotland, and Canada, and outperformed Spanish and American students However, their achievement was significantly below that evident in France, Switzerland, and Korea.

There was a clear difference between the performance of boys and girls on this topic, with the average performance of boys exceeding that of girls by 8 percentage points in Ireland Measurement questions show the biggest gender difference of all the mathematics topics for Irish students This may reflect the fact that over half the measurement questions (7 out of 13) require the student to engage in problem-solving, an activity in which boys appear to have an advantage over girls at this age level

FIGURE 2 3

SOLVING A WORD PROBLEM INVOLVING PERIMETER OF A RECTANGLE

Topic Measurement *Skill Problem Solving*



The distance around the rectangle above is exactly 12 metres The length of the rectangle is l metres and the width is w metres Which of the following could be the values of l and w?

A $l = 10$ $w = 2$
B $l = 8$ $w = 4$
C $l = 4$ $w = 4$
D * $l = 4$ $w = 2$

	Ireland	England	Scotland	France	Spain	Switz	US
% Correct	56	66	65	54	76	64	45

According to school principals, Measurement was emphasized 'a lot' with 13-year olds in just over half the Irish post-primary schools. Countries in which greater emphasis on the topic was reported were Italy (Emilia-Romagna) (90% 'a lot'), Switzerland (70%), England (63%), Scotland (57%), and Canada (53%). Again it is noticeable that the countries performing best on the overall test (China, Korea, and Taiwan) do not place a lot of emphasis on Measurement in the mathematics syllabus at this age level. Students in Taiwan, where only 9% of schools reported emphasizing Measurement, had an average achievement score of 64% on the topic, the highest score of all comprehensive populations.

The example question shown in Figure 2.3 asked students to pick a possible length and width for a rectangle of a given perimeter. The average percentage answering the question correctly over all countries was 44. In Ireland, there was no difference between the proportions of boys and girls that responded correctly to the question.

Geometry

Eleven questions on the test dealt with Geometry. These required students to demonstrate knowledge of properties of circles, rectangles, triangles, cubes, angles, and lines of symmetry. Students were also required to visualize geometric figures and to solve problems from classroom and real-life situations.

Irish students did not perform as well on Geometry questions as on other topics. Boys in Ireland outperformed girls on the Geometry questions (63% correct vs. 57% correct).

Though Irish students performed approximately at the overall mean in Geometry, they fared poorly in relation to most of their geographical and cultural neighbours. Their mean score was significantly below the means for students in Scotland, France, Switzerland, and Canada. The country with the highest score on the Geometry section was China, followed by the Soviet Union, Korea, Taiwan, and Switzerland. Irish achievement on the example question shown in Figure 2.4 (a problem involving the perimeter of a triangle) was roughly equal to the international average of 60% correct. No difference in response pattern was found between boys and girls.

Geometry was heavily emphasized in most of the high-performing countries. School principals in China (80%), the Soviet Union (83%), and Korea (67%) all reported a high degree of emphasis on this topic. Taiwan is an exception, where only 14% of principals reported that the topic was 'emphasized a lot.' The percentage of Irish principals (37%) who reported that Geometry was 'emphasized a lot' was lower than in most high-achieving countries and suggests

that less emphasis is placed on the topic in Irish schools than is placed on Numbers and Operations (63%) or Measurement (52%)

FIGURE 2 4

SOLVE A PROBLEM INVOLVING PERIMETER OF A TRIANGLE

Topic Geometry *Skill Problem Solving*

A triangle has two sides that are equal in length and a third side that is 3 cm long If the perimeter of the triangle is 19 cm, what is the length of one of the equal sides?

Answer _____

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	61	69	70	60	61	79	53	72	68

Data Analysis, Statistics, and Probability

There were just nine questions in the test relating to Data Analysis, Statistics, and Probability, amounting to 12% of the test. Students were required to read and interpret bar charts, line graphs, circle graphs, data tables, to compute an arithmetic mean, and to demonstrate an understanding of basic probability concepts There were three questions assessing Conceptual Understanding, five assessing Procedural Knowledge, and just one on Problem-Solving

The performance of Irish students on this topic was relatively the same as on the test as a whole Their average score did not differ significantly from the international average (see Table 2 4) The attainment of boys and girls was similar Several countries exhibited unusual performance levels on this topic France, Canada, Scotland, the United States, England, and Portugal all performed relatively better than would be expected on the basis of their overall performance In contrast, the Soviet Union, Slovenia, Jordan, Mozambique, and unusually, China, performed at a relatively lower level than on the test as a whole

Comparing average Irish attainment in Data Analysis, Statistics, and Probability with the international average on the topic may be misleading Information in Table 2 4 provides a more revealing comparison with selected individual countries From it, we can see that Irish pupils score below all but two of the Western countries in the group

Responses to the three questions based on the line graph in Figure 2 5 illustrate more clearly the position of Ireland compared to other countries Forty-seven percent of Irish principals reported that their schools emphasized

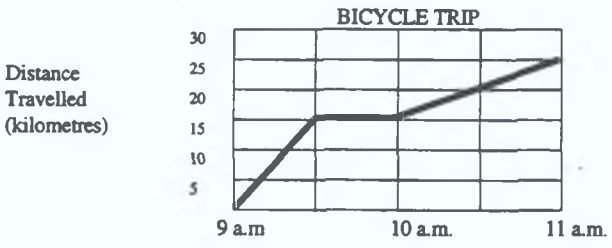
the tables and graphs component of this topic 'a lot.' Corresponding figures for probability and statistics were 3% and 28% respectively. It can be inferred, therefore, that tables and graphs are relatively important areas of study for Irish students at this age. In most other countries also, principals reported placing most emphasis on tables and graphs. An exception was Korea, where 53% of principals reported that probability was emphasized 'a lot.'

FIGURE 2.5.

INTERPRET DATA FROM A LINE GRAPH

Topic: Data Analysis, Statistics, and Probability *Skill: Procedural Knowledge*

Questions 10-12 refer to the following graph, which shows how far a person rode on a bicycle and how long it took.



10. How many km did the person ride altogether?

Answer: _____ km

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	71	88	90	77	67	84	68	72	88

11. For how many minutes did the person stop during the trip?

Answer: _____ minutes

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	57	76	76	78	44	72	56	62	81

12. How many km did the person ride in the last half-hour of the trip?

Answer: _____ km

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	65	80	77	73	58	70	65	71	61

Algebra and Functions

There were 15 questions in the test dealing with Algebra and Functions (i e , 20% of the test) These questions required pupils to demonstrate an understanding of algebraic and functional concepts and to use those concepts to solve problems involving formulae, verbal descriptions, diagrams, and tables Students were required to express relationships in equations, to substitute numbers for variables, and to solve formulae for one variable

Once again, the performance of Irish students reflected their overall level of performance They performed roughly at the same level as other Western European countries in the study, with the exception of Switzerland, where students answered more questions correctly Boys in Ireland performed better on this topic than girls (58% versus 53% correct) Students from China, the Soviet Union, Hungary, and Israel performed better on this section of the test than they did on the test as a whole, while their peers from Italy (Emilia-Romagna), Canada, and Mozambique performed below their overall standard

Several of the countries with a high level of performance on the overall mathematics test reported a high degree of emphasis on Algebra and Functions in their curricula This was particularly true of China (93% 'a lot'), the Soviet Union (96%), Hungary (90%), and Korea (86%), although Switzerland, with an average emphasis of only 23%, was an exception to this trend In Ireland, the percentage of principals who reported that Algebra and Functions were emphasized 'a lot' was 67%, which may be compared to 93% in Spain, 82% in France, 53% in England, and 46% in Scotland

FIGURE 2 6

TRANSLATE FROM A VERBAL DESCRIPTION INTO AN ALGEBRAIC EQUATION

Topic Algebra and Functions *Skill Conceptual Understanding*

When seven times a number is increased by six the result is forty-one Which of the following equations represents this relationship?

A * $7n + 6 = 41$
B $7n - 6 = 41$
C $7n \times 6 = 41$
D $7(n + 6) = 41$

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	54	47	49	56	53	59	57	49	78

MATHEMATICS PERFORMANCE OF 13-YEAR OLDS BY COGNITIVE PROCESS

The questions in the mathematics test were designed to require one of three levels of cognitive processing: Conceptual Understanding, Procedural Knowledge, and Problem Solving. About one-third of the questions belong in each category.

Questions demanding Conceptual Understanding require students to exhibit an understanding of mathematical facts and concepts, including number facts; properties of measurement; geometry concepts; properties of charts, graphs, and tables; concepts of statistics and probability; and the conventions of algebraic expressions and equations. Procedural Knowledge questions involve the application of knowledge and concepts to completing routine tasks, typically following standard procedures taught in the classroom. Problem-Solving questions require students to use their reasoning and analytic abilities in unique situations, often in several steps.

Irish 13-year olds performed at about the same level on questions of Conceptual Understanding, Procedural Knowledge, and Problem Solving as on the test as a whole. In each case, the average for Irish students is close to the international average. In Ireland, boys outscore girls on questions requiring Conceptual Understanding and Problem Solving. The difference between boys' and girls' scores in Procedural Knowledge is not statistically significant.

CONCLUSION

Results of the survey suggest that the average achievement level in mathematics of Irish 13-year olds is somewhere in the middle of the countries that participated in the study. The scores of the most and the least mathematically able Irish students are in the middle range also. When compared with the eight countries selected for special analysis in this report, Irish students seem relatively strong in Numbers and Operations but weak in Geometry and in Data Analysis, Statistics, and Probability. Students in China, Korea, Taiwan, Switzerland, the Soviet Union, and Hungary achieve at levels significantly above those found in Ireland and thereby give some indication of the levels of mathematics knowledge and skills that 13-year olds are capable of attaining.

Boys tend to have higher scores than girls in Ireland across topic areas and skill domains with the exception of Numbers and Operations, Data Analysis, Statistics, and Probability, and Procedural Knowledge. Much curricular emphasis in Ireland was reported on Numbers and Operations with more moderate emphasis on Measurement and Data Analysis. With some exceptions, countries where students perform well on the overall test tend to stress Geometry

and Algebra and Functions while placing less emphasis on Numbers and Operations and Measurement In Irish schools, the opposite situation seems more common

Chapter 3. Mathematics Performance of 9-Year Olds

STRUCTURE OF THE TEST

The mathematics test for 9-year olds consisted of 62 questions, one of which was eliminated from further analysis when it was found that it did not function in the same way across all populations. Consequently, summary statistics presented in this chapter are based on responses to 61 questions. The questions in the test were subdivided into the same five content areas as the version administered to 13-year olds. The relative emphasis across topics was different, however, with more emphasis on Numbers and Operations and less on Geometry and on Algebra and Functions. Table 3.1 shows the distribution of questions across the five content areas.

TABLE 3.1

NUMBERS AND PERCENTAGES OF QUESTIONS BY TOPIC ON MATHEMATICS TEST (AGE 9)

	Numbers and Operations	Measure-ment	Geometry	Data Analysis, Statistics, and Probability	Algebra and Functions	Total
Number of Questions	32	9	6	8	6	61
Percentage	52	15	10	13	10	100

OVERALL PERFORMANCE

Pupils were assessed in mathematics at age 9 in 14 countries. Countries in which comprehensive populations were sampled at this age level included Ireland, Spain, Hungary, Slovenia, the Soviet Union, Israel, the United States, Canada, Korea, and Taiwan.

Countries in which comprehensive populations were not sampled ('special populationsn') at the 9-year old level included England, Scotland, Portugal, and Italy (Emilia-Romagna). In Portugal, children in only some grades were assessed, thereby excluding some 9-year olds. In England and Scotland, almost all age-eligible children were targeted in the sample, but only 56% of English and 62% of Scottish schools agreed to participate. Similarly in the case of

Emilia-Romagna in Italy, though almost all 9-year olds were included in the population, only 65% of principals were willing to allow the survey to proceed in their schools In contrast, 94% of Irish schools participated

Irish 9-year olds responded correctly on average to 60% of the mathematics questions, just below the international average of 63% (see Table 3 2) The highest average score attained on the test was by pupils in Korea, the lowest by Portuguese pupils As was the case with the test for 13-year olds, it is possible to identify three groups of countries based on average mathematics achievement those whose average performance is above that of Irish pupils, those performing at the same level, and those performing below the average level of Irish pupils

TABLE 3 2

AVERAGE PERCENTAGES CORRECT ON MATHEMATICS TEST OVERALL SCORES AND SCORES ATTAINED BY PUPILS AT 10TH AND 90TH PERCENTILES (AGE 9)

	Average Overall Score	Percentage correct attained by students at 10th Percentile	90th Percentile
IAEP Average	63 (0 9)		
Comprehensive Populations			
Korea	75 (0 6)	51 (4 6)	93 (0 0)
Hungary	68 (0 6)	41 (1 2)	90 (2 5)
Taiwan	68 (0 8)	41 (1 8)	92 (1 7)
Soviet Union	66 (1 3)	38 (0 7)	90 (0 7)
Israel	64 (0 7)	39 (3 1)	87 (2 1)
Spain	62 (1 0)	33 (2 0)	87 (0 0)
Ireland	**60 (0.8)**	**31 (1.5)**	**85 (3 9)**
Canada	60 (0 5)	36 (1 5)	84 (0 0)
United States	58 (1 0)	30 (2 1)	84 (0 0)
Slovenia	56 (0 6)	34 (0 8)	79 (0 3)
Special Populations			
Italy (Emilia Romagna)	68 (0 9)	43 (0 3)	90 (1 7)
Scotland	66 (0 9)	39 (2 8)	90 (4 6)
England	59 (1 9)	33 (0 5)	87 (2 5)
Portugal	55 (0 9)	32 (0 8)	82 (2 6)

Note Standard errors are presented in parentheses

In the top group are Korea, Hungary, Taiwan, Italy (Emilia-Romagna), the Soviet Union, Scotland, and Israel Fifteen percentage points separate the

average mathematics scores of pupils in Ireland and Korea. Three of the countries in the top group, Italy (Emilia-Romagna), Scotland, and Israel, have superior average performances at the younger age level but not among 13-year olds. The second group consists of Spain, Ireland, Canada, England, and the United States. Two countries, Slovenia and Portugal, display average scores below that of Irish pupils.

DIFFERENTIAL PERFORMANCE OF HIGH AND LOW ACHIEVERS

The 90th percentile score for Irish pupils (the score on the test above which the top 10% of pupils are to be found) is 85 percent. This is roughly equivalent to those for England, Spain, Canada, and the United States. Across all countries, the 90th percentile is 87% correct; thus, Ireland lies slightly below the overall figure. As shown in Table 3.2, high achieving Scottish and Hungarian pupils do particularly well, with a 90th percentile score of 90% while the 90th percentile for Korean pupils is 93% of the questions. The score corresponding to the 10th percentile (the score at or below which the bottom 10% of pupils are located) is 31% in Ireland, 6 points below the average. Pupils in Korea at the 10th percentile correctly answer slightly more than half the questions on the test.

MATHEMATICS PERFORMANCE OF 9-YEAR OLDS BY GENDER

The performance of boys is not, in general, superior to that of girls at the 9-year old level. In only three countries, Korea, Italy (Emilia-Romagna), and Israel, do boys perform significantly better than girls. Irish boys do no better than girls, a finding that holds across all topics. The average number of correct answers for girls is actually higher than that for boys on the overall test in two content categories, Measurement, and Data Analysis, Statistics and Probability, and in two process categories, Conceptual Understanding and Procedural Knowledge. However, none of these differences is statistically significant.

There was a high degree of agreement among pupils with the statement that 'Mathematics is for boys and girls about equally' in almost all countries. Only in Korea did substantial numbers disagree, with 25% considering mathematics more for boys, and 27% more for girls. Korea also has the largest difference in overall average score between boys and girls (77% vs. 72%). In Ireland, 10% of pupils considered mathematics to be more for boys and 7% said that it was more for girls.

MATHEMATICS PERFORMANCE OF 9-YEAR OLDS BY TOPIC

The questions in the test for 9-year olds were classified by content and process categories in the same way as those at the 13-year old level. There is

proportionately more emphasis on Numbers and Operations at the younger age level, with 52% of the questions in this category, than at age 13, where 36% of questions fall in this category This increase is offset by a corresponding decrease in emphasis on questions on Algebra and Functions (20% at age 13 down to 10% at age 9), and on Geometry (15% down to 10%) Average pupil performance for all countries in the different topic areas is presented in Table 3 3

For comparative purposes across topic areas, the same countries are used as were used in the comparison among 13-year olds, with the exception of France and Switzerland which did not participate in the survey at the younger age level In Table 3 4, as in Table 2 4, the average scores of Irish pupils are taken as a reference point in each topic, and the pluses, zeros, and minuses indicate countries in which pupils performed less well, equally, or better than Irish pupils, respectively Percentage correct figures for each topic may be found in Table 3 3

TABLE 3 3

AVERAGE PERCENTAGES CORRECT ON MATHEMATICS TEST
OVERALL SCORES AND SCORES BY TOPIC (AGE 9)

	Overall	Numbers and Operations	Measure-ment	Geometry	Data Analysis Statistics and Probability	Algebra and Functions
IAEP Average	63	61	67	64	68	62
Comprehensive Populations						
Korea	75	75	73	75	79	72
Hungary	68	68	72	69	63	72
Taiwan	68	67	69	69	73	64
Soviet Union	66	66	71	64	60	68
Israel	64	64	70	59	64	67
Spain	62	61	61	60	69	58
Ireland	**60**	**58**	**64**	**58**	**65**	**59**
Canada	60	55	65	65	72	56
United States	58	54	63	60	73	55
Slovenia	56	53	62	63	54	58
Special Populations						
Italy (Emilia Rom)	68	67	73	65	71	61
Scotland	66	62	71	69	74	63
England	59	54	67	67	70	57
Portugal	55	54	58	56	57	55

TABLE 3.4

DIRECTION OF DIFFERENCE BETWEEN
AVERAGE PERFORMANCE ON MATHEMATICS TEST OF IRISH PUPILS AND
PERFORMANCE OF PUPILS IN SELECTED COUNTRIES (AGE 9)

	Overall	Numbers and Operations	Measure-ment	Geometry	Data Analysis Statistics and Probability	Algebra and Functions
England	0	0	0	-	-	0
Scotland	-	-	-	-	-	0
Spain	0	0	+	0	-	0
United States	0	0	0	0	-	+
Canada	0	+	0	-	-	0
Korea	-	-	-	-	-	-
IAEP Average	-	0	-	-	0	0

+ The average performance of Irish pupils is higher than that of other country
0 No statistical difference in average scores
- The average performance of Irish pupils is below that of other country
Statistical difference calculations based on Bonferroni procedure (2.62 standard errors)

In general, the performance of Irish 9-year olds on questions from the individual content areas reflects their overall level of performance. However, when compared only with the countries shown in Table 3.4, it is evident that Irish pupils are relatively weak in Geometry and in Data Analysis, Statistics and Probability. In addition, their achievement is lower than Scottish pupils in all but Algebra and Functions, and than Korean pupils in all areas.

Numbers and Operations

Over half of the questions on the test for 9-year olds measured pupils' understanding of numbers and their application in computation and estimation and in life-like situations. Approximately 40% of the third class mathematics syllabus in Ireland is devoted to this general topic, an emphasis that is roughly the same as in England, Scotland, Spain, and the United States (Center for the Assessment of Educational Progress, 1991).

Irish pupils scored approximately at the international average on this topic, as denoted by the 0 in Table 3.4. Irish pupils responded correctly to more questions on Numbers and Operations than Canadian children but did not achieve at as high an average level as children in Scotland or Korea.

Two of the questions that were used in calculating the percentage correct scores for Numbers and Operations are shown in Figures 3.1 and 3.2, along with the percentages of pupils in selected countries that answered them correctly. The question in Figure 3.1 was designed to measure pupils' conceptual understanding of common and decimal fractions. Fifty-two percent of Irish pupils answered the question correctly, substantially more than in England, Scotland, the United States, or Canada. Boys and girls in Ireland answered the question correctly in equal proportions.

FIGURE 3.1.

TRANSLATE A FRACTION WITH DENOMINATOR 10 INTO DECIMAL FORM

Topic: Numbers and Operations *Skill: Conceptual Understanding*

Which of the following decimals is equal to $\frac{9}{10}$?

A. 0.1
B. 0.3
C.* 0.9
D. 9.0

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	52	30	39	60	32	33	77

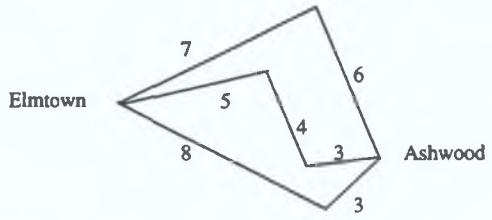
The example in Figure 3.2 required pupils to select between three competing routes from one town to another on a schematic map using the criterion of shortest distance. The task required the addition of whole numbers, followed by a comparison of numbers of different magnitudes. Less than a quarter of Irish pupils supplied the correct answer (11 km). In no other country was such a low score recorded. Boys were more successful than girls in the Irish sample.

School principals in most countries, including Ireland, indicated a high level of emphasis on whole number operations for this age group (93% indicated that the topic was emphasized 'a lot' in Ireland). Irish schools are unusual in the degree of emphasis placed on the other two subtopics, common fractions and decimal fractions. Their emphasis was exceeded only in the Italian province of Emilia-Romagna.

FIGURE 3.2.

FROM A MAP, CALCULATE THE LENGTH OF THE SHORTEST ROUTE BETWEEN 2 TOWNS

Topic: Numbers and Operations *Skill: Procedural Knowledge*



The figure above shows three different routes between two places, measured in km.
How long is the shortest of these routes?

Answer: _____

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	24	34	34	39	31	39	47.

FIGURE 3.3.

TOPIC EMPHASIS IN THIRD CLASS MATHEMATICS

To what extent are the following topics emphasized in third-class mathematics classes in your school?

	A lot	Some	Not at all
Whole number operations	93	7	0
Common fractions	50	48	1
Decimal fractions	37	57	6
Measurement (such as length, width, and area)	47	53	0
Geometry (such as shapes and solid figures)	22	75	3
Tables and graphs	53	47	0

Note. Numbers in Figure 3.3 refer to the percentages of Irish principals who indicated different degrees of emphasis on subtopics. Percentages may not add to 100 due to rounding.

Measurement

The Measurement questions tap understanding of basic measurement concepts and their application in typical classroom and real-world situations.

Questions require pupils to work with units of temperature, time, and length, as well as to complete patterns There are nine measurement questions four assessing Conceptual Understanding, four Procedural Knowledge, and one Problem Solving Irish schools appear to pay relatively less attention to Measurement than to Numbers and Operations in third class Only 47% of principals reported emphasizing Measurement 'a lot' as opposed to 93% for whole number operations Interestingly, few of the high-achieving countries report much emphasis on Measurement in the modal grade level for 9-year olds For example, in Korea, only 32% of principals indicated that Measurement is emphasized 'a lot' On the other hand, in Italy (Emilia-Romagna), where students also did well on this section of the test, 97% of principals stated that the topic was emphasized 'a lot.'

Irish pupils scored on average 3 percentage points below the mean over all countries in Measurement It can be inferred that they have about the same knowledge and understanding of measurement concepts as children in England, the United States, and Canada As was the case with Numbers and Operations, Irish performance in measurement is significantly below that in Scotland and Korea. On the question shown in Figure 3 4, the average percentage correct over all countries is 55 which is close to the Irish mean score of 53 The number of pupils internationally who answered the question correctly was lower than for most of the other measurement questions Irish boys and girls responded correctly to the question in equal proportions

FIGURE 3 4

TRANSLATE A FRACTION WITH DENOMINATOR 10 INTO DECIMAL FORM

Topic Measurement *Skill Procedural Knowledge*

The distance around a square is 20 cm What is the length of one side of the square?

A 2 cm
B 4 cm
C * 5 cm
D 10cm

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	53	58	63	39	48	46	69

Geometry

Questions in Geometry assess pupils' knowledge of geometric figures and relationships, as well as skills in working with this knowledge. The six Geometry questions concentrate on pupils' understanding of symmetry and of two- and three-dimensional shapes. Given that there seems to be relatively little emphasis on Geometry in third classes (22% said 'a lot') in Irish schools, we should not be surprised if pupils do not do very well on questions involving shapes and solid figures. This proved to be the case. Irish pupils responded correctly to 58% of the questions, 6 percentage points below the over-all mean. English pupils also received relatively little instruction in geometry (31% said 'a lot') at age 9 in comparison to whole number operations (91%) and Measurement (63%). They did, however, correctly answer 67% of the Geometry questions, making their performance on this topic relatively superior to their overall performance.

Pupils in England, Scotland, Canada, and Korea did better than Irish pupils on the Geometry items whereas Spanish and American pupils did just about the same. This general pattern is reflected in responses to the question presented in Figure 3.5, which requires the identification of a rectangle from a two-dimensional sketch. This question was answered correctly by a greater percentage of pupils (92%) than any other question on the test. In Ireland, the percentage correct was lower than for any other country (82%). There was no difference between the proportion of boys and girls who answered the question correctly in Ireland.

FIGURE 3.5.

IDENTIFY A RECTANGLE FROM A PICTURE

Topic: Geometry *Skill: Conceptual Understanding*

What shape is shown above?

A. A circle
B. A triangle
C. A square
D.* A rectangle

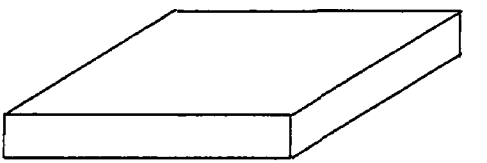
	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	82	94	95	91	86	91	90

Another question measuring pupils' conceptual understanding of geometry (Figure 3 6) requires them to count the faces of a three-dimensional figure Though the scores of Irish pupils were somewhat better relative to some countries (e g , Spain and the United States), their performance was statistically lower than that of pupils in Scotland, Canada, and Korea, a finding that closely mirrors the relative pattern for the Geometry section as a whole (see Table 3 4) Girls did as well as boys on this question in Ireland

FIGURE 3 6

COUNT THE FACES OF A SOLID FIGURE

Topic Geometry *Skill Conceptual Understanding*



In the figure above, only three faces of the box can be seen What is the total number of faces that the box has?

Answer: _____

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	74	77	84	63	53	79	83

Data Analysis, Statistics, and Probability

Eight questions focus on Data Analysis, Statistics, and Probability, constituting approximately 13% of the questions on the mathematics test at age 9 Pupils had to read and interpret bar and pie charts and to complete a bar graph In one question they were asked to determine the probability of a simple event, and in two others to solve problems using information provided in a table or pie chart

Though Irish 9-year olds score close to the international mean on questions related to this topic, they lag significantly behind pupils in all other countries in the more restricted comparison group (Table 3 4) This is despite the fact that, compared to all other countries, more Irish principals reported placing a lot of emphasis on this topic with third classes Pupils in Canada, the United States,

Scotland, and England, where relatively less emphasis is placed on tables and graphs, perform better in this category than they do on the overall test.

Pupils generally do well on this part of the test compared to other sections. The average percentage score over all countries is 68. A question on this section of the test is presented in Figure 3.7. Across all countries, 59% of pupils correctly answered this question. Approximately the same proportions of boys and girls solved the problem in Ireland.

FIGURE 3.7.

USING CLUES ABOUT CARDS, FIGURE OUT WHICH CARD WAS CHOSEN

Topic: Data Analysis, Statistics, and Probability *Skill: Problem Solving*

Colour	Number	Size
Red	7	Large
Green	8	Small
Yellow	5	Large
Blue	6	Large

The table above describes four cards. Each is a different colour, has a different number on it, and is either large or small. A card is chosen that is large, *not* red, and has a number greater than 5 on it. What colour is the card that is chosen?

A. Red
B. Green
C. Yellow
D.* Blue

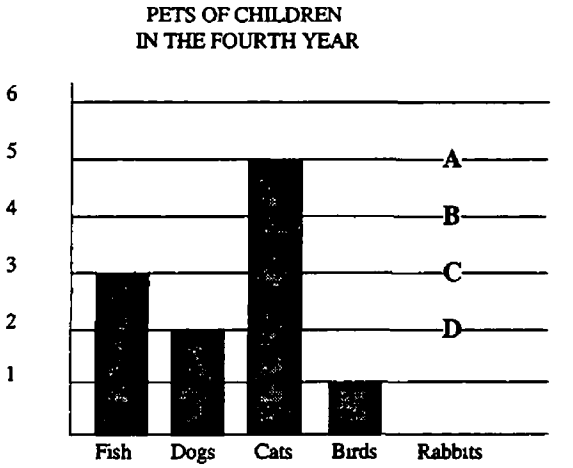
	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	48	54	59	60	59	62	70

The question shown in Figure 3.8 was answered by a greater number of pupils. However, pupils in most of the comparison countries achieved at higher levels than Irish pupils.

FIGURE 3 8

COMPLETE A BAR GRAPH

Topic Data Analysis Statistics and Probability *Skill Procedural Knowledge*



Josie has almost finished making the graph above If there are 4 rabbits where should Josie put the top of the bar for rabbits?

A At A
B * At B
C At C
D At D

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	65	75	76	61	77	73	87

Algebra and Functions

Pupils' familiarity with Algebra and Functions was assessed using 6 questions (almost 10% of the test) The questions emphasize whole number sequences and inferences from numerical relationships, such as solving problems of the following type 8+9 = 10 + ?

Pupils in most countries achieved at the same levels in Algebra and Functions as in the whole test Nine-year olds from Hungary, Israel, and Slovenia obtain comparatively higher scores than their overall level of achievement, while pupils

from Italy (Emilia-Romagna) achieve at relatively lower levels in this area than they do overall. Irish pupils responded correctly to approximately the same number of Algebra questions as did pupils in most other countries, though they scored higher than American pupils and lower than Koreans.

Figure 3.9 shows the Algebra and Functions question that was answered correctly by the greatest number of pupils. Given a sequence of numbers, pupils are required to find the next number in the pattern. Over the 14 countries, 85% of students correctly selected option D. Equal proportions of Irish boys and girls answered this question correctly.

FIGURE 3.9.

GIVEN A PATTERN OF NUMBERS, FIND THE NEXT NUMBER

Topic:Algebra and Functions *Skill: Problem Solving*

2, 6, 10, 14, ☐

A pattern of numbers is shown above. What number goes in the box?

A. 4
B. 8
C. 14
D.* 18

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	81	87	95	88	95	94	91

MATHEMATICS PERFORMANCE OF 9-YEAR OLDS BY COGNITIVE PROCESS

Irish pupils achieved at levels below the international average on all three process areas. Average percentages correct for all countries are contained in Table B-4 in Appendix B. On questions measuring Conceptual Understanding, the Irish average is 59% correct, compared to the international average of 63 percent. They answered 64% of the Procedural Knowledge-based questions correctly, 3% below the average, and with 56% correct on Problem Solving, they are also 3% below the average. Boys and girls achieved at about the same level on the three skill areas in Ireland.

CONCLUSION

The average achievement of Irish 9-year old pupils is close to the average achievement of pupils of the same age in other countries in the study The scores of the strongest and weakest pupils in Ireland are at or slightly below, the scores of comparable pupils in other countries Boys achieve at about the same level as girls on all topic areas and skill domains in Ireland Although there was general agreement that mathematics is equally for boys and girls in Ireland (83%), this is a lower percentage than among 13-year olds (95%)

Across topic areas, Irish pupils score at the international average on Numbers and Operations, Data Analysis, Statistics, and Probability, and Algebra and Functions, whereas achievement was below average on Measurement and Geometry Average Irish performance is below the international average in the three skill domains of Conceptual Understanding, Procedural Knowledge, and Problem Solving Even though Irish achievement on Data Analysis, Statistics, and Probability is close to the international mean, it is lower than in any of the other countries in the reference group of six countries

Irish schools place a heavy emphasis on Numbers and Operations, especially fractions and decimals, and on tables and charts which are the main component of the Data Analysis, Statistics, and Probability content category for this age group In contrast to the emphasis on Numbers and Operations and on tables and charts, Irish schools appear to pay relatively less attention to Measurement and Geometry Many of the other countries report higher degrees of emphasis on these topics

Chapter 4. Science Performance of 13-Year Olds

STRUCTURE OF THE TEST

The science test consisted of 72 items but eight were eliminated following preliminary analysis, because they did not function in the same way across all populations. Thus, the scores presented in this chapter are based on student responses to 64 questions.

As in the case of the mathematics test, the science instrument was designed to assess various topics and types of knowledge and skills related to those topics. Four major content areas of science are included: Life Sciences, Physical Sciences, Earth and Space Sciences, and the Nature of Science. Fuller explanations are provided on each of these areas in a later section, along with sample questions. The distribution of questions across the four topic areas is presented in Table 4.1.

TABLE 4.1

NUMBERS AND PERCENTAGES OF QUESTIONS BY TOPIC ON SCIENCE TEST (AGE 13)

	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science	Total
Number of Questions	19	25	9	11	64
Percentages	30	39	14	17	100

OVERALL PERFORMANCE

Average scores (percentage of science questions answered correctly) for students in each country are presented in Table 4.2. Also listed are the scores corresponding to the 10th and 90th percentile in each country. The highest average score attained is in Korea where students, on average, answer 78% of questions correctly; the lowest, 46%, was recorded in Fortaleza, Brazil. Over all countries, the average score is 67% correct. A group of nine countries have an average level of science performance that is above the international average. This group is made up of Korea, Taiwan, Switzerland, Hungary, the Soviet Union, Slovenia, Italy (Emilia-Romagna), Israel, and Canada.

Most of the countries have an average level of science performance close to the international average. On average, Irish students, however, responded correctly to only 63% of questions on the test, which is significantly below the

international mean This relatively poor Irish performance on the IAEP II test replicates a similar finding in the 1988 IAEP I test (Lapointe et al, 1989) The inclusion of additional countries and more comprehensive questions in IAEP II serves to confirm the original finding

TABLE 4 2

AVERAGE PERCENTAGES CORRECT ON SCIENCE TEST
OVERALL SCORES AND SCORES ATTAINED BY STUDENTS
AT 10TH AND 90TH PERCENTILES (AGE 13)

	Average Overall Score	Percentage correct attained by students at 10th Percentile	90th Percentile
IAEP Average	67 (0.5)		
Comprehensive Populations			
Korea	78 (0 5)	58 (3 8)	94 (0 0)
Taiwan	76 (0 4)	52 (0 0)	94 (0 0)
Switzerland	74 (0 9)	58 (0 6)	92 (0 0)
Hungary	73 (0 5)	52 (0 0)	92 (0 0)
Soviet Union	71 (1 0)	51 (1 9)	89 (2 3)
Slovenia	70 (0 5)	50 (0 0)	89 (0 0)
Italy (Emilia-Romagna)	70 (0 7)	48 (0 0)	89 (0 8)
Israel	70 (0 7)	48 (3 9)	89 (0 0)
Canada	69 (0 4)	48 (1 7)	88 (0 0)
France	69 (0 6)	45 (1 7)	89 (0 0)
Scotland	68 (0 6)	45 (0 0)	88 (2 6)
Spain	68 (0 6)	48 (0 2)	86 (2 6)
United States	67 (1 0)	44 (5 1)	86 (0 0)
Ireland	**63 (0 6)**	**41 (2.3)**	**84 (3.2)**
Jordan	57 (0 7)	36 (0 0)	78 (1 6)
Special Populations			
England	69 (1 2)	44 (3 3)	89 (0 0)
China	67 (1 1)	45 (1 6)	88 (1 6)
Portugal	63 (0 8)	42 (3 1)	84 (0 0)
Brazil (São Paulo)	53 (0 6)	33 (0 8)	75 (3 9)
Brazil (Fortaleza)	46 (0 6)	31 (0 0)	67 (0 6)

Note Standard errors are presented in parentheses

From the perspective of the Irish results, the countries can be divided into three groups on the basis of average performance In most of the 19 countries, the average percentage correct in science is greater than that attained by Irish students Irish students attain scores that do not differ significantly from those obtained by students in Portugal, and have higher average scores than Jordanian and Brazilian students

DIFFERENTIAL PERFORMANCE OF HIGH AND LOW ACHIEVERS

The weakest Irish students have a level of scientific knowledge and skills that is significantly below that of the weakest pupils in all but Jordan and Brazil. Irish students at the 10th percentile (i.e., the point at or below which only 10% of students are found) obtain scores on the science test that are similar to those of the bottom 2 to 3% of students in Korea, Switzerland, Hungary, the Soviet Union, Israel, Canada, and Spain. The score corresponding to the 10th percentile for Swiss students is 58%, meaning that many of the weakest Swiss 13-year olds know almost as much science as the average Irish 13-year old. Much the same can be said of the weakest Koreans.

Ireland's highest performing 13-year olds (i.e., those scoring above the 90th percentile) also achieve at a level below most of their counterparts in this study. The score corresponding to the 90th percentile in Ireland is 84 percent. Only in Jordan and Brazil is the 90th percentile lower. In four countries (Hungary, Korea, Switzerland, and Taiwan) students at the 90th percentile answered more than 92% of questions correctly. Indeed, the best Irish students are not far ahead of the average students in these four countries or in the Soviet Union and Slovenia. Only the top 2 to 3% of Irish students achieve at the same levels as the top 10% in most countries.

SCIENCE PERFORMANCE OF 13-YEAR OLDS BY GENDER

In almost every country that took part in the science test for 13-year olds, on average, boys answer more questions correctly than girls (Taiwan, England, and Jordan are exceptions). In Ireland, boys responded correctly to 66% of the questions, compared with a correct response rate of 61% by girls.

Despite the achievement difference in performance between boys and girls in most countries, the vast majority of 13-year olds in the survey consider that science is 'equally for girls and for boys.' For the questionnaire item in Figure 4.1, 4% of Irish students chose option A, 1% chose option B, and 95% selected C. Those Irish students who believe science to be gender-related do not, on average, correctly respond to as many science questions as do those who believe that the subject is equally for boys and girls. The two countries with the lowest percentage agreement with statement C, Taiwan and Jordan, are among the few with no gender difference in science performance.

FIGURE 4 1

STUDENTS GENDER PERCEPTION OF SCIENCE

With which of the following statements about science do you agree?

A Science is more for boys than for girls.
B Science is more for girls than for boys
C Science is for boys and girls about equally

TABLE 4 3

AVERAGE PERCENTAGES CORRECT ON SCIENCE TEST
OVERALL SCORES AND SCORES BY TOPIC (AGE 13)

	Overall	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science
IAEP Average	67	68	64	67	71
Comprehensive Populations					
Korea	78	80	76	75	79
Taiwan	76	78	75	72	76
Switzerland	74	74	70	75	80
Hungary	73	77	70	72	75
Soviet Union	71	73	71	73	68
Slovenia	70	73	67	70	73
Italy (Emilia Rom)	70	72	67	71	73
Israel	70	65	70	68	79
Canada	69	69	65	68	79
France	69	68	67	67	76
Scotland	68	67	66	64	77
Spain	68	70	64	69	70
United States	67	69	62	67	76
Ireland	**63**	**61**	**61**	**66**	**71**
Jordan	57	59	54	61	56
Special Populations					
England	69	68	67	66	77
China	67	64	68	70	70
Portugal	63	66	58	61	68
Brazil (São Paulo)	53	56	49	56	53
Brazil (Fortaleza)	46	51	43	49	45

SCIENCE PERFORMANCE OF 13-YEAR OLDS BY TOPIC

The science test is composed of questions from four content areas of science: Life Sciences (30% of the test), Physical Sciences (39%), Earth and Space Sciences (14%), and the Nature of Science (17%). In addition, three cognitive process categories, Knows Science (23%), Uses Science (48%), and Integrates Science (28%), were also used to classify the questions. Average percentages correct for all countries in each topic are shown in Table 4.3. The relatively poor overall achievement level of Irish students is reflected in their performance in Life Sciences and Physical Sciences. In Earth and Space Sciences and the Nature of Science, Irish performances is on par with that of students in other countries.

A more focused review of the performance of Irish pupils in comparison to pupils in eight other countries is presented in Table 4.4. As in the mathematics assessment, these specific countries were chosen for comparative purposes due to their geographic, economic, cultural, and historical links with Ireland. Korea was also included due to its consistently high performance on international tests. The minus signs in the Overall (first) column in Table 4.4 indicate that Irish students responded correctly to fewer questions on the entire test than in all but one of the eight selected comparison countries.

TABLE 4.4

DIRECTION OF DIFFERENCE BETWEEN AVERAGE PERFORMANCE ON SCIENCE TEST OF IRISH STUDENTS AND PERFORMANCE OF STUDENTS IN SELECTED COUNTRIES (AGE 13)

	Overall	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science
England	-	-	-	0	-
Scotland	-	-	-	0	-
France	-	-	-	0	-
Spain	-	-	-	-	0
Switzerland	-	-	-	-	-
United States	0	-	0	0	-
Canada	-	-	-	0	-
Korea	-	-	-	-	-
IAEP Average	-	-	-	0	0

\+ The average performance of Irish students is higher than that of other country
0 No statistical difference in average scores
\- The average performance of Irish students was below that of other country

Statistical difference calculations based on Bonferroni procedure (2.78 standard errors).

Life Sciences

Questions on Life Sciences address the areas of energy transformation, heredity and genes, structure and function of organisms, plants, animal behaviour, and ecology Students were required to classify plants and animals, identify parts of the human anatomy, and make distinctions between mammals and reptiles Of the 19 Life Science questions, 10 assess how well pupils Know Science, 6 assess how they Use Science, and 3 assess Integration of Scientific Knowledge

Irish students responded correctly on average to 61% of the questions in Life Sciences, compared with the international average of 68 percent The Irish average is significantly below the international average, as signified by the minus sign in the bottom line of column two of Table 4 4 The average percentage correct of Irish students is also below that of all eight of the selected comparison countries In most of the countries assessed, students perform about as well on Life Science questions as on the test as a whole Irish students, however, perform less well on these questions than on the overall test Their average performance is 4 percentage points below the international average on the overall test, but their performance is 7 points below the international average for Life Science questions Thirteen-year olds in Israel and China also perform less well on Life Science questions, whereas students in Hungary perform better on these questions than in general Boys in Ireland perform better on the Life Science questions than girls (63% vs 59%) to much the same extent as on the science test as a whole

An example of a Life Sciences question is the question on food chains in Figure 4 2 Over all countries, 71% of students selected the correct option compared to 65% of Irish students In Ireland, a greater percentage of boys than girls answered this question correctly

The item in Figure 4 3, which measures knowledge of adaptation in the plant kingdom, was answered correctly by 44% of students across all countries Highest achievers were Soviet and Swiss children, 57% of whom identified the correct answer In Ireland, 5% more boys than girls answered the question correctly

School principals were asked to indicate the degree of emphasis placed on seven Life science topics These were plants, animals, cell structure and function, the human body, evolution, heredity and genes, and the environment There was considerable variation across countries in the degree of emphasis on the seven topics The percentage of Irish schools reporting that each topic was emphasized 'a lot' varied from 60% (the human body) to 6% (heredity and genes), with an average of 31% over all topics

FIGURE 4.2

FOOD CHAINS

Topic: Life Sciences *Skill: Uses Science*

Grass, insects, blackbirds, and hawks are found in a grassland community. In what order should they be to show the food chain in this community?

A.* Grass → insects → blackbirds → hawks
B. Grass → blackbirds → hawks → insects
C. Hawks → blackbirds → grass → insects
D. Blackbirds → hawks → insects → grass

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	65	66	75	76	70	73	69	70	92

FIGURE 4.3

ADAPTATION OF LEAF SIZE IN PLANTS

Topic: Life Sciences *Skill: Uses Science*

Plants that grow on the forest floor often have larger leaves than plants that grow in an open field. How does this adaptation of larger leaves help the forest plants?

A. By keeping the plants warm.
B. By attracting insects to the plants.
C. By gathering oxygen for the plants.
D.* By gathering light for the plants.

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	31	42	38	41	55	57	41	39	48

Physical Sciences

The aspects of Physical Sciences that were assessed deal with the fundamental components of the natural universe — space, time, matter, and energy Students were required to infer from diagrams, interpret simple graphs, and answer questions about motion, mass, electricity and circuitry, light and sound, properties of matter, atoms and molecules, temperature and heat, and chemical reactions and changes

The average performance of Irish students on this topic (61% correct) is poor compared to achievement levels in other countries Irish students attained an average score that is below seven of the eight countries in the selected comparison, the exception being the United States where the average score on Physical Sciences is almost identical to that in Ireland On average, Irish boys perform better than girls on Physical Science questions The gender difference is 6 5 percentage points, which may be compared with a difference of 5 3% on the overall test

In every country, performance on Physical Science questions approximates performance on the test as a whole In Ireland, the average performance level on these questions is 3% below the international average for the topic This is similar to the Irish performance over all questions on the test

Responses to the Physical Science question in Figure 4 4 illustrate the poor relative performance of Irish students on the topic as a whole Eighty-seven percent of students in the survey answered this question correctly On only two other questions on the test do students achieve in higher proportions In Israel, 95% of students correctly chose option D

FIGURE 4 4

IDENTIFY ELECTRICAL CONDUCTOR

Topic Physical Sciences *Skill Knows Science*

Which of the following materials conducts electricity best?

A Plastic
B Paper
C Glass
D * Copper

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	73	93	88	90	90	86	88	85	97

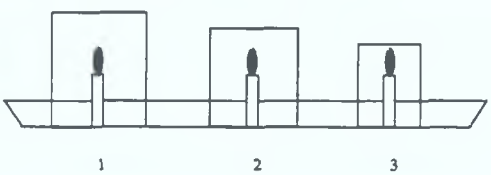
The question on the test that was answered by the highest percentage of students also measured understanding of conductors and insulators. Students were asked to choose the best conductor to complete a battery-powered electrical circuit where the choices given were a piece of wood, a plastic hair comb, a rubber, and an iron nail. Eighty-nine percent of all students but only 78% of the Irish sample correctly chose the iron nail.

Another question on which students scored at high levels assessed understanding of the oxygen requirements for combustion (see Figure 4.5). Seventy-six percent of students in all countries correctly answered the question. In Ireland, three-quarters of boys and under two-thirds of girls answered correctly.

FIGURE 4.5

OXYGEN REQUIREMENTS FOR COMBUSTION

Topic:Physical Sciences *Skill:Integrates Science*



As shown above, jars were placed over identical lighted candles at the same time. Which of the following will happen?

A. All the flames will go out immediately.
B. The flames will go out in this order: 1, 2, 3.
C.* The flames will go out in this order: 3, 2, 1.
D. The candles will burn awhile, and then all the flames will go out at the same time.

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	70	84	81	79	79	83	79	82	87

Of the four content areas assessed, the relative emphasis attached to Physical Sciences in the Irish science syllabus for first year post-primary students was estimated to be 35%, a percentage equal to that devoted to Life Sciences (Center for the Assessment of Educational Progress, 1991). Principals indicated the degree of emphasis placed on eight topics in Physical Science. These topics were electricity and magnetism; mass, motion and gravity; light and sound; solids, liquids and gases; atoms and molecules; periodic table of elements; chemical substances; and temperature and heat. The percentage of Irish school principals

reporting that topics were emphasized 'a lot' ranged from 27 (light and sound) to 56 (atoms and molecules) Averaged over the eight topics, Physical Sciences were emphasized 'a lot' in 41% of Irish post-primary schools Thirteen percent of principals reported that the topic was not emphasized at all

Responses from school principals in some countries indicate wider diversity in the emphasis placed on topics in Physical Sciences than in Ireland Eighty four percent of principals in Korea reported a lot of emphasis on electricity and magnetism, but only 10% reported similar emphasis on mass, motion, and gravity In Taiwan, the situation was reversed, with just 11% reporting a lot of emphasis on electricity and magnetism, but 81% emphasizing mass, motion, and gravity In Korea, only electricity and magnetism (84% reporting a lot of emphasis) and atoms and molecules (74%) are given substantial emphasis, while in Taiwan, curricular focus is on mass, motion, and gravity (81%), atoms and molecules (56%), and solids, liquids, and gases (56%) Slovenia seems to concentrate on the chemical aspects of Physical Science In contrast, Irish schools seem to place a moderate degree of emphasis on each topic

Earth and Space Sciences

The nine questions relating to Earth and Space Sciences assess knowledge of solar systems, water cycles, fossils, and soil erosion Just one question on this topic falls into the Knows Science category, with the remaining eight fall in the Uses Science category There are no Integrates Science questions on this topic

The highest performing countries on Earth and Space Sciences are Korea and Switzerland, each of which has an average percentage correct of 75 percent Most countries have an average performance level on this topic comparable to their overall performance on the science test The average performance of students in Ireland is not significantly below the international average for this topic However, in relative terms, Irish students perform just about the same on questions on Earth and Space Sciences as on the test as a whole, when sampling error is taken into account Of countries in the comparison group, only Spain, Switzerland and Korea outperform Ireland No statistical difference was found between the average Earth and Space Sciences score of Irish students and the mean scores of students in England, Scotland, France, the United States, or Canada.

The difference in performance levels of Irish boys and girls is greater on questions on Earth and Space Sciences than on questions on Life Sciences or Physical Sciences or on the test as a whole On average, boys responded

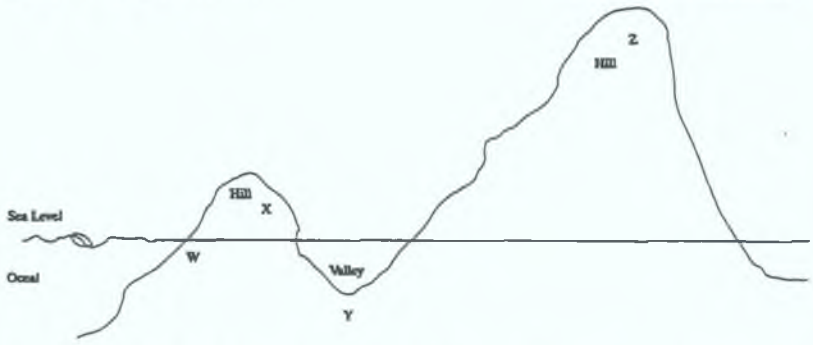
correctly to 70% of the Earth and Space Science questions while girls responded to 62 percent.

The question answered correctly by the least number of students (only 33% of the sample worldwide) measured understanding of the relationship between barometric pressure and height. This question is presented in Figure 4.6. Jordanian students do best on the question, 54% of them indicating that pressure reading would be greatest at lowest altitude (in the valley). Students in the Brazilian city of Fortaleza fare worst, only 17% identifying the correct answer. In Ireland, 30% of students respond correctly and boys outperform girls.

FIGURE 4.6

OXYGEN REQUIREMENTS FOR COMBUSTION

Topic:Earth and Space Sciences *Skill:Understands Science*



At locations W, A, Y, and Z shown above, readings of barometric pressure were recorded at the same time. The weather was clear in all four locations. At which location would the reading most likely be the greatest?

A. W
B. X
C.* Y
D. X

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	30	31	28	27	29	40	22	31	38

Figure 4 7 contains another question that closely mirrors the relative position of Irish 13-year olds on Earth and Space Sciences On this question, which probed students' knowledge of the structure of the solar system, the overall percentage correct internationally is 80 This question was answered correctly by more Irish boys than girls

FIGURE 4 7

STRUCTURE OF THE SOLAR SYSTEM

Topic Earth and Space Sciences *Skill Knows Science*

Each year the Earth makes one orbit around which of the following?

A * The Sun
B Saturn
C The Moon
D All the planets

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	80	79	75	88	87	88	84	81	88

School principals indicated the degree of emphasis placed on three topics of Earth and Space Sciences *rocks and minerals*, weather and climate, and stars and planets In no country did they report a high degree of emphasis on all three topics, and in several countries little emphasis was placed on any of them Principals in France (99%) and in Korea (71%) reported a lot of emphasis on rocks and minerals, in Jordan (78%), the Soviet Union (73%), and Hungary (70%), there was a lot of emphasis on weather and climate, overall, little attention was devoted to stars and planets

Irish principals indicated a low level of emphasis on all three topics Only 6% reported a lot of emphasis on rocks and minerals, with 10% emphasizing weather and climate, and 6% stars and planets Almost two-thirds of principals reported that no emphasis whatsoever was attached to Earth and Space Sciences in their schools

Nature of Science

Questions on the Nature of Science were designed to assess knowledge and understanding of the principles and procedures of scientific inquiry The 11 questions on this topic, comprising 17% of the test, require students to interpret

data from charts, graphs, and diagrams; to formulate hypotheses; and to deduce results from described experiments.

Average Irish performance is higher on this topic than on the test as a whole. This is also the case for Israel, Canada, France, Scotland, and the United States. Average Irish performance on Nature of Science questions is identical to the international average of 71%, which contrasts with their below-average performance on Life Sciences and Physical Sciences. Nonetheless, the attainment of Irish students is significantly below that of students in all but one country in the comparison group of eight countries. A number of countries performed below their overall performance level on Nature of Science questions, including Taiwan, the Soviet Union, Jordan, and Brazil. The Nature of Science is the only science topic on which the performance of girls in Ireland was comparable to that of boys.

Figure 4.8 presents a question dealing with the design of experiments. As the percentage correct figures show, the relative performance of Irish students on this question reflects their position on the entire topic. Fifty-five percent of Irish students answered the question correctly, compared to 57% of all participants in the study. The Irish score is below that of all the comparison countries with the exception of Spain.

School principals were asked to indicate the degree of emphasis placed on just two topics in the Nature of Science: scientific processes (e.g., observing, classifying, measuring, and recording results), and how to design experiments and test hypotheses. As with topics from other areas of the science test, there is a lot of variation across countries in the degree of emphasis reported. England, Scotland, and Canada all reported a lot of emphasis on scientific processes, and also had average student performance levels above the international average on the Nature of Science questions. However, several other countries with high performance levels reported much less emphasis on scientific processes. For example, only 19% of Korean and 23% of Swiss principals said that scientific processes were emphasized a lot in their schools; yet students in these two countries answered over three-quarters of test questions correctly, which is significantly above the international average. In half of the Irish post-primary schools, principals indicated that a lot of emphasis was placed on this topic.

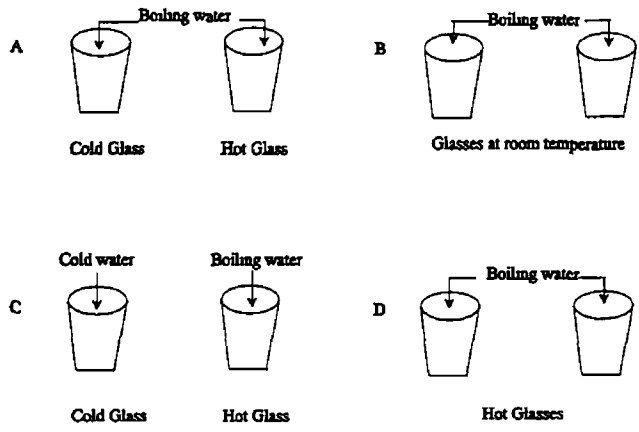
Principals reported less emphasis on how to design experiments. Canada (65%) and Israel (60%) reported the highest degree of emphasis. In Ireland, just 22% of principals reported that this topic was emphasized a lot.

FIGURE 4 8

CHOOSE THE CORRECT EXPERIMENT TO TEST A HYPOTHESIS

Topic Nature of Science *Skill Integrates Science*

When John poured boiling water into a glass the glass broke He thought that the great difference in temperature between the water and the glass caused the glass to break Which of the following would be the best test of his hypothesis?



	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
% Correct	55	63	58	71	42	70	62	70	63

SCIENCE PERFORMANCE OF 13-YEAR OLDS BY COGNITIVE PROCESS

Questions in the science test were designed to assess students' performance at three different levels of cognitive functioning Knows Science, Uses Science, and Integrates Science

Questions in the Knows Science category require students to exhibit basic knowledge of scientific facts and concepts including scientific terminology and principles Typically, recall of specific scientific facts is stressed, thereby suggesting a relatively low level of cognitive processing Approximately 23% of questions on the test fell into this category Uses Science questions require students to combine factual knowledge with rules and formulae for a specific purpose Questions in this category require understanding of simple scientific principles, interpretation of simple tables, and making inferences about the

outcomes of experimental procedures, and require a higher level of cognitive processing than the Knows Science questions. Forty-eight percent of the test questions assessed the ability to use science. Questions in the Integrates Science category involve advanced cognitive processing where students are asked to draw conclusions on the basis of available data. These questions assess the ability to generalize, hypothesize, and reason by synthesizing specific information. Approximately 28% of the questions in the test were of this type.

In general, students from most of the countries performed better on questions from the Knows Science category than on questions from the Uses Science or Integrates Science categories. However, participants from Ireland, and from four other countries (Israel, Canada, France, and China) have lower average performance levels in this category relative to their overall performance. The average score for Irish students is about 7 percentage points below the international average. In the Uses Science and Integrates Scicnce categories, Irish students perform at about the same level as on the test as a whole.. The achievement of Irish boys is, on average, almost 5% higher than the achievement of Irish girls on the three cognitive areas. The difference is especially pronounced in Uses Science (7%).

CONCLUSION

The achievement of students in Ireland in science is lower than that of students in more than three-quarters of the countries that participated in the survey. Both the most and least scientifically able Irish students achieve at levels well below comparable students in almost all other countries. There is a significant gender gap, in favour of boys, in most countries, including Ireland. In Ireland, girls equalled boys' scores for only Nature of Science items. On all other areas, including the three process areas, the scores of boys are superior.

Irish students achieve at lower levels relative to students in other countries in Life Sciences and Physical Sciences, but not in Earth and Space Sciences or in Nature of Science. Scores on Life Sciences are particularly low. Most emphasis in science in first-year classes in Ireland is on Physical Science; somewhat less emphasis is placed on Life Sciences and Nature of Science. Very little emphasis is placed on Earth and Space Sciences in Irish classrooms, though students do relatively well on the test in this area

Chapter 5. Science Performance of 9-Year Olds

STRUCTURE OF THE TEST

A test containing 60 questions on science was administered to 9-year olds in 14 countries Two questions were eliminated after preliminary analyses indicated that they did not function in the same way across all countries Thus, pupil scores presented here are based on responses to 58 questions The same four major content areas were addressed as in the survey of 13-year olds, and questions were designed to assess three levels of cognitive functioning Knows Science, Uses Science, and Integrates Science

TABLE 5 1

NUMBERS AND PERCENTAGES OF QUESTIONS BY TOPIC ON SCIENCE TEST (AGE 9)

	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science	Total
Number of Questions	23	17	10	8	58
Percentages	40	29	17	14	100

OVERALL PERFORMANCE

The overall performance of Irish 9-year olds on the science test was relatively poor compared with children in other countries Irish pupils, together with pupils in Portugal and Slovenia, have an average performance level that is significantly below the international average of 62% of the questions answered correctly In contrast, 9-year olds in Korea, Taiwan, the United States, and Italy (Emilia-Romagna) have an average performance level significantly above the international average All other countries perform at about the international average There is no significant difference between the average performance levels of Irish, Portuguese, and Slovenian pupils Irish pupils, therefore, have the joint lowest average performance levels of the survey countries

The average performance of the 14 countries is shown in Table 5 2 along with data regarding the achievement of pupils at the 10th and 90th percentiles Pupils in Korea achieved, on average, a score of 68 percent Pupils in Italy (Emilia-Romagna), Taiwan, and the United States also performed well above

the mean. Pupils in seven countries (England, Canada, Hungary, Scotland, Spain, the Soviet Union, and Israel) attained scores that are close to the international mean of 62 percent. The mean science score for Ireland is 57 percent.

TABLE 5.2

AVERAGE PERCENTAGES CORRECT ON SCIENCE TEST: OVERALL SCORES AND SCORES ATTAINED BY STUDENTS AT 10TH AND 90TH PERCENTILES (AGE 9)

	Average Overall Score	Percentage correct attained by students at: 10th Percentile	90th Percentile
IAEP Average	62 (0.5)		
Comprehensive Populations			
Korea	68 (0.5)	50 (0.0)	85 (0.0)
Taiwan	67 (0.5)	45 (7.2)	86 (0.0)
United States	65 (0.9)	43 (5.1)	85 (0.0)
Canada	63 (0.4)	43 (0.0)	81 (0.0)
Hungary	63 (0.5)	45 (0.0)	79 (0.0)
Spain	62 (0.7)	42 (1.6)	81 (0.0)
Soviet Union	62 (1.2)	43 (1.4)	79 (4.8)
Israel	61 (0.7)	41 (0.0)	81 (0.0)
Slovenia	58 (0.5)	40 (0.4)	75 (0.0)
Ireland	**57 (0.7)**	**36 (1.3)**	**76 (0.0)**
Special Populations			
Italy (Emilia-Romagna)	67 (0.9)	48 (0.3)	86 (1.7)
England	63 (0.9)	41 (0.0)	83 (0.0)
Scotland	62 (0.7)	43 (0.0)	81 (3.5)
Portugal	55 (0.7)	38 (0.0)	72 (0.0)

Note. Standard errors are presented in parentheses.

DIFFERENTIAL PERFORMANCE OF HIGH AND LOW ACHIEVERS

The relatively low average attainment of 9-year old Irish children in general in science is also evident among the highest performing tenth of the sample. The 90th percentile for Irish pupils (the score on the science test above which the top 10% of pupils are to be found) is 76% of questions answered correctly (see Table 5.2). The 90th percentiles in other countries are: England, 83%; Scotland, 81%; Spain 81%; US 85%; Canada, 81%; and Korea, 85 percent.

The performance of low achieving 9-year olds in Ireland is also relatively low by international standards In Ireland, the 10th percentile is 36%, a score typically attained by pupils at the 5th percentile in almost all other countries Indeed, the score attained by pupils at the 10th percentile in Korea and Italy (Emilia-Romagna) is close to the mean score for all Irish pupils

SCIENCE PERFORMANCE OF 9 YEAR OLDS BY GENDER

In 8 of the 14 countries assessed, boys have a higher average performance level than girls This gender difference is evident in Ireland, Korea, Taiwan, Hungary, Canada, Spain, Israel, and Portugal In Ireland, boys outperform girls by 3 percentage points on average

In almost all of the countries assessed, there appears to be agreement among 9-year olds that science is equally appropriate for boys and for girls In Ireland, 12% of pupils believe that science is more for boys, 7% think that it is more for girls, and 81% respond that it is equally for boys and girls The conception that science is a boys' subject is more firmly rooted in Ireland than in any country with the exception of Korea. In that country, 31% indicate that science is more for boys and 26% that it is more for girls The biggest gender difference in performance is also to be found among Korean 9-year olds

SCIENCE PERFORMANCE OF 9 YEAR OLDS BY TOPIC

The science test for 9-year olds is composed of questions from four content areas of science Life Sciences (40%), Physical Sciences (29%), Earth and Space Sciences (17%), and the Nature of Science (14%) In the test for younger children, there is relatively greater emphasis on Life Science and correspondingly less on Physical Sciences than in the test for 13-year olds As regards cognitive process categories, there is relatively greater emphasis on the Knows Science category and relatively less on the Uses Science and Integrates Science categories in the 9-year old test than in the test for older pupils

The average scores attained by pupils in the 14 countries in each topic area are presented in Table 5 3 along with average overall attainment A summary of Ireland's performance relative to six other countries is presented in Table 5 4 Neither France nor Switzerland participated in the age-9 survey Information is presented for overall score and for the four content areas separately The number and pattern of minus signs in Table 5 4 indicate that, with the exception of Earth and Space Sciences, the average achievement of Irish pupils is below that of pupils in all the selected comparison countries

TABLE 5.3

AVERAGE PERCENTAGES CORRECT ON SCIENCE TEST: OVERALL SCORES AND SCORES BY TOPIC (AGE 9)

	Overall	Life Sciences	Physical Sciences	Earth & Space Sciences	Nature of Science
IAEP Average	62	63	59	64	64
Comprehensive Populations					
Korea	68	69	68	62	71
Taiwan	67	65	68	67	67
United States	65	65	58	71	71
Canada	63	63	58	67	67
Hungary	63	65	56	68	62
Spain	62	66	54	63	65
Soviet Union	62	64	58	63	60
Israel	61	61	60	61	64
Slovenia	58	59	57	58	54
Ireland	**57**	**55**	**54**	**63**	**60**
Special Populations					
Italy (Emilia-Rom)	67	71	61	67	67
England	63	62	60	66	66
Scotland	62	61	59	65	68
Portugal	55	58	50	57	52

TABLE 5.4

DIRECTION OF DIFFERENCE BETWEEN AVERAGE PERFORMANCE ON SCIENCE TEST OF IRISH PUPILS AND PERFORMANCE OF PUPILS IN SELECTED COUNTRIES (AGE 9)

	Overall	Life Sciences	Physical Sciences	Earth & Space Sciences	Nature of Science
England	-	-	-	0	-
Scotland	-	-	-	0	-
Spain	-	-	0	0	-
United States	-	-	-	-	-
Canada	-	-	-	-	-
Korea	-	-	-	0	-
IAEP Average	-	-	-	0	-

\+ The average performance of Irish pupils is higher than that of other country
0 No statistical difference in average scores
\- The average performance of Irish pupils is below that of other country
Statistical difference calculations based on Bonferroni procedure (2.62 standard errors)

Life Sciences

Questions on Life Sciences were designed to assess knowledge of and ability to classify plants and animals as well as to ascertain what pupils know about the human body The relative emphasis on Life Sciences was estimated to be approximately 35% of the basic science element of the Environmental Studies syllabus for third classes in Ireland (Center for the Assessment of Educational Progress, 1991) Information provided by the primary school principals indicates that in 44% of schools the subtopic plant is emphasized 'a lot' in third class science Corresponding figures for animals and the human body are 54% and 8% respectively In contrast, over 70% of Spanish, Portuguese, and Soviet principals indicated that all three subtopics are emphasized a lot in their schools

Irish pupils responded correctly to an average of 55% of the questions on Life Sciences This average is significantly below the international average of 63% correct on the topic and is the lowest average score attained in any of the 14 countries Pupils in Italy (Emilia-Romagna) and Korea achieved the highest average scores For most countries, performance on the Life Science questions is comparable to their overall performance on science, though pupils from Italy (Emilia-Romagna) and Spain do rather better on Life Science questions than on the test as a whole Ireland is the only country in which average performance on Life Science questions is even lower than average performance on the test as a whole

FIGURE 5 1

PLANT GROWTH

Topic Life Sciences *Skill Knows Science*

When seeds are watered they swell up and within a few days small roots appear What is this process called?

A * Sprouting
B Sowing
C Blossoming
D Planting

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	52	76	70	42	67	58	91

Figure 5 1 provides a sample question on Life Sciences Pupils in many countries performed well on this question Nine out of every 10 Korean pupils answered it correctly compared with 2 out of every 10 in the French-speaking

school system in Ontario, Canada. Five out of 10 Irish children correctly answered the question, whereas the average for all countries was 6 out of 10.

Physical Sciences

Physical Sciences items on the test concentrate on understanding of space, time, matter, and energy. Questions deal with electricity and magnetism; mass, motion and gravity; light and sound; and solids, liquids, and gases. The relative emphasis on Physical Sciences (35%) in the basic science element of the Environmental Studies syllabus for third classes in Ireland was estimated to be equal to that of Life Sciences (Center for the Assessment of Educational Progress, 1991). The responses of principals, however, suggest that this topic receives scant attention, if any, from third class teachers.

Irish pupils performed relatively poorly on the Physical Sciences questions. On average, they responded correctly to 54% of questions, 5% below the international average. Though the Irish score is essentially equivalent to that of Spanish 9-year olds, it is well below that achieved by students in other countries, with the exception of Portugal where pupils, on average, correctly answered only half of the questions.

A significant gender difference in favour of boys is evident in Ireland on this topic; boys, on average, score 4 points higher than girls. Boys also outscore girls on average in Spain, Korea, the US, and Canada. In England and Scotland, the average performance of girls is equal to that of boys.

Only one question on Physical Sciences is knowledge-based. Twelve questions assess use of science and four assess integration of scientific knowledge. One of the latter types of question is presented in Figure 5.2. Over all countries, only 53% of children correctly identified option D as the answer, thus making this one of the questions in the entire test on which pupils did least well. Irish pupils did relatively well with almost half answering it correctly. This question calls for the integration of science knowledge to evaluate the best procedure under specified conditions for achieving a desired result. Though Irish pupils performed below the mean on Integrating Science, they were more successful on this category of question than on either Knowledge or Use of Science.

Figure 5.3 presents a question that more closely mirrors the performance of Irish pupils in comparison with students elsewhere. It requires a rudimentary knowledge of the laws of gravity. Over all countries, 65% of students recognised that gravity pulls objects to Earth after they have been thrown into the air. In Ireland, only 49% of girls answered the question correctly, whereas 62% of boys did so.

FIGURE 5 2

CHEMICAL CHANGES RECOVERING A SOLID FROM A SOLUTION

Topic Physical Sciences *Skill Integrates Science*

How can solid salt be recovered after it has been dissolved in water?

A By stirring the water
B By means of a paper filter
C By means of a strong magnet.
D * By boiling off the water

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	47	47	51	58	41	43	79

FIGURE 5 3

GRAVITY

Topic Physical Sciences *Skill Understands Science*

Why does an object return to the Earth after it has been thrown into the air?

A The Earth is spinning
B The Earth is magnetic
C * Gravity pulls objects down
D Air pushes objects down

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	56	70	62	46	72	61	47

Earth and Space Sciences

Ten questions (17% of the test) measure pupils' knowledge of rocks and minerals, weather and climate, and stars and planets More specifically they focus on the earth's place in the universe, the earth-moon-sun system, the solar system, the water cycle, water quality, water on and within the land, and elementary aspects of weathering and erosion Of the four topics comprising the test, one-fifth of the available time was estimated to be devoted to Earth and Space Sciences in the science syllabus for third class (Center for the Assessment of Educational Progress, 1991)

Irish pupils performed better on the Earth and Space Sciences questions than on any other part of the science test. They performed approximately at the international average. With an average score of 63% of questions correctly answered, their average score is approximately equal to the average in England, Scotland, Spain, and Korea, but not as high as in North America. Irish boys, on average, attained a score of 66% whereas girls responded correctly to only 60% of the questions. On the sample question shown in Figure 5.4, 73% of children in the 14 countries got the correct answer, and Irish boys outperformed girls.

FIGURE 5.4

STARS: PRODUCTION OF LIGHT

Topic: Earth & Space Sciences *Skill: Knows Science*

Which of the following gives off its own light?

A. A mirror
B. The Moon
C.* The Sun
D. A white piece of paper

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	67	67	66	90	85	78	76

FIGURE 5.5

STRUCTURE OF THE SOLAR SYSTEM

Topic: Earth & Space Sciences *Skill: Knows Science*

Each year the Earth makes one orbit around which of the following?

A.* The Sun
B. Saturn
C. The Moon
D. All the planets

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	53	61	53	72	69	55	66

Figure 5 5 presents a knowledge-based question on the structure of the solar system Overall, 62% of 9-year olds answered the question correctly In Ireland, 53% answered correctly and more boys than girls chose the correct answer

Responses from school principals suggest that the topic Earth and Space Sciences is emphasized 'a lot' in 18% of third classes Fifty-six percent reported 'some' emphasis, whereas 25% indicated that the topic is not emphasized at all This can be contrasted with averages for Physical Science where 65% of principals reported that the topic is not covered at all

Nature of Science

The eight questions on the Nature of Science were designed to assess pupils' knowledge and understanding of the characteristics and methods of scientific inquiry This section of the test focuses on observing, organizing/classifying, measuring, recording results, and inferring meaning In addition, some questions assess familiarity with designing experiments and conducting inquiries Irish pupils correctly answered, on average, 60% of these questions, significantly below the international average of 64 percent. Proportionally, girls achieve at the same level as boys on questions assessing the Nature of Science, making it and Life Sciences the only topics on which achievement does not seem to be associated with gender at the 9-year old level

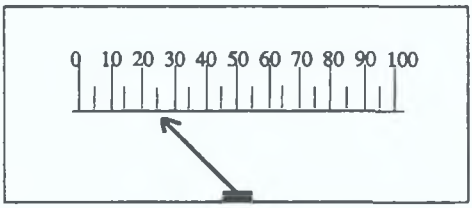
Average Irish scores lag behind those of the six countries in the comparison group, as shown by the column of minus signs in Table 5 4 Pupils in the United States did particularly well on questions assessing the Nature of Science In this context it may be relevant that 39% of American principals reported emphasizing scientific processes 'a lot' at this grade level In contrast, only 6% of Irish principals indicated this degree of emphasis Half of Scottish and 81% of English schools also lay heavy emphasis on this aspect of science According to information provided by school principals, the design of experiments is stressed 'a lot' in the Environmental Studies syllabus in only a handful of Irish third classes

The question in Figure 5 6 required pupils to read a weight in kilograms from a scale Over all 14 countries, the average percentage correct is 81 on this question, whereas in Ireland it is 70 Irish boys performed better than girls As evident from the figures accompanying the question, the attainment of Irish 9-year olds is not as good as that recorded in the comparison countries

FIGURE 5.6

READING SCALES

Topic: Nature of Sciences *Skill: Knows Science*



What weight does the scale drawn above show

A. 22 kilograms
B. 25 kilograms
C.* 27 kilograms
D. 30 kilograms

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	70	76	77	76	79	78	93

A more complex question (Figure 5.7) required pupils to understand the information contained in a table and draw a conclusion based on the information. Roughly half of pupils world-wide correctly selected option A. English children, with an average percentage correct of 60, performed best on this question whereas only 38% of Taiwanese children answered it correctly. Fewer Irish pupils chose the correct answer than pupils in any Western European country. Irish boys and girls answered the question correctly in equal proportions.

FIGURE 5 7

DRAWING A CONCLUSION FROM AN EXPERIMENT

Topic Nature of Sciences *Skill Knows Science*

Name of Substance	Will Attract	Will Not Attract
Iron Nail	X	
Wooden tootpick		X
Glass Marble		X
Steel Spoon	X	
Silver Coin		X
Copper Wire		X

Sally tried a magnet on several objects and made the table above What can Sally correctly say from this information?

A * Magnets attract some metals but not others
B Magnets attract all metals and do not attract any non-metals
C Magnets attract some glass items
D Magnets attract wood

	Ireland	England	Scotland	Spain	US	Canada	Korea
% Correct	44	60	58	48	49	49	55

SCIENCE PERFORMANCE OF 9-YEAR OLDS BY COGNITIVE PROCESS

The performance of pupils in all countries was fairly consistent across all three cognitive processes Irish pupils score below the mean in each of the categories Knows Science (-7%), Uses Science (-5%) and Integrates Science (-4%) The highest scorers in Knows Science are pupils in Italy (Emilia-Romagna) and Korea, the lowest scorers are in Ireland and Portugal Taiwanese and Koreans do best in Uses Science, Portuguese and Slovenians do worst On questions assessing Integration of Science, Taiwan and Korea again lead the way, Ireland and Portugal are ranked lowest In Ireland, boys attain higher scores than girls in Knows and Uses Science but girls' scores are equivalent in Integrates Science

CONCLUSION

The average scores achieved by Irish pupils are among the lowest on the test administered to 9-year olds. Pupils in all but Portugal and Slovenia attain higher average scores. The relative performances of Ireland's 'best' and 'weakest' pupils are also among the lowest of all countries. Many of the weakest Korean and Italian pupils attain scores comparable to average pupils in Ireland. The relatively low achievement of Irish pupils is evident in all aspects of the test with the exception of Earth and Space Sciences on which Irish scores are close to the international average. Moderate emphasis is said to be placed on Life Sciences and the Nature of Science in Irish third classes whereas very little is placed on Physical Sciences or on the Nature of Science.

In many countries, including Ireland, boys achieve at higher levels than girls. In Physical Sciences, Earth and Space Sciences, Knows Science, and Uses Science, the scores of Irish boys are higher. Girls perform just as well in Life Sciences, the Nature of Science, and Integrates Science.

Chapter 6. 13-Year Olds in School and at Home

CHARACTERISTICS OF THE COUNTRIES

The students who participated in the survey of 13-year olds were drawn from 20 countries, which included countries in Western and Eastern Europe, North and South America, the Middle and Far East, and Africa Half of the countries are European One participating country, China, is home to almost a quarter of the earth's people Other large countries are Brazil, the Soviet Union, and the United States The smallest country in population, Slovenia, has fewer people than individual cities in many of the participating countries Demographic and other system-wide data for the participating systems are presented in Table 6 1 In this table, the data reflect the entire country, even though only particular regions (e g , Emilia-Romagna in Italy, 15 Swiss cantons) or cities (e g , São Paulo and Fortaleza in Brazil) may have been included in the study

Ireland is one of the least urbanized countries in the study, with 57% of the population living in urban areas Half of the countries are at least 75% urban, a fact that undoubtedly shapes educational practice, for example in relation to school size Great variation in wealth is evident across the countries The per capita Gross National Product is highest in Switzerland (IR£19,108), followed by the US, Canada, and France

Comparatively, Ireland spends a higher percentage of its wealth on education than do most other countries in the study The percentage of GNP spent on education in Ireland in the late 1980s was estimated to be around 6 7, compared to 10 2 in Israel and 2 7 in China Among the eight participating Western European countries, the average percentage of GNP spent on education was 4 9

In most countries, compulsory schooling begins at age six In England and Scotland, children commence the first of the formal grades (equivalent to first class in Irish primary schools) one year earlier, whereas in Brazil, China, Mozambique, Slovenia, the Soviet Union, and the German-speaking part of Switzerland, entry to the first grade is delayed until children are aged seven Some countries provide education before the age of compulsory schooling also For example, though the law in Ireland does not require children to attend school until they are aged six, almost all are enrolled in primary schools for two years prior to their entry into the first grade During the course of these two years in 'infant' classes, children receive substantial amounts of academic instruction in a relatively formal educational environment (O'Rourke & Archer, 1987) Similarly, though French children are not required to attend school until they are

six, many are enrolled in state-provided preschool programmes from an early age.

TABLE 6.1

CHARACTERISTICS OF THE COUNTRIES

	Population	Percentage Urban	Per Capita GNP[a] (£)	Percentage GNP on Education	Age Start School
Brazil	150,368,000	75	1,549	3.3	7
Canada	26,620,000	76	11,943	7.4	6
China	1,133,683,000	26	246	2.7	6.5 or 7
England[b]	47,536,000	92	7,533	5.2	5
France	56,647,000	73	11,329	6.1	6
Hungary	10,437,000	62	1,718	5.7	6
Ireland[c]	**3,509,000**	**57**	**5,246**	**6.7**	**6**
Israel	4,666.000	89	6,129	10.2	6
Italy	57,512,000	65	9,532	4.0	6
Jordan	3,169,000	70	1,054	7.1	6
Korea	42,793,000	70	2,679	4.5	6
Mozambique	15,696,000	13	78	—	7
Portugal	10,388,000	30	2,581	4.4	6
Scotland[b]	5,094,000	92	7,533	5.2	5
Slovenia	1,948,000	74	4,991	3.4	7
Soviet Union	290,122,000	66	6,022	7.0	6 or 7
Spain	39,618,000	76	5,574	3.2	6
Switzerland	6,756,000	60	19,108	4.8	6 or 7
Taiwan	20,221,000	74	3,005	3.6	6
United States	251,394,000	77	13,654	7.5	6

Unless otherwise stated, data reflect the entire country, not merely the participating region, or city.

[a] Per Capita Gross National Product figures in Irish Pounds (calculated from US dollar figures at exchange rate of IR£1 = $1.45).

[b] With the exception of population figures, English and Scottish figures are based on estimates for the United Kingdom.

[c] The Age Start School figure for Ireland reflects the fact that children are legally required to begin school at age six. It should be noted, however, that almost all Irish children are enrolled for two years in primary school infant classes which are freely available to all children and which include significant academic work.

CHARACTERISTICS OF SCHOOLS

System Characteristics

The duration and structure of the school year differs from country to country The school year in Irish post-primary schools begins in early September and concludes at the beginning of June, a pattern similar to that in North America. However, in some countries, the timing and structure of the school year is determined locally, especially in countries with federal governmental structures such as Switzerland and Germany This can result in substantial differences in practice from region to region Other aspects of time in school may also be of interest, such as its allocation to various subjects within the curriculum and the amount of time actually spent by students learning This latter aspect of time in school, sometimes referred to as 'time-on-task,' is based on calculations that specifically exclude time spent by students on school-based activities such as educational tours, sporting events, fund-raising, and other non-academic activities that are, nonetheless, integral parts of the school calendar in many educational systems

To get a more precise measure of time spent directly on school-related activities, school principals were asked to indicate the actual number of days per year devoted solely to instruction Further information was obtained about the amount of time devoted to mathematics and science in the curriculum each year This subject-specific information will be presented later in the chapter

By comparison with the educational systems involved in the study, Ireland has a relatively short school year for 13-year olds but a relatively long school day In Portugal, students spend on average 172 days a year in school, as compared with 173 days in Ireland France and the United States also have a relatively short school year with, on average, 174 and 178 days respectively In contrast, Korea and Taiwan both have school years, on average, of 222 days duration, whereas Chinese 13-year olds attend school for 251 days per year Within some systems, there is considerable variation in the length of the school year from school to school It is likely that some of the variation reflects the policies of regional or otherwise decentralized school administrations within countries For example, recent research indicates that in Switzerland and Spain, most educational decisions are made at the school or regional level (Organisation for Economic Co-operation and Development, 1993), In Switzerland, each of 26 cantons formulates separate policies concerning educational policy, teacher certification, curriculum, instructional materials, and standards (Lapointe et al, 1992) In Ireland, 65% of schools report working fewer than 176 days with the remaining 35% opening for between 176 and 200 days Average figures for Ireland and eight education systems of particular interest are presented in Table 6 2

TABLE 6.2

TIME SPENT IN SCHOOL (AGE 13)

	Ireland	England	Scotland	France	Spain	Switz	US	Canada	Korea
No. of Days[a]									
151 - 175	65	3	3	49	30	15	23	1	0
176 - 200	35	91	97	40	40	39	77	99	0
200 - 225	0	5	0	6	26	14	0	0	77
225	0	0	0	0	0	32	0	0	23
Average Days[b]	173	192	191	174	188	207	178	188	222
Average Hours[c]	931	960	1031	1073	893	1052	1003	953	977

[a] Figures in the first four rows indicate the percentage of schools in each country reporting school year lengths in the different bands.

[b] Number of days in the school year averaged over all sampled schools in each country.

[c] Length of the school year in hours averaged over all sampled schools in each country.

At the time when this survey was conducted the official number of school days in the post-primary school year was 180 for students involved in public examinations and 168 for other students, including those in first year. The item on the questionnaire sent to school principals asked: 'How many days of student instruction are there in the school year?' Principals would probably not have included days assigned for trips, sports, meetings with parents, etc. in their estimate of the instructional year. It is also possible that some principals interpreted the question as referring to the school year for examination classes while some reported figures for non-examination classes. The average of 173 days instruction per year confirms the findings of Burke, Dobrich, and Sugrue (1992) who reported the same figure.

The average duration of instruction during each school day in each country was obtained from school principals' responses to a question concerning the number of minutes instruction in each school day. The question referred only to instruction for 13-year olds, not the entire student body in the school. Instruction included classes in art, music, and physical education, but excluded lunchtime, break, time spent changing classes, and study periods. The instructional day for Irish 13-year olds was reported to be, on average, 323 minutes (5 hours and 23 minutes) which is longer than for most of the countries in the study. France, however, is the country in the study with the most time devoted to instruction

each school day, with an average of 6 hours 10 minutes Though Ireland and France share a school year of similar duration, the extra 47 minutes instruction each school day for French students accumulates to an extra 142 hours instruction per year The United States also has a relatively long school (instructional) day of 5 hours and 38 minutes Over the course of the school year, Irish students receive an estimated 931 hours of instruction on average, as shown in the bottom row of Table 6 2 This is less than in the other reference countries with the exception of Spain, where students receive 893 hours instruction The figures for Ireland can be compared with the findings of Burke et al (1992) who found that the average time spent on instruction each day, including assessment and examination time with first and second year classes, was 304 minutes, which gives a total of 828 hours each year These findings constrast with the those in our study and highlight the need to interpret data from surveys carefully

Various characteristics of school-related life in Ireland and in some other countries are presented in Table 6 3 The average class size for first year students in Ireland is 27 Taken over all countries, the average class size is 30 students This average is influenced greatly by the inclusion of four systems with unusually large classes (Korea, 49, Taiwan, 44, China, 48, and Mozambique, 51) When these systems are removed from the calculations, the average drops to 26 Of the Western European countries, only Spain, with 29, has an average class size that is larger than Ireland The lowest class size is in Switzerland, which has an average of 18

Approximately one-quarter of Irish 13-year olds are enrolled in classes containing fewer than 25 students In contrast, over half of English, Scottish, and American students attend classes with fewer than 25 students On the other hand, the majority of Korean (93%) and Taiwanese (71%) students attend classes that have more than 45 students

On average, Irish post-primary schools are smaller in size than schools in most participating countries According to information provided by school principals, approximately two-thirds of post-primary schools in the survey enrolled fewer than 500 students (67% of schools) This is roughly in agreement with Department of Education statistics (63% of schools) for the year when the survey was conducted (Ireland, Department of Education, 1992) In the survey schools, 8% of 13-year olds were enrolled in schools that had more than 750 students (The population in Department of Education statistics is one-fifth)

There is a tendency toward larger schools in many of the other countries in the study For example, over half the English and Scottish students are in schools of over 750 students and over three-quarters of Korean and Taiwanese teenagers

attend schools of more than 1000 students. Two interesting exceptions to this rule are France and Switzerland. In Switzerland, nearly two-thirds of students attend schools enrolling fewer than 500 students.

TABLE 6.3

SCHOOL CHARACTERISTICS (AGE 13)

	Average Class Size[a]	Large Schools[b]	Computer Availability[c]	Computer Use[d]	General Homework[e]
Ireland	27	21	45	13	65
England	22	51	88	44	30
Scotland	24	58	89	38	14
France	25	24	71	57	55
Spain	29	31	13	12	63
Switzerland	18	10	20	25	21
United States	23	44	88	37	30
Canada	25	30	69	42	27
Korea	49	79	55	10	40

[a] Average number of students in classes that include most 13-year olds
[b] Percentage of students in schools with a total enrolment of more than 750 students
[c] Percentage of students in schools with at least 10 computers available for use by 13-year olds .
[d] Percentage of students who *ever* use a computer for schoolwork or homework
[e] Percentage of students who spend 2 hours or more on general homework every day. Percentages for each country reflect the average of responses to the homework question from the mathematics and science sample, i.e. (Mathematics + Science) ÷ 2

The provision of computers to post-primary schools has increased in recent years. Most schools in Ireland have already invested in such equipment, and instruction in their use for various parts of the curriculum is provided for students. New Junior Certificate syllabi in Business Studies and Technical Graphics that incorporate computer-based learning have given new impetus to the introduction of computing technology to schools.

The school questionnaire sought information on the numbers of microcomputers or terminals available for 13-year old students to use. Students were asked about the degree to which computers are used by them in completing work either in school or at home. Not surprisingly, the availability of computers to 13-year olds varies from country to country. Almost all English and Scottish students attend schools that have 10 or more computers available for their use

whereas only 13% of Spanish students have such a number of computers available in school In Scotland, over half the students are in schools that have more than 40 computers available for 13-year-olds Forty-five percent of Irish students attend schools that have at least 10 computers while 18% have no computers at all in their schools Many of the systems reporting widespread availability of computers also tend to have larger schools, for example England, Scotland, the US, Canada, Korea, and Taiwan Economies of scale may partly explain the distribution of computing facilities across the countries in the study

The use of computers for schoolwork or homework varies also by country Such use is not common among Irish, Spanish, or Korean 13-year olds Only 13% of Irish students reported ever using computers for school-related work as compared with considerably more Scottish, English, and French students The average percentage of questions answered correctly by students in Ireland who use computers does not differ from the average of those who do not use them

Irish students spend more time completing their nightly homework in all subjects than is common in many other countries Roughly two-thirds of Irish 13-year olds report spending two hours or more on general homework each day, a proportion similar to that recorded in Italy (Emilia-Romagna), Spain, and Hungary Spending this amount of time on general homework is much less common among students in Scotland, England, Switzerland, and the United States

This study does not reveal any simple relationship between the amount of time spent in school and performance on the mathematics and science tests While some high-performing countries have a longer school year or a longer school day, these characteristics were also present among some low-achieving countries For example, the high-achieving Oriental countries in mathematics (China, Korea, and Taiwan) do have long instructional years However, some countries with relatively long school years perform at relatively low levels on the mathematics test (Slovenia, Spain, and Jordan) On the other hand, although the school year in Hungary is 273 hours shorter than in Ireland and despite the fact that a similar time is devoted to mathematics annually, the average mathematics achievement of Hungarian students is among the highest of all countries This ambiguity is in keeping with many studies that specifically examined the influence on achievement of longer school years (for a review, see Frederick & Walberg, 1980)

A series of analyses linking school, classroom, and personal student variables to achievement in mathematics and science were conducted It was found that the amount of time spent on general homework is positively and linearly related

to mathematics and science performance in Ireland. Students who spend longer on general homework each day tend to achieve at higher levels on both tests. This association was also recorded in England, Scotland, France, Taiwan, Hungary, the Soviet Union, Jordan, and Fortaleza, Brazil. In some countries, even though higher mathematics scores are associated with more homework, higher science scores are not, and vice-versa. In one country, Canada, homework is negatively associated with mathematics and science achievement.

The Teaching of Mathematics

We saw earlier that Irish 13-year olds are in school for fewer hours in a year than students in most other participating countries. Irish students also receive the least amount of mathematics instruction in a year, being in mathematics class, on average, for 109 hours a year. Systems with roughly similar patterns in relation to mathematics are Hungary (110 hours), Jordan (115), Slovenia and Portugal (119 each). Schools in Switzerland, the Soviet Union, Taiwan, Israel, and Spain offer considerably more instruction in mathematics. Relevant figures for Ireland and other countries of interest are presented in Table 6.4.

According to information provided by school principals, Irish post-primary schools spend approximately 12% of the available instructional time in first year on mathematics, roughly the same as in France, Portugal, England, the US and Taiwan. One of the highest-achieving systems - the Soviet Union - spends just over one-fifth of curricular time on mathematics, as does Fortaleza, Brazil, one of the lowest-achieving systems. In Switzerland, approximately 16% of time is devoted to mathematics; in Korea the figure is 14%; and in Hungary, another high-performing country, 17% of the time during the relatively short school year of 658 hours is devoted to mathematics.

Regular tests or quizzes throughout the week at school are not common for Irish students, with only one-fifth reporting that they take at least one test per week. In no country is a lower level of regular testing evident. Within systems, the association between number of tests taken per week and student performance on the mathematics test is not consistent. In Ireland, frequency of testing is not associated with achievement. Positive relationships between testing and achievement, however, are evident for France, the US, Canada, Taiwan, the Soviet Union, and Mozambique. In nine countries, greater levels of testing is associated with lower achievement.

TABLE 6 4

THE TEACHING OF MATHEMATICS (AGE 13)

	Hours Maths Per Year[a]	% Instructional Time on Maths[b]	% Tested Once per Week[c]	% Streamed by Maths Ability[d]	% Taught by Specialists[e]
Ireland	109	12	19	72	65
England	122	13	28	92	99
Scotland	134	13	17	18	100
France	133	12	64	19	94
Spain	147	16	31	2	87
Switzerland	173	16	40	14	32
United States	135	13	68	64	96
Canada	141	15	53	14	43
Korea	132	14	28	0	96

[a] Average hours of mathematics instruction received by students annually
[b] Percentage of total annual instructional time for all subjects devoted to mathematics
[c] Percentage of students who take a mathematics test or quiz at least once a week.
[d] Percentage of students in schools that stream first year mathematics classes by ability
[e] Percentage of students taught by teachers who teach mathematics most or all of the time

Streaming of post-primary students into mathematics classes using ability as a placement criterion is common in Ireland Seventy-two percent of Irish 13-year olds are enrolled in schools that practice streaming Only in England is streaming more widely applied, where 92% of students are streamed Streaming for mathematics classes is also common in schools in Israel, Taiwan, and the United States Most countries in the survey, however, prefer to place 13-year olds in mixed-ability classes For example, in France four-fifths of students and in Hungary all students are taught in mixed-ability classes

Irish 13-year olds are generally taught mathematics by specialist teachers, that is, teachers whose primary responsibility is to teach mathematics most of the time There are specialist teachers of mathematics in 71% of Irish schools, catering for 65% of students In most other countries, higher proportions of students are taught by specialist mathematics teachers For example, virtually all students are taught by mathematics specialists in England, Scotland, France, Portugal, the Soviet Union, the US, Korea, Taiwan, and China School principals in countries that mainly use specialist teachers reported that most of the teachers had taken some post-secondary course in mathematics apart from courses in how to teach the subject An interesting exception to this pattern is Korea, where seven out of ten principals reported that none of the teachers had taken post-secondary

mathematics courses. Therefore, the majority of teachers of mathematics in Korea teaching that subject most or all of the time have no formal academic qualifications in mathematics above those obtained in secondary school.

It was reported earlier that Irish 13-year olds spend more time on general homework than students in most other countries (see Table 6.3 and Table C-11 in Appendix C). However, Irish students do not spend an unduly large amount of time on mathematics or science homework. For example, students in seven countries spend more time on mathematics homework each week. Seventeen percent of Irish students spend four or more hours on mathematics homework weekly, though half of them spend one hour or less. One hour or less was the most common response in most countries with the exception of China, Israel, and Korea. In China, the most common response was four hours or more, whereas in Israel and Korea it was two to three hours a week. In Ireland and in 13 other countries, more time spent on mathematics homework is associated with higher performance on the mathematics test.

Irish students tend to work less often with mathematics objects such as counting blocks, geometric shapes, or geometric solids than do students in most other countries. The use of electronic calculators is also less common in Ireland than in most countries. Whereas in Ireland, just 25% of students report using a calculator in school, in England, Scotland, France, Canada, Hungary, and Taiwan, over two-thirds of students say that they used a calculator in school. In these six countries, the average mathematics score of the group of students that use calculators is significantly higher than the average scores of the group that does not. In Ireland, however, there is no difference between the average mathematics scores of the two groups.

The Teaching of Science

On average, first year students in Ireland receive approximately 2 hours and 40 minutes of science instruction per week. Combined with information on the length of the school year, it can be calculated that, on average, Irish secondary schools provide 92 hours of science instruction per year for their first year students (Table 6.5). Only Fortaleza (Brazil) and Portugal offer fewer hours science instruction annually. In most countries, between 10% and 14% of curricular time is spent teaching science. The one-tenth of time devoted to science in the Irish curriculum is roughly similar to the proportion spent in Scotland, France, Switzerland, Canada, and Korea (see Table C-1 in Appendix C). However, although the proportion of curricular time spent on teaching science in Ireland is similar to these countries, Irish students receive fewer hours science instruction annually because of their relatively short school year.

TABLE 6 5

THE TEACHING OF SCIENCE (AGE 13)

	Hours Science Per Year[a]	% Never Experiment[b]	% Special Labs[c]	% Streamed by Science[d]	% Science Homework[e]
Ireland	92	27	61	34	5
England	124	2	79	49	2
Scotland	114	3	95	2	2
France	101	20	78	10	1
Spain	118	51	78	0	12
Switzerland	105	36	54	15	1
United States	138	25	54	27	7
Canada	98	13	38	7	4
Korea	107	35	41	1	9

[a] Average hours of science instruction received by students annually
[b] Percentage of students who never conduct experiments individually or in groups in school
[c] Percentage of students in schools with one or more specialized laboratories (chemistry, biology physics)
[d] Percentage of students in schools that stream first year science classes by ability
[e] Percentage of students who spend 4 hours or more on science homework every week.

Regardless of how long is spent in science class each year, little will be learned by students unless the time is used in a way that facilitates learning Various instructional strategies are typically used by teachers, for example, lecturing, group work, discovery learning, and experimentation The introduction of audio, video, and computer equipment into secondary schools has further widened the instructional resources available, especially in the teaching of science The increasing emphasis on developing students' laboratory skills in Britain and the United States reflects increasing interest in experimentation in science syllabi in those educational systems (Rosier & Keeves, 1991) In Ireland, laboratory work in secondary school science has received particular attention in the new science syllabus for the Junior Certificate recently introduced into schools Under the new guidelines, teachers are expected to develop in their students 'manipulative skills procedural skills skills of observation and practical investigation' (National Council for Curriculum and Assessment, 1989b, p 5)

In light of these trends, it is revealing to note that less than half of Irish 13-year olds conduct experiments on their own or in groups at least once a week and that slightly over a quarter never conduct science experiments at all in school Among

participating countries, there is great variation in the extent to which students engage in experimental work in school. In Spain, for example, over half the students report never doing practical, hands-on science work. The fact that there is relatively little emphasis on practical work can be inferred also from responses from students in Italy (Emilia-Romagna), Switzerland, Korea, Israel, Portugal, and Brazil. Scientific experimentation is very much used as a teaching strategy in England and Scotland, however, where over 80% of students report practical work at least once a week and over half carry out experiments several times each week. In contrast, only 12% of Irish students engage in practical work more than once per week.

The nature of post-primary science syllabi would seem to require the existence of adequate laboratories in schools. However, almost one-quarter of Irish principals (representing schools enrolling almost one-fifth of students) reported that their schools had no science laboratories whatsoever. With the exception of Switzerland, where 45% of schools report no labs, no other Western European system has so few laboratories. The lack of science facilities in Swiss schools may be partly explained by the unusually small size of school in that system. In Ireland also, it is likely that many of the schools reporting that they have no laboratories are the smaller ones.

The availability of specialized laboratories for biology, chemistry, and physics for 13-year olds varies greatly across systems in the study. Almost all Soviet, Scottish, and Taiwanese students attend schools that have separate laboratories whereas such extensive facilities are rare in Italy (Emilia-Romagna), Jordan, and Mozambique. In Ireland, 61% of students attend schools that have separate specialized laboratories.

Thirty-four percent of Irish students attend schools where science classes are streamed by ability. This is a high percentage compared to other countries, only a few of which favour grouping by ability, namely Taiwan, England, the US, and Brazil (Fortaleza).

It was noted above that most Irish students report spending one hour or less on mathematics homework each week. The same is true of science, with just under three-quarters of students falling into this category. Two or three hours is spent weekly on science homework by one-fifth of students, while, as shown in the last column of Table 6.5, 5% report spending four hours or more. Spending four or more hours on science homework each week is less common in other Western European countries with the exceptions of Portugal and Spain. Overall, students in 12 countries spend more time on science homework than 13-year olds in Ireland. In seven countries, including Ireland, spending more time on science homework was found to be related to higher science achievement; the

group of Irish students who spent two or more hours on science homework attained, on average, at least 5 percentage points more on the test than the group who spent one hour or less

Weekly testing of students in science is not common in most systems in this study Only in four countries (the Soviet Union, Taiwan, Jordan, and the United States) did more than two-thirds of students report taking a science test at least once a week In all other countries, fewer than half of the students reported being tested as frequently as once a week Fewer than one-fifth of Irish students are tested so frequently, and the science scores of the frequently tested group were found to be no higher, on average, than scores of students who are tested less frequently

CHARACTERISTICS OF HOMES

Many studies (e g , Coleman et al, 1966, Peaker, 1967, White, 1982), including ones in Ireland (e g , Kellaghan, 1977, Kellaghan & Macnamara, 1972), have documented the relationship between the home environment of a child and achievement at school Data concerning home characteristics included in the present study relate to family size, number of books in the home, television viewing patterns, interest in reading, and parental attitude to education Data were also obtained on students' self-assessment of their mathematical and scientific knowledge The relationships between these variables and achievements in mathematics and science were examined

Family size was found to be relatively small in most of the industrialized countries in the study As evident from Table 6 6, however, Ireland is unusual in that more than one-third of its 13-year olds reported that they have four or more brothers and/or sisters This proportion of students from large families far exceeds that recorded in most other countries Only in Jordan and Mozambique are there higher proportions of students with such large families An examination of the relationship between family size and academic performance within each country found a negative relationship in most cases Ireland was one of the few exceptions to this pattern, no association was found between family size and achievement in either mathematics or science

Approximately one-quarter of Irish 13-year olds come from homes in which there are fewer than 25 books This is comparable to the percentages reported for France, Scotland, and Korea, but higher than those in England, Switzerland, Canada, and the US In only two industrialized countries (Taiwan and Portugal) do more than a quarter of students say that they have fewer than 25 books in the home In almost all countries, including Ireland, there is a positive association

between the number of books in the home and student achievement in mathematics and science.

Approximately 4 out of 10 Irish students report reading for fun every day (32% read once or twice a week, 11% read once or twice a month; and 16% never or hardly ever read for fun). The proportion reading each day is similar to that in most other Western European countries where reading almost every day is the most common response among students. Switzerland contains the highest proportion of daily readers, Korea and Taiwan, the lowest. Less than 30% of 13-year olds in Korea, Taiwan, China, Jordan, and the United States report reading for fun on a daily basis. Indeed, only 11% of Koreans report reading daily, the lowest level in all the countries studied. This is also well below the 25% of their 9-year olds who reported reading on a daily basis. Though a minority of Irish students report reading every day, a total of 73% read for fun at least once a week (including the every day group). More disturbing, perhaps, is the finding that 16% of Irish 13-year olds never or hardly ever read at home. In Ireland, as in most other countries, students who read more frequently tend to perform at higher levels on the achievement tests. This positive relationship holds also in countries such as Korea and Taiwan where relatively few students seem to read for fun every day.

A study of the television viewing patterns of students in the study reveals the most common response to be that between two and four hours television is watched each school night. In Ireland, almost two-thirds of students indicate this level of viewing. Twenty-seven percent report watching one hour or less. More prolonged television viewing, five hours or more daily, is reported by 9% of Irish teenagers. The percentage of Irish students that report such prolonged television viewing is substantially less than the corresponding percentage in England and Scotland. At 24%, Scotland's percentage of students watching five or more hours television per day is the highest across all countries. Over one-fifth of 13-year olds in five systems (Israel, Scotland, the United States, Fortaleza, and Mozambique) report watching television for such extended periods, whereas in Slovenia, France, and China, the figures are one-twentieth or less. A majority of students in France and China watch one hour or less per evening. The reasons for this in the case of French youth are unclear. However, it can be assumed that the Chinese figure reflects the limited availability of television.

TABLE 6 6

CHARACTERISTICS OF HOMES (AGE 13)

	More Than 4 Siblings[a]	Fewer Than 25 Books in Home[b]	Read for Fun Every Day[c]	Watch TV 5+ Hours/Day[d]
Ireland	35	24	41	9
England	9	15	39	19
Scotland	9	25	38	24
France	11	25	40	5
Spain	11	20	35	11
Switzerland	4	16	50	7
United States	17	18	29	21
Canada	8	14	37	15
Korea	20	25	11	11

Note All figures in this table were obtained by averaging the percentages separately provided by the mathematics and science samples of students

[a] Percentage of students who have 4 or more siblings

[b] Percentage of students with fewer than 25 books at home

[c] Percentage of students who read for fun almost every day

[d] Percentage of students who watch television at home for 5 hours or more every school day

In eight countries, including Ireland, lower achievement is found among 13-year olds who watch greater amounts of television nightly In Ireland, this negative association is especially evident among students in the prolonged-viewing group (5 hours or more) In mathematics, the average percentage of items correctly answered by students in the 5+ hours group is 11% lower than in the group of students who watch television for two to four hours per night and 14% lower than in the group that watch one hour or less Students who watch television for less than one hour per night also have an average score which is three percentage points higher than the average score of the group who watch for two to four hours

Students were asked to indicate how often they watch a film, video, or television programme about science at home Almost half the Irish 13-year olds report that they never watch any television programmes containing substantial scientific content This is a high proportion compared to all other countries in the study, but especially compared to Western European countries, in most of which only between 20% and 30% of students report that they do not view scientific programmes Students in continental European countries are much more likely to watch television programmes containing scientific content than are students in Ireland, England, or Scotland

Attitudinal Characteristics

Information on student and parental (as reported by the students) attitudes to mathematics and science was collected as part of the survey. Responses to four questionnaire items were combined to form one index of student attitude to mathematics (see Figure 6.1). A similar index of attitude to science was constructed. Students were asked to indicate to what extent they agreed with each of the statements in Figure 6.1 and, on the basis of their responses, were categorized as generally holding positive, negative, or neutral attitudes.

FIGURE 6.1

EXTRACT FROM IAEP STUDENT QUESTIONNAIRE: VIEWS ON MATHEMATICS

- Mathematics is useful in solving everyday problems.
- It is important to know some mathematics in order to get a good job.
- I am good at mathematics.
- My parents want me to do well in mathematics.

The majority of students in the study expressed positive attitudes toward mathematics and science, though the proportion expressing positive attitudes is substantially lower for science than for mathematics, a finding in all countries with the exception of Jordan where science was more favourably viewed. In Ireland, 88% of respondents hold generally positive views on mathematics, whereas over 90% are positive about it in England, Scotland, the US, Canada, and Israel. In 11 countries, attitude is related to achievement levels in mathematics, though Ireland is not one of these countries. Many students in high-performing countries (Korea, Taiwan, the Soviet Union, and China) do not view mathematics as positively as might have been expected; only between 70% and 80% of them are positive about the subject. For example, 3 out of every 10 Taiwanese children can be classified as holding negative, or at best neutral, positions about mathematics.

In all countries, with one exception, the majority of students exhibit generally positive attitudes to science. The exception is Korea, in which only 27% of students report positive attitudes. When combined with the fact that Koreans also seem to be the least positive about mathematics at age 13, it seems ironic that they do particularly well in both subjects. Fifty-seven percent of the Irish cohort can be classified as holding favourable attitudes to science, 36% are undecided, and 9% are negative. The proportion who hold positive attitudes is comparable to that of most of the country's Western European and North American

neighbours The possible importance of student attitude is underscored by the finding that when analyses are conducted within each country, a positive association between science achievement and attitude is found in 14 countries, including Ireland

Approximately 6 out of 10 Irish students report that they receive help with mathematics homework at home, a proportion roughly comparable to that found in most other Western countries The nature of the help offered by parents (or older siblings) is unknown However, it is clear from the analysis of these data that in Ireland, the group of students who receive help do not achieve at higher levels in mathematics than students who receive no help It may be that weaker students are more likely to obtain help

Whatever about actually receiving help with mathematics from parents, the vast majority of students in all countries agreed with the statement that their parents wanted them to do well in the subject In Ireland, 94% of 13-year olds hold this view When analysed within countries, agreement with the statement is positively related to mathematics performance in eight countries, including Ireland Seventy percent of Irish students report that they discuss what they learn in mathematics class in the home It seems that parents are more likely to convey an impression to their children that they want them to do well or to ask them about mathematics classes than they are to actually help them with homework

An indication of home support for science learning comes from student responses to a question as to whether or not anyone at home ever talks to them about what they learn in science class The level of interest shown by Irish parents is roughly similar to that shown by Western European parents in general In Ireland, the average percentage of items correctly answered by students in the group whose parents talk to them about science is 4 points higher than in the group of students whose parents do not talk to them It seems that parents are more likely to inquire about science than actually help their children with homework Forty-four percent of Irish 13-year olds indicated that they sometimes receive help with science homework

In most countries, between 30% and 60% of students agreed with the statement, 'My parents are interested in science ' In Ireland, the figure is 38 percent Spanish students report the highest degree of parental interest in science, while only 19% of Taiwanese students, one of the high-performing science groups, agree with the statement. A positive association between this variable and science achievement was observed in eight countries, including Ireland

CONCLUSION

Ireland, one of the least urbanized countries that participated in the survey, has an average per capita GNP slightly below the international mean but spends a relatively high percentage of GNP on education. The age at which children must attend school is similar to most other countries.

The length of the school year varies considerably from country to country and even within countries. Students from Oriental countries in the study spend the greatest number of instructional days in school each year, students in Ireland almost the least. Irish first year students receive relatively fewer hours instruction per year in all subjects, including mathematics and science. The average class size for 13-year olds is higher in Ireland than in most Western countries but is highest in the Far East. School size in Ireland is small compared to other countries; two-fifths of Irish students attend schools that enrol less than 500 students. There is wide variation in the availability and use of computers in schools, with more computers in countries that typically have larger schools. In Ireland, although half of students are in schools that have more than 10 computers, only 13% of students report using them. The obvious conclusion to be drawn is that the presence of computers in schools does not necessarily mean that they will be used regularly by students, a view confirmed by a recent international study on the use and integration of computers in education (International Association for the Evaluation of Educational Achievement, 1994). One-fifth of Irish first year students are enrolled in schools that have no computers. Students in Ireland tend to receive more homework in all subjects than in other countries but spend relatively less time on mathematics and science homework. The mathematics and science scores of students in Ireland who reported more hours spent at homework are higher than those reporting fewer hours.

Streaming of students into separate classes based on mathematics and science ability is more common in Ireland than in most countries. Students in Ireland take fewer tests and quizzes, work with calculators, practical objects, and other materials in mathematics less often, and engage in less experimentation and practical science work than in most other countries in the survey. One-quarter of Irish schools do not have any science laboratories.

The average family size in Ireland is relatively large and although in most countries, lower test scores are typically obtained by students from larger families, this was not the case in Ireland. The number of students who engage in leisure reading each day in Ireland is roughly similar to numbers elsewhere, although a relatively high proportion say that they never read for fun. More

regular reading is associated with higher test scores in many countries, including Ireland Television viewing patterns of Irish students are similar to those in other countries also Many more English and Scottish students, however, seem to spend a lot of time watching television each evening whereas French students say that they watch relatively little television Students in Continental European countries watch programmes about science more frequently than students in Ireland or Britain Lower test scores are obtained by students who watch greater amounts of television in Ireland and in many other countries

Students are, in general, positively disposed to mathematics, somewhat less to science In most countries, students who are more positive about a subject perform better on the test Many students reported that they receive help with homework, the percentage in Ireland is comparable to percentages elsewhere Students in Ireland perceive their parents to be interested in mathematics and science just about as much as students do in other countries

Chapter 7. 9-Year Olds in School and at Home

CHARACTERISTICS OF THE SCHOOLS

System Characteristics

Obtaining accurate and reliable information from young children, who are limited in their ability to read and understand written questions, is problematic. To keep the burden on the younger children to a minimum, only a few questions were included on the background questionnaire administered to 9-year olds. The questions dealt with basic biographical information, reading and television viewing habits, homework, attitudes to mathematics and science, and activities undertaken in mathematics classes in school. Additional information was obtained from the principal teacher in each primary school, who completed a detailed questionnaire which solicited information on the school, classes, and teachers, and on the syllabi being followed. Questions related to curricular issues focused on third class, as this was the class in which most of the 9-year olds were enrolled.

The official length of the primary school year in Ireland was 184 days at the time when the IAEP survey was conducted. However, the number of days devoted to instruction is usually less due to festivals, sporting events, and other exceptional closures. All schools in Ireland reported school years of between 176 and 200 days. The responses from most of the schools in Canada, England, Hungary, Italy (Emilia-Romagna), Scotland, Slovenia, and the United States also fall into the range 176-200 days. Portuguese, Soviet, and Spanish 9-year olds are more likely to be in school for fewer than 176 days, whereas the majority of Israeli, Korean, and Taiwanese pupils attend school for more than 200 days per year. All Korean schools enrol children for more than 200 days per year, with over one quarter offering instruction for more than 225 days. The percentages of pupils attending schools that offer more than 200 days instruction per year is given in Table 7.1 for selected education systems.

In half of the countries most 9-year old pupils receive between four and five hours instruction in school each day. These include Ireland (87% of pupils), England, Scotland, Canada, Portugal, Spain, and Taiwan. Over half the 9-year olds in the US receive between five and six hours instruction daily while a quarter receive more than six hours. Department of Education guidelines in Ireland mandate that 'the period of secular instruction to be provided for in the time-table of each school day must be at least four hours' (Ireland. Department of Education, 1965, p. 28). When time allocated to instruction in Religion is added, the effective guideline for instructional time is 4 hours and 30 minutes each day

in most primary schools in Ireland Burke et al (1992) calculated that the average instructional time during the school day is, in practice, 4 hours and 51 minutes, because teachers use some of the time allocated to morning assembly and roll call for teaching The figures yielded in the IAEP survey would seem to confirm the findings of Burke et al

TABLE 7 1

SCHOOL CHARACTERISTICS (AGE 9)

	200+ Days Per Year[a]	5+ Hours Per Day[b]	In Schools <11 Teachers[c]	One or More Computers[d]	Behaviour Problems[e]
Ireland	0	10	54	57	12
England	0	11	41	100	10
Scotland	4	8	29	97	11
Spain	23	16	5	25	32
United States	2	76	8	96	10
Canada	0	11	8	98	8
Korea	98	1	7	100	52

[a] Percentage of pupils in schools that provide instruction for more than 200 days per year
[b] Percentage of pupils in school that provide instruction for more than 5 hours per day
[c] Percentage of pupils in schools with fewer than 11 full-time teaching members of staff (excludes non-teaching principals or vice principals)
[d] Percentage of pupils in schools that have at least 1 computer available for 9 year-olds
[e] Percentage of pupils in schools with moderate or serious problems regarding pupil discipline

Though Irish primary schools tend to offer instruction for fewer days per year than some other countries, this is partially compensated for by a longer school day For example, Korea, in which the school year is at least 200 days, offers more than four hours instruction per day to just 6% of its 9-year olds Almost all Irish pupils (97%) receive more than four hours instruction each day

Of all 14 countries, only Portugal has a higher percentage of small schools (fewer than 11 teachers) than Ireland Eighty-two percent of Irish and 87% of Portuguese schools in the survey fell into this category In Ireland, such small schools contain 54% of pupils (Table 7 1), a finding that is confirmed by Department of Education statistics (Ireland Department of Education 1992) In contrast, only 20% of US schools are small, and just 8% of pupils attend them In Korea, 40% of schools are small, enrolling 7% of 9-year olds The Oriental countries seem to have many more pupils attending very large schools, i e , staffed by over 40 teachers Over two-thirds of pupils in Korea and Taiwan attend such schools No pupils in Ireland or Scotland and relatively few in England,

Spain, or the United States in the survey attended schools of this size. In some countries where average mathematics achievement was highest [Korea, Hungary, Taiwan, and Italy (Emilia-Romagna)], three-quarters or more of 9-year old children attended large schools staffed by more than 30 teachers.

It should be noted that there was a difference between the percentage of students found to be enrolled in schools of between 11 and 20 teachers in the IAEP study (41%) and percentages for the same school year provided by the Department of Education for schools of 11-19 teachers (33%). Similarly, Department statistics show that 12% of students attend schools that had 20 or more teachers, whereas responses to the IAEP survey showed 5% in schools that have more than 21 teachers. Slight variations in the cut-off figures used by both agencies (e.g., 11-20 teachers used by IAEP, 11-19 used by the Department) may explain some of the discrepancy.

The percentages of schools reporting that there are one or more computers available to the target age group are presented in Table 7.1. Fewer than half the pupils in Portugal, the Soviet Union, Spain, and Taiwan have access to a computer in school. Over all 14 countries, three of the four highest-achieving ones have relatively fewer computers than Ireland. Forty-seven percent of Hungarian, 46% of Italian (Emilia-Romagna), and 75% of Taiwanese children are enrolled in schools that do not provide any computers and who therefore, it can be assumed, do not teach mathematics or logic games using them. In England, Canada, and the United States, virtually all schools sampled provide computers for 9-year olds.

Twelve percent of Irish children are in schools in which principals report moderate or serious problems with pupil discipline. This is about the same as in England and Scotland. Fewer Canadian children are enrolled in schools with disciplinary problems. School environments with such problems are more prevalent in Spain and Korea than in Ireland. Other countries where principals report unusually high incidences of pupil misbehaviour are Hungary (32%), Slovenia (32%), and Israel (20%).

Typically, 9-year olds in the study spend less than one hour completing their homework for all school subjects each evening. In England, a majority of children reported that they usually do not have homework. In Ireland, 2% reported receiving no homework. One in six of the Irish 9-year olds reported that they spend two hours or more on all homework every day, roughly the same proportion as reported in the United States and Korea (see Table C-11 in Appendix C) but well above the proportions reported in Scotland and Canada. Spanish children spend more time on homework than Irish children.

The linear relationship between the amount of time spent on general homework and performance on the mathematics test was examined within each country in the study Time spent on homework was positively related to mathematics and science performance in Ireland, Israel, and Taiwan That is, pupils who spent longer on general homework each day tend to do better on both tests However, pupils who spend longer on homework in Scotland and Canada tend to do worse on the two tests

TABLE 7 2

PERCENTAGE DISTRIBUTION OF STUDENTS IN MODAL GRADE BY CLASS SIZE (AGE 9)

	Percentage of Children in Class				
	< 16	16-25	26-35	36-45	> 45
Western Europe					
Italy (Emilia-Rom)	46	48	0	0	6
England	1	21	75	3	0
Ireland [a]	11	9	56	24	0
Portugal	15	63	13	7	1
Scotland	5	28	66	0	1
Spain	2	30	53	15	0
Eastern Europe					
Hungary	4	58	32	1	6
Slovenia	2	57	41	0	1
Soviet Union	3	34	61	2	0
America					
Canada	2	36	60	0	1
United States	4	49	47	0	0
Middle & Far East					
Israel	1	12	59	22	5
Korea	0	3	7	10	79
Taiwan	0	1	9	21	68

Note Rows may not add to 100 due to rounding

[a] Irish figures are for third class where most 9 year olds are located

Table 7.2 shows the distribution of pupils across classes of different sizes. It is evident that third class children are taught in classes that contain significantly more pupils in Ireland than in other Western countries. Almost one- quarter of Irish children are taught in classes with more than 35 pupils compared with only 3% of English children. In contrast, 89% of Korean and Taiwanese children attend class with more than 35 pupils, the majority of them in classes with more than 45 pupils. None of the third class children assessed in Ireland were in classes that had more than 45 pupils. It is not possible from available statistics to directly compare the IAEP figures for Ireland with Department of Education statistics because of the way in which the data have been grouped. It does seem, however, that there is a considerable discrepancy between IAEP and Department figures for the percentage of students in very small classes. The IAEP figures show 11% of pupils (third class) in classes (classrooms) containing fewer than 16 pupils, Department statistics show 2.4% in classsrooms containing fewer than 19 pupils.

The Teaching of Mathematics

Table 7.3 includes information relevant to the teaching of mathematics to 9-year olds in Ireland and in the six countries in the restricted comparison group. Pupils in Ireland, England, Scotland, Italy (Emilia-Romagna), Portugal, and the United States typically receive more than five hours of mathematics instruction each week. Over a quarter of Irish pupils get less than four hours of instruction, however. Typically, between two and a half and three and three quarters hours of mathematics instruction is provided in Korean and Taiwanese schools, though these countries do have substantially more school days than Ireland or other European countries.

Irish pupils work on mathematics exercises on their own in class slightly more often than most other European children but they use mathematics tools and objects such as counting blocks, geometric shapes, and geometric solids about as frequently as children in most other countries. Korean pupils tend neither to work independently on problems nor with materials during school time. A majority of 9-year olds are in ability-based mathematics groups within their classes in Ireland, England, and Scotland. Grouping is less prevalent in all the other school systems. It should be noted that the countries with the highest achievement levels in Mathematics [Korea, Hungary, Taiwan, and Italy(Emilia-Romagna)] all report lower percentages of pupils in ability-grouped classes than Ireland, Scotland, or England. For example, in Taiwan, only 6% of children are grouped by ability for mathematics classes.

TABLE 7 3

THE TEACHING OF MATHEMATICS (AGE 9)

	5+ Hours Maths Per Week[a]	Work on Exercises on Own Often in Class[b]	Work With Maths Tools Often in Class[c]	Grouped by Maths Ability Within Classes[d]	2+ Hours Maths Homework Per Week[e]
Ireland	42	51	14	59	37
England	61	47	18	53	17
Scotland	72	48	13	90	16
Spain	55	60	23	13	54
United States	40	44	19	34	34
Canada	32	48	13	34	29
Korea	0	23	11	41	49

a Percentage of pupils who receive more than 5 hours mathematics instruction per week
b Percentage of pupils who often work by themselves on mathematics exercises during mathematics class
c Percentage of pupils who often work with mathematics tools during class
d Percentage of pupils in schools that group by ability within third class mathematics classes
e Percentage of pupils who spend 2 hours or more on mathematics homework every week.

The 9-year old pupils in the survey indicated that they typically spend less than one hour completing their mathematics homework each week Though less than one hour was the most frequent response of pupils in Ireland also, almost 4 out of 10 children reported spending more than two hours completing their weekly mathematics homework This is a considerably higher proportion than in either England or Scotland, which is not surprising given the higher proportions of pupils in those systems who reported receiving no homework in any subjects A majority of Hungarian, Spanish, and Taiwanese pupils spend more than two hours on mathematics homework weekly Bearing in mind the length of the school year, not only do Korean and Taiwanese pupils spend longer in school each year but many of them also spend longer practising the skills learned in school by spending extended periods completing homework assignments

In most countries, including Ireland, time doing exercises individually in class is associated with higher mathematics achievement In addition, lower mathematics scores are achieved by pupils who spend additional class time working with practical mathematics objects and materials in all but Korea, Taiwan, Spain, and Portugal

The Teaching of Science

On average, three hours per week are devoted to Social and Environmental Studies in the middle classes of Irish primary schools (Review Body on the Primary Curriculum, 1990). This broad subject subsumes the areas of history, geography, nature study, civics, and basic science. With such a range of subjects to be covered, it is not surprising that relatively little time is devoted to basic science in third class.

Approximately one half of the Irish 9-year old pupils receive less than one and a quarter hours of science instruction each week, a proportion that is low compared with those recorded in all other countries in the survey (see Table C-2 in Appendix C). However, this figure may be inaccurate since almost half of the school principals did not respond to the relevant item on the questionnaire. This untypically low response rate may reflect the difficulty of disentangling science from other topics covered in Social and Environmental Studies in the primary curriculum.

Typically, most education systems offer the majority of their pupils between one and a quarter and two and a half hours science each week, though in England, Spain, the United States, Korea, and Taiwan many pupils learn science for over two and a half hours a week. For example, three quarters of Spanish and almost all Korean and Taiwanese 9-year olds study science for more than two and a half hours a week.

In countries that did well in the science test, such as Korea, Taiwan, and the United States, there is considerably more time devoted to science each week in the curriculum, and in the case of Korea and Taiwan, the potential learning effect of this is magnified by the longer school year. Three-quarters of students in Italy (Emilia-Romagna), however, receive less than two and a half hours of science instruction per week, yet students in this country did very well on the science test.

The relatively low emphasis on science in general in third class in Ireland is accompanied by a lack of emphasis on experimental work (see Table C-10 in Appendix C). Half of the Irish pupils reported never completing any type of science experiment by themselves or with other pupils in school. Experimental work is substantially more common in other countries, with the exception of Italy (Emilia-Romagna). Even though the time devoted to basic science in Irish and Scottish schools is roughly equal, Scottish pupils follow a more hands-on syllabus.

Despite the relatively low emphasis given to basic science in Irish schools, a quarter of the 9-year olds report that they often read books about science and nature in school. This proportion compares favourably with other countries.

Sixteen percent of the Irish pupils did report, however, that they never read a science or nature book, almost twice the percentage in Spain, Portugal, and the United States It is not possible to determine from the responses to the questionnaire item (Figure 7 1) whether this is teacher-directed reading of elementary Environmental Studies texts or represents independent selection of science and nature-based books from school or other libraries For the majority of countries, science performance is not related to reading science or nature books in schools Exceptions are Korea, Taiwan, the United States, and Hungary

FIGURE 7 1

EXTRACT FROM PUPIL QUESTIONNAIRE
READING ABOUT SCIENCE AND NATURE[1]

How often do you read books about science and nature in school?

A Often
B Sometimes
C Never

CHARACTERISTICS OF HOMES

As was evident from the responses of 13-year olds, family size in Ireland exceeds that in all other countries surveyed Almost one-third of 9-year olds have four or more brothers or sisters, confirming the findings from the study of the older students Families of this size are considerably less common elsewhere and are very rare in Hungary and Italy (Emilia-Romagna)

The availability of books in Irish homes is similar to that in other countries, with the exception of Portugal and Taiwan, where there are fewer books Information on reading and television viewing patterns for 9-year old pupils in seven countries is presented in Table 7 4 In most countries, pupils report that they read for fun every day Exceptions are Korea and Taiwan where the most common response by pupils was that they read once or twice weekly In contrast, two-thirds of Soviet children claim to be daily readers Though half of the Irish 9-year olds report reading for fun every day, one-quarter never read for fun

[1] IAEP Student Questionnaire Science Age 9

at home. This is one of the highest proportions of non-readers among all the countries. Only in Scotland do so many children read so little. In general, 9-year olds spent more time than their older schoolmates reading for fun. In Ireland, and in 11 other countries, pupils who read more frequently perform better on the mathematics and science tests.

Approximately three-quarters of pupils reported that they watch two hours or more television every school night in most countries, including Ireland. Prolonged television viewing, five hours or more daily, is more prevalent at age 9 than among older pupils. Watching television for five or more hours per night is approximately as common in Ireland as in England, Scotland, the United States, and Canada, where about one-quarter of 9-year olds report this level of viewing. Such extended viewing is least common in Italy (Emilia-Romagna), Korea, Slovenia, and Taiwan, where less than 10% of pupils report spending more than five hours watching television. In eight countries, including Ireland, there is no clear tendency for 9-year old pupils who watch television for more than five hours a day to perform at lower levels in mathematics and science. Such a relationship is found, however in Canada, Korea, Taiwan, Hungary, and Slovenia.

TABLE 7.4

READING AND TELEVISION VIEWING PATTERNS (AGE 9)

	Read for Fun Every Day[a]	Watch TV 5+ Hours Per Day[b]
Ireland	48	23
England	50	23
Scotland	45	24
Spain	55	19
United States	46	26
Canada	48	22
Korea	25	10

Note. Figures in this table were obtained by averaging the percentages separately provided by the mathematics and science samples of pupils.

[a] Percentage of pupils who read for fun almost every day.
[b] Percentage of pupils who watch television at home for 5 hours or more every school day.

Pupil Attitudes

Between 80% and 90% of pupils in most countries, including Ireland, feel that their parents want them to do well in mathematics Spanish pupils more often report a positive attitude to mathematics in the home, whereas such support and interest is less apparent from the responses of Soviet pupils An indication of support for science in the homes was inferred from pupils' responses to a question asking them if their parents were themselves interested in science Typically, between 40% and 50% of pupils indicated that their parents were interested in science A greater level of support was reported by pupils in Italy (Emilia-Romagna) and less by pupils in the Soviet Union

In Ireland, 39% of 9-year old pupils considered that they were good at science Only Taiwan had a lower percentage of pupils who considered themselves good at science

Children from countries in the survey with the highest achievement levels in mathematics (Korea, Hungary, Taiwan) feel less confident about their mathematics ability than do 9-year olds from other countries In the United States, where average performance on the mathematics test is relatively modest, almost three-quarters of pupils think that they are good at mathematics In no other country do children demonstrate such faith in their mathematical ability The relationship between self-confidence and achievement, it should be noted, is inverse at the country level, it may not hold within countries (see also Kifer & Robitaille, 1989)

Pupils were asked whether they agreed that mathematics is equally for boys and for girls or whether it is more for one gender than another Responses are presented in Table 7 5 for selected countries In most countries, between 80% and 90% of pupils responded that mathematics is for boys and girls about equally In Ireland, the response was 83%, lower than that recorded in England, Scotland, or Spain Greater proportions of pupils in three countries, Korea, the Soviet Union, and Taiwan, tended to view mathematics as gender-linked Less than half of Korean pupils viewed mathematics as being equally for boys and girls In Ireland, the average percentage of questions answered correctly by the group of pupils who said that mathematics is for boys and girls equally was 18% greater than for the group that said it was more for boys and 24% greater than the group that said it was more for girls

Slightly more Irish than Scottish or Spanish children considered that mathematics is more for boys than girls In the Soviet Union, however, mathematics is more clearly viewed as a boys' subject by a substantial proportion of the 9-year old cohort

Eighty one percent of Irish pupils said that science is for boys and girls about equally, 12% said that it was more for boys, 7% more for girls. This was a typical response pattern in many countries. The average science scores of the group of pupils who said that science is for boys and girls equally is 5% greater than for the group that said it was more for boys and 14% greater than the group that said it was more for girls.

TABLE 7.5

MATHEMATICS EQUALLY FOR BOYS AND GIRLS (AGE 9)

	More For Boys Than Girls	More For Girls Than Boys	Equally For Boys And Girls
Ireland	10	7	83
England	7	4	89
Scotland	5	5	90
Spain	6	4	90
United States	10	7	83
Canada	8	7	84
Korea	25	27	48
Taiwan	10	11	79
Soviet Union	17	7	76

Note. Figures are the percentage of pupils agreeing with each of the statements about mathematics.

CONCLUSION

The results of this survey indicate that school size in Ireland is relatively small compared to other countries, the majority of primary schools having fewer than 11 on the teaching staff. Class size is larger than in most countries, with the exception of Korea and Taiwan where typical classes contain more than 45 pupils. Information on length of school year and amount of instructional time may not be reliable, but it seems that children in Portugal, the Soviet Union, and Spain spend fewer days in school each year while children in Israel, Korea and Taiwan spend more. The availability of computers in schools in Ireland is the same as in other countries and incidences of pupil misbehaviour are roughly similar also. Time spent completing general homework (less than one hour a day) and mathematics homework (less than one hour a week) by Irish pupils is roughly the same as in other countries, though assignment of any homework is

uncommon in England There is a positive association between homework and test scores among pupils in Ireland

In schools in most countries, including Ireland, five or more hours are typically devoted to mathematics instruction each week. Less time is allotted in Korea and Taiwan, but relatively long school years made up this shortfall Pupils in Ireland work on exercises on their own in mathematics classes more often and they work with mathematics tools and objects just about as often as children in other countries Whereas grouping of children by ability within mathematics class is the norm in Ireland, England, and Scotland, it is not as common elsewhere

In most countries, between one and a quarter and two and a half hours are devoted to science instruction each week, but in Ireland pupils typically received less Though science lessons are characterized by considerable experimental work in many countries, notably England, Scotland, and the United States, this was not found to be the case in Ireland

Typically, half the children in participating countries, including Ireland, read for fun every day but a relatively high proportion of Irish children never read at home Reading was found to be associated with higher test scores Irish pupils watch about as much television as children elsewhere, two to four hours each evening being common About one-quarter of pupils in many countries, however, watch more than five hours television each night Television viewing is not associated with low mathematics or science achievement in Ireland Nine-year olds watch more television than 13-year olds

Most pupils feel that their parents want them to do well in mathematics and that their parents are themselves interested in science, but pupils in Ireland do not feel very confident about their science ability Pupils, in general, feel that mathematics and science are for boys and girls equally In Ireland, the achievement scores of pupils who hold this view are higher than the scores of those who do not

Chapter 8. What Have We Learned From Iaep II?

ACHIEVEMENT RESULTS

At age 13, students in Korea, Taiwan, Switzerland, the Soviet Union, Hungary, and China have the highest average performance in mathematics. Irish 13-year olds achieve at similar levels in mathematics to students in most Western countries. They perform relatively well in Numbers and Operations but their achievement in Geometry and in Data Analysis, Statistics, and Probability is weak by comparison with achievement levels in Europe on these topics. Irish achievement in Measurement and Algebra and Functions is generally similar to that elsewhere in Europe but below the levels of the highest achieving populations in Korea, Taiwan, Switzerland, and the Soviet Union.

Among 9-year olds, the highest average mathematics performance is found in Korea, Taiwan, Italy (Emilia-Romagna), Hungary, the Soviet Union, and Israel. The average performance of Irish pupils is similar to that in most other European countries although they fare comparatively poorly in Geometry and in Data Analysis, Statistics, and Probability, a pattern that is also evident amongst the older age group. Achievement in Numbers and Operations, Measurement, and Algebra and Functions is close to the international average. Results of the mathematics tests at both age levels reveal that the pattern of relatively poor performance on Data Analysis, Statistics, and Probability evident amongst Irish 9-year olds does not seem to be resolved by the time students reach the age of 13. This is despite the fact that, at age 9, Ireland leads all countries in this study in terms of reported emphasis on the topic and is still sixth at age 13.

The science achievement of Irish 13-year olds is low compared to students in most other countries. Although many neighbouring European countries have average achievement levels in mathematics that are similar to Ireland, almost all have higher average performance in science. Average science achievement in Ireland is similar to that in Jordan, Brazil, and Portugal. Compared to students in other European and North American countries, Irish students perform relatively well in Earth and Space Sciences and in the Nature of Science but are weak in Life Sciences and Physical Sciences. The science achievement of Irish 13-year old students is below that of students in some countries (e.g., Switzerland, Korea, Taiwan) in every topic area.

The pattern of achievement of Irish 9-year olds across science topics is similar to that of the 13-year old cohort and their average level of achievement is also well below the average levels of students in most countries. Pupils in the United

States and Canada outperform Irish pupils in all four topics at the 9-year old level

In general, the countries with the highest average performance in mathematics tend also to perform well on the science test at 13 years of age In science, a notable omission from the top group of countries is China, which has the highest average performance level in mathematics, but performs at the international average in science On the other hand, 13-year old students from Slovenia, whose performance in mathematics is close to the international average, do relatively better on the science test

The relative performance of Irish 13-year olds on the science test is not as good as on the mathematics test There are several countries in which students have an average level of performance that is comparable to that of Irish students in mathematics but have a superior average performance level in science Among these countries are Slovenia, Italy (Emilia-Romagna), Israel, Canada, France, Scotland, and England Although Spanish 13-year olds answered, on average, fewer mathematics questions correctly than Irish students, they have a higher average science performance

Irish 9-year olds also perform relatively less well in science than in mathematics Ranked eighth in mathematics, they are thirteenth (out of 14) in science There is considerable movement in rankings of the average performance of countries from mathematics to science at age 9, with a rank-order correlation of only 54 between the rank ordering of countries in the two achievement areas Of the systems that participated at both age levels, those that perform best in mathematics (Korea, Taiwan, Italy) tend also to do best in science Those that do worst in mathematics also fare poorly in science (Slovenia and Portugal) Many of the other countries, however, improve or fall in ranking from one subject to another For example, the United States ranks twelfth in mathematics but is fourth in science Hungary, second in mathematics, is seventh in science England, eleventh in mathematics, is fifth in science

GENDER DIFFERENCES

At age 9, boys and girls in most countries, including Ireland, have approximately equal performance levels in mathematics At age 13, in Ireland and in seven other countries, however, gender differences in favour of boys are evident Irish girls have a lower overall score than Irish boys and also perform less well in the areas of Measurement, Geometry, Algebra and Functions, Conceptual Understanding, and Problem Solving

Gender differences in science are more widespread and more pronounced. At age 9, the average achievement of girls is below that of boys in over half the countries, including Ireland. By age 13, a gender difference appears in most countries. Among Irish pupils, a science achievement difference in favour of boys is evident on the overall science score, in Physical Sciences, in Earth and Space Sciences, as well as in the skill area of Knows Science. The main changes in differences between boys and girls between ages 9 and 13 are in the areas of Life Sciences and Integrates Knowledge, where there are no gender differences at 9, but differences do appear at age 13.

The pattern and timing of gender differences seem to indicate that differential performance in science is well established by the middle grades of primary school and that the difference increases by the end of first year in post-primary school. Of 14 countries, in which the science test is administered to both age groups, five have no gender difference at age 9 but have at age 13. With regard to mathematics, gender differences in achievement seem to be somewhat less established in primary school. Though a gender gap opens between ages 9 and 13 in Ireland, it may be noted that in Israel and Korea, the gender difference present at age 9 has been eliminated by age 13.

CURRICULAR EMPHASIS

Irish 13-year olds spend relatively fewer hours per year learning mathematics and science than their peers abroad; the time devoted to mathematics in Ireland is less than in any other country. Compared to Irish students, 13-year olds in China, Switzerland, the Soviet Union, and Taiwan spend considerably longer at mathematics — between 40% (Taiwan) and 136% (China). Irish primary schools also teach considerably less science than elsewhere.

Irish post-primary schools spend about the same proportion of instructional time each week at mathematics as in many other countries. Much the same can be said about the relative emphasis on science within the overall curriculum, especially in relation to other European countries. This indicates that Irish schools devote as much of their curricular space to mathematics and science as elsewhere, but students in many other countries spend more time learning these subjects because they have a longer school year.

Countries differ in the emphasis they place on various topics within mathematics and science. In general, many high-achieving countries emphasize Geometry, Data Analysis, Statistics, and Probability, and Algebra with 13-year olds. Less emphasis is typically placed on Number and Operations and Measurement. Irish post-primary schools, on the other hand, seem to stress

Numbers and Operations and Data Analysis, placing less emphasis on Geometry and Algebra Irish primary schools place unusually high emphasis on Numbers and Operations at the 9-year old level

In science, consistent curricular patterns are more difficult to detect Many countries devote a lot of time to Earth and Space Sciences with 13-year old students Though Ireland seems to place less emphasis on Earth and Space Sciences, it should be noted that the main components of this topic are Rocks and Minerals, and Weather and Climate Both these areas receive substantial attention in the Junior Certificate Geography Syllabus (National Council for Curriculum and Assessment, 1989b) Whereas many countries target only a few areas within Physical Sciences for detailed treatment, Irish schools place moderate emphasis on all aspects of Physical Science In most countries, less emphasis is placed on Nature of Science at age 13 than at age 9 In Ireland, little emphasis is given to this topic at either age level Moderate emphasis is given to Earth and Space Sciences with relatively little to Life Sciences or Physical Sciences with the younger age group

SCHOOL FACILITIES AND EDUCATIONAL PRACTICES

The typical primary and post-primary school in Ireland is small compared to schools in most other countries Average class size in Irish post-primary schools is similar to class sizes in many of the educational systems surveyed The Irish primary school system contains a higher proportion of large classes than most other countries

Computers and specialized science laboratories tend to be more common in schools in countries where school size is relatively large Computer availability in Ireland is relatively low in post-primary schools, but on a par with other countries at the primary level In addition, fewer Irish post-primary schools have specialized science laboratories for chemistry, physics, and biology than is the case in most other countries The fact that one-quarter of Irish post-primary school principals report that their schools have no science laboratories whatsoever is remarkable given the place accorded to science in the Junior Certificate programme

Calculator use in school amongst 13-year olds is common in a majority of countries but not in Ireland The use of calculators is generally less common among 9-year olds, especially in Ireland Irish students use mathematics and science materials less often than in other countries and it is relatively uncommon for Irish students in either age group to engage in experimental work in science At primary level, practical work in science, if only watching the teacher carry

out experiments, is reasonably common in most countries, but not in Ireland, though Irish 9-year olds do read about science and nature in schools just about as frequently as children elsewhere.

Grouping of 9-year old pupils into ability groups for mathematics classes is more common in Ireland than in most other countries. At post-primary level, Ireland is also one of relatively few countries where streaming of students into separate mathematics classes within schools is widespread. Streaming into separate science classes by science ability is also restricted to Ireland and to a handful of other countries.

Practice regarding the streaming of pupils varies very much from country to country. For example, a comparison of the 9-year old data with those for 13-year old students indicates that within-class ability grouping in primary schools is followed by outright streaming of post-primary students into different mathematics classes in Ireland and England. In contrast, whereas almost all Scottish 9-year olds are grouped in mathematics classes, most 13-year olds in that system are taught in mixed-ability mathematics classes. Similarly, schools in Hungary and Korea tend to group 9-year olds by ability within mathematics classes but do not stream mathematics classes for 13-year olds, preferring instead to educate their students in mixed-ability classes.Taiwanese schools, on the other hand, do not group 9-year olds by ability within mathematics classes but do stream mathematics classes for 13-year olds.

Though most of the mathematics teachers of 13-year olds in Ireland are specialist teachers (i.e., they teach mathematics most or all of the time), the proportion of specialists is low by international standards. Almost all science teachers are science specialists in Ireland. Regular testing of 13-year olds in mathematics and science is less common in Ireland than in most countries in the study.

THE CHILDREN AND THEIR HOMES

Family size in Ireland is unusually large relative to almost all other countries that participated in the study. Only in a few developing countries are there so many children in each family. Irish homes contain approximately the same number of books as homes elsewhere and, although regular reading for fun is quite common in almost all countries, a sizeable number of Irish children do not seem to engage in leisure reading at all.

Watching television is a more popular pastime than reading amongst both age groups. Watching extensive amounts of television is more prevalent at age 9 than

at age 13 although, at both age levels, two to four hours per night is not unusual Sizeable proportions of children in many countries seem to watch more than five hours of television each school evening, especially at the younger age level Though in Ireland television viewing seems to decrease as children enter early teenage years, this is not the case in England or Scotland Nonetheless, a large majority of Irish 13-year olds still watch more than two hours television each evening French children watch relatively little television, although they and their continental peers are more likely to watch films, videos, or television programmes about science at home than are children in Ireland, England, or Scotland

In general, the vast majority of children in most countries hold positive attitudes to mathematics Attitudes to science are somewhat less positive The children also reported that their parents, while generally very interested in mathematics, are less concerned about science Students in general consider that they are good at mathematics and science, though Irish students' confidence in their science ability is relatively low Parents in most countries give considerable help with mathematics homework, but rather less with science homework They do, however, frequently converse with their children about what they learn in science class Overall, Irish attitudes and beliefs in relation to the two subjects reflect those prevalent in other countries

FACTORS ASSOCIATED WITH ACHIEVEMENT

The test results for each student can be viewed as a snapshot of their achievement at a single point in time Clearly visible in the background of the snapshot are many additional variables, simultaneously viewed For example, responses to the questionnaires allow us include background information about students, information about the schools that they attend, and data concerning teaching methods employed in the schools at the time when the students were tested What is important to realize is that all such information is gathered at one point in time, namely, close to the time that the students sat the test For that reason, nothing is known about the achievement levels of students at the beginning of the school year, or prior to that, so that inferences about what factors influenced the test scores are largely speculative

It is preferable to view the data in terms that are associative rather than causal For example, it is clear from information in the survey that students who spend more time reading for fun tend also to be those who score highest on the tests This relationship is found in three-quarters of the countries, including Ireland However, we cannot say that increased levels of reading cause higher

achievement; rather that students who read most tend also to have high achievement scores. Though we might like to conclude from the association that more reading causes higher test scores, to look at those two variables in isolation ignores a myriad of other factors that may interact in the relationship.

Bearing in mind that the existence of an association does not necessarily imply a causal relationship, it is possible to identify associations between certain variables and test scores. The most consistent associations are found between some of the student background factors and achievement. In addition to the positive relationship between reading and achievement in most countries, the number of books in a child's home is also found to be associated with achievement; students reporting more books at home tend also to be those students who score highest on the tests. This is found in all countries with the exception of Mozambique. Less consistent associations are found between students' attitude to subject matter, parents' interest in subjects, and achievement. In Ireland, students who report greater levels of parental interest in mathematics and science tend to score higher on the test than students who report lower interest levels. Though Irish students who themselves have positive attitudes to science perform better on the science test than those who have less positive attitudes, no such relationship is found between interest in mathematics and mathematics test scores.

In three-quarters of the countries, students who come from large families tend to perform at levels on the tests that are significantly below students from smaller families. Exception to this finding are Ireland, Italy (Emilia-Romagna), Jordan, and Mozambique where no consistent relationships are found.

Television viewing habits are significantly associated with achievement in many countries at both age levels. At age 13 in nearly half of the countries, including Ireland, students who watch more television tend also to be those who perform poorly on the mathematics and science tests. In most of the remaining countries, no relationship is found. In Portugal, however, students who watch more television have higher scores in both mathematics and science than those who watch less, a relationship also found with Israeli 9-year olds. The association between television and achievement is less consistent among 9-year olds. In five of the countries, more television is associated with lower scores whereas in eight countries, including Ireland, no relationship is found.

School-related factors found to be associated with student achievement include the amount of time spent completing homework, the amount of time students spend doing mathematics exercises on their own in class, and the amount of time they spend listening to the teacher give a mathematics or science lesson. In Ireland and about half the countries, the relationship between time at

general homework and test scores is positive among 13-year olds Less consistency is found among 9-year olds, though Irish pupils who report spending longer at general homework do tend to outperform those who devote less time to homework At age 13, there is a tendency for Irish students who spend more time completing mathematics and science homework to perform better on the tests in those subjects This pattern is evident across many countries, especially in relation to mathematics homework

Spending time completing mathematics exercises on their own in class is also associated with higher test scores in a majority of countries, including Ireland In half of the countries, students who report spending more time listening to a teacher give a mathematics or science lesson achieve higher scores than students who report that they spend less time listening to the teacher

Variables found to be negatively associated with achievement in many countries are the amount of time spent solving problems in small groups during mathematics class, time spent doing science experiments in school, and frequency of working with mathematics equipment. The positive relationship between achievement and time spent completing mathematics exercises in isolation seems to confirm the negative association between lower levels of group work and mathematics scores That greater levels of science experimentation is associated with lower achievement levels may, perhaps, be partly explained by the pencil-and-paper format of the IAEP science test The consistently negative association (in 10 countries) between test scores and working with mathematics equipment such as counting blocks, geometric shapes, or geometric solids in mathematics class may come as a surprise However, it may be that difficulties in understanding terminology (for example, geometric solids) in the question asked of pupils may have contaminated the responses of 9-year old children or that this is an activity more typical of younger children and only engaged in by lower-achieving 9-year olds

It was often difficult to establish a clear association between curricular emphasis as reported by the principal and student achievement For example, the two highest performing countries on Physical Sciences are Korea and Taiwan Korea emphasizes electricity and magnetism, Taiwan does not, Korea does not emphasize mass motion and gravity but Taiwan does It may be significant that both of these high-performing countries seem to place emphasis on specific areas of Physical Science at this age level Switzerland is unusual among high-performing countries in that no particular area appears to receive a lot of emphasis

Possibly a clearer relationship exists in relation to mathematics topics As mentioned in Chapter 3, Irish schools appear to pay relatively less attention to

Measurement than to Numbers and Operations in third class. Few of the high-achieving countries report much emphasis on Measurement in the modal grade level for 9-year olds, though in Italy (Emilia-Romagna) almost all school principals reported that the topic is emphasized 'a lot.' Conflicting patterns such as this highlight the difficulty of linking variations in school curricular policies to pupil achievement scores.

CONCLUSION

The Second International Assessment of Educational Progress provides a rich source of information that is of relevance to teachers, parents, educational policy makers, and the general public. For some, interest may focus on the achievement levels in mathematics and science among Irish students and how these levels compare to achievement in other countries. Others might be primarily interested in the educational facilities available in Irish schools, and how these compare to facilities elsewhere. Those concerned with gender equity in education may wish to consider carefully the findings in relation to achievement differences between Irish boys and girls. They may also compare these differences to gender differences evident in other countries. Curriculum planners may be interested to know how the emphases within mathematics and science curricula in Ireland compare to curriculum structures elsewhere. Teachers may note differences in the organization of instruction from country to country, for example, in relation to streaming.

It is hoped that the findings of the study will help inform the ongoing debate on the future direction of the Irish educational system. Outcomes and recommendations from this debate will set the agenda in educational practice far into the next century, a century that is likely to be characterized by increasing levels of international contact in varying spheres of human activity. In light of increasing mobility of people, goods, services, and ideas across national boundaries, it would seem important in determining Irish educational policy to be able to take into account information about the functioning of educational systems in other countries.

References

Burke, A , Dobrich, P , & Sugrue, C (1992) Time for school An international comparative survey *Oideas, 38*, 5-40

Center for the Assessment of Educational Progress (1991) *The 1991 IAEP assessment objectives for mathematics, science, and geography* Princeton, NJ Educational Testing Service

Coleman, J S , Campbell, E Q , Hobson, C J , McPartland, J , Mood, A M , Weinfeld, F D & York, R L (1966) *Equality of educational opportunity* Washington DC US Government Printing Office

Darlington, R B (1990) *Regression and linear models* New York McGraw-Hill

Elley, W B (1992) *How in the world do students read?* The Hague International Association for the Evaluation of Educational Achievement

Frederick, W C , & Walberg, H J (1980) Learning as a function of time *Journal of Educational Research, 73*, 183-194

Greaney, V , & Close, J (1989) Mathematics achievement in Irish primary schools *Irish Journal of Education, 23*, 51-64

International Assessment of Educational Progress (1992) *IAEP Technical Report* Princeton, NJ Educational Testing Service

International Association for the Evaluation of Educational Achievement (1994, January) *IEA newsletter, 25*, p 3

Ireland Department of Education (1965) *Rules for national schools* Dublin Stationery Office

Ireland Department of Education (1992) *Statistical report 1990/91* Dublin Stationery Office

Kellaghan, T (1977) Relationships between home environment and scholastic behavior in a disadvantaged population *Journal of Educational Psychology, 69*, 754-760

Kellaghan, T , & Macnamara, J (1972) Family correlates of verbal reasoning ability *Developmental Psychology, 7*, 49-53

Kifer, E & Robitaille D F (1989) Attitudes, preferences and opinions In D F Robitaille & R A Garden (Eds), *The IEA study of mathematics II Contexts and outcomes of school mathematics* Oxford Pergamon

Lapointe, A E , Askew, J M , & Mead, N A (1992) *Learning science* Princeton, NJ Educational Testing Service

Lapointe, A. E., Mead, N. A., & Askew, J. M. (1992). *Learning mathematics.* Princeton, NJ: Educational Testing Service.

Lapointe, A. E., Mead, N. A., & Phillips, G. W. (1989). *A world of differences. An international assessment of mathematics and science.* Princeton, NJ: Educational Testing Service.

Lazer, S. (1992). *Learning about the world.* Princeton, NJ: Educational Testing Service.

Martin, M. O. (1990). Mathematics achievement in sixth class in Irish primary schools. *Irish Journal of Education*, 22, 27-39

Mosteller, F., & Tukey, J. W. (1977). *Data analysis and regression.* Reading, MA: Addison-Wesley.

National Council for Curriculum and Assessment. (1989a). *The Junior Certificate. Geography syllabus.* Dublin: Author.

National Council for Curriculum and Assessment. (1989b). *The Junior Certificate. Science guidelines for teachers.* Dublin: Author.

Organisation for Economic Co-operation and Development. (1993). *Education at a glance. OECD indicators.* Paris: Author.

O'Rourke, B., & Archer, P. (1987). A survey of teaching practices in the junior grades of Irish primary schools. *Irish Journal of Education*, *21*, 53-79.

Passow, A. H., Noah, H. F., Eckstein, M. A., & Mallea, J. R. (1976). *The national case study: An empirical comparative study of twenty-one educational systems.* Stockholm: Almqvist & Wiksell.

Peaker, G. F. (1967). The regression analyses of the National Survey. In Great Britain. Department of Education and Science. *Children and their primary schools. A report of the Central Advisory Council for Education (England). Volume 2: Research and Surveys.* London: Her Majesty's Stationery Office.

Postlethwaite, T. N., & Wiley, D. E. (1992). *The IEA study of science II: Science achievement in twenty-three countries.* Oxford: Pergamon.

Review Body on the Primary Curriculum (1990). *Report.* Dublin: National Council for Curriculum and Assessment/Department of Education.

Rosier, M. J., & Keeves, J. P. (Eds.). (1991). *The IEA study of science I: Science education and curricula in twenty-three countries.* Oxford: Pergamon Press.

Semple, B. (1992). *Performance assessment: An international experiment.* Princeton, NJ: Educational Testing Service.

Travers, K. J., & Westbury, I. (Eds.). (1989). *The IEA study of mathematics I: Analysis of mathematics curricula.* Oxford: Pergamon.

White, K R (1982) The realtion between socioeconomic status and academic achievement *Psychological Bulletin, 91,* 461-481

Appendix A: Populations Participating in Iaep II

TABLE A-1

DESCRIPTIONS OF LIMITED POPULATIONS

Population		Included		Excluded
Brazil, Age 9	3%	13-year olds in grades 5 through 8 in cities of São Paulo and Fortaleza.	97%	13-year olds in grades other than 5 through 8 in São Paulo (20% of those in school) and in Fortaleza (34%). 13-year olds not in school (8% of those in São Paulo and 15% of those in Fortaleza). 13-year olds in schools in other cities and rural areas.
Canada, Age 9	74%	9-year olds in English-speaking schools in British Columbia and New Brunswick. 9-year olds in English- and French-speaking schools in Ontario and Quebec.	26%	9-year olds in French-speaking schools in New Brunswick. 9-year olds in six other provinces and territories.
China, Age 13	38%	13-year olds in 17 provinces and independent cities of Beijing, Tienjing, and Shanghai in middle schools (grades 7 through 9).	62%	13-year olds below grade 7 in 20 provinces and cities (10% of those in school). 13-year olds not in school (about 49% of 13-year olds). 13-year olds in schools in 9 provinces and autonomous regions with predominantly non-Chinese populations.
Israel, Age 9	71%	9-year olds in public Hebrew-speaking schools.	29%	9-year olds in non-public Hebrew-speaking schools (7%). 9-year olds in Arabic schools (about 20% of 9-year-olds).
Israel, Age 13	71%	13-year olds in public Hebrew-speaking schools.	29%	13-year olds in non-public Hebrew-speaking schools (about 10%). 13-year olds in Arabic schools (about 20%).
Italy, Age 9	4%	9-year olds in schools in Emilia-Romagna.	96%	9-year olds in 19 other Italian provinces.

Population		Included		Excluded
Italy, Age 13	6%	13-year olds in schools in Emilia Romagna	94%	13-year olds in 19 other Italian provinces
Mozambique Age 13	1%	13-year olds in schools of cities of Maputo and Beira.	99%	13-year olds not in school (about 75% of 13-year-olds) 13-year olds in other cities and rural areas
Portugal, Age 9	81%	9 year olds in grades 3 and 4	19%	9-year olds in grades other than 3 and 4 (16%)
Portugal Age 13	68%	13-year olds in grades 5 through 9	32%	13 year olds in grades other than 5 through 9 (about 18% of those in school) 13-year olds not in school (about 16%)
Soviet Union, Age 9	63%	9-year olds in Russian-speaking schools in 14 republics	37%	9-year olds in non-Russian-speaking schools in 14 republics 9-year olds in schools in Uzbeckistan
Soviet Union, Age 13	60%	13-year olds in Russian-speaking schools in 14 republics	40%	13 year olds in non-Russian-speaking schools in 14 republics 13 year olds in schools in Uzbeckistan
Spain, Age 9	80%	9-year olds in all Spanish-speaking schools except those in the Catalan autonomous community	20%	9-year olds in all schools in Catalan region 9-year olds in exclusively Valencian and Basque-speaking schools
Spain, Age 13	80%	13-year olds in all Spanish-speaking schools except those in the Catalan autonomous community	20%	13 year olds in all schools in the Catalan region 13-year olds in Valencian and Basque-speaking schools
Switzerland, Age 13	76%	13-year olds in German-, French- and Italian-speaking public schools in 15 cantons	24%	13-year olds in private and Romansch schools in 15 cantons 13-year olds in the remaining 11 cantons

Note Unless noted above all populations included 90% or more of their age-eligible children

TABLE A-2

OVERALL SUMMARY OF TEST ADMINISTRATION BY COUNTRY AND CANADIAN PROVINCES

	Scheduled Assessment Month	Who Gave Test	Test Admin-istrator Trained	Practrice Test Used	% of Site Visits	% of Accurate Scores[a]
Brazil, both cities	Sept. '90	External Admin.	Yes	No	23	99.5
Canada,						
Alberta	March '91	School Personnel	No	No	20	99.7
British Columbia	March '91	School Personnel	No	No	Informal	99.5
Manitoba	March '91	School Personnel	Yes	No	18	99.6
New Bruns. English	March '91	School Personnel	Yes	Opt.	15	99.8
New Bruns. French	March '91	School Personnel	Yes	Yes	39	Not done
Newfoundland	March '91	School Personnel	No	No	21	99.0
Novia Scotia	March '91	School Personnel	No	No	21	99.9
Ontario	March '91	School Personnel	Yes	Yes (9) Opt. (13)	19	98.1
Quebec	March '91	School Personnel	Yes	Yes	22	98.2
Saskatchewan	March '91	School Personnel	No	No	Informal	99.3
China	March '91	School Personnel	Yes	No	19	99.3
England	March '91	School Personnel	No	No	Informal	99.6
France	March '91	School Personnel	Yes	Yes	21	99.4
Hungary	March '91	External Admin.	Yes	No	16	99.5
Ireland	March '91	School Personnel	No	No	Informal	99.6
Israel	March '91	School Personnel	Yes	No	19	100.0
Italy, Emilia-Romagna	March '91	School Personnel	Yes	No	21	98.0
Jordan	March '91	School Personnel	Yes	Yes	24	99.3
Korea	Sept '90	School Personnel	Yes	Yes	20	99.5
Mozambique	Sept '90	External Admin.	Yes	No	Informal	Not done
Portugal	March '91	External Admin.	Yes	Yes (9) No (13)	20	99.8
Scotland	March '91	School Personnel	No	Opt. (9) No (13)	Informal	99.2
Slovenia	March '91	External Admin.	Yes	Opt.	10	99.8
Soviet Union	March '91 (9) April '91 (13)	School Personnel	Yes	Yes	52	99.3
Spain	March '91	External Admin.	Yes	Opt. (9) No (13)	20	99.7
Switzerland	March '91	School Personnel	Yes	No	Informal	99.5
Taiwan	March '91	School Personnel	Yes	No	20	99.8
United States	March '91	School Personnel	No	No	16	99.8

Admin. = Administrators, Opt. = Optional

[a] This number represents the mean of the percentages of accurate scores for mathematics constructed-response questions.

TABLE A-3

NUMBER OF SCHOOLS AND PUPILS ASSESSED AND RESPONSE RATES (AGE 13)

	Number of Schools Assessed	Weighted School Response Rate	Number of Pupils Assessed in Mathematics	Number of Pupils Assessed in Science	% Pupil Response Rate [a]	Combined Overall % Response Rate [a]
Brazil, Fortaleza	118	97	1 482	1 505	93	89
Brazil, São Paulo	108	95	1,484	1,469	93	88
Canada[b]	1,373	97	19 691	19,738	94	91
China	119	100	1,774	1 775	99	96
England	83	52	890	929	91	47
France	103	93	1 768	1,787	97	90
Hungary	144	100	1,632	1 623	93	93
Ireland	110	96	1 654	1 657	94	90
Israel	110	98	1,583	1,584	95	93
Italy, Emilia-Romagna	90	82	1 478	1,485	95	78
Jordan	106	85	1,580	1,588	99	84
Korea	110	100	1 637	1,635	99	99
Mozambique	13	100	1 174	-----	66	66
Portugal	89	82	1,510	1 520	94	77
Scotland	92	82	1,564	1,584	90	74
Slovenia	114	100	1,596	1 598	95	95
Soviet Union	138	97	1 816	1 839	95	86
Spain	109	93	1,624	1 609	96	89
Switzerland	397	82	3 644	3 653	98	80
Taiwan	108	100	1 780	1 786	98	98
United States	96	77	1 407	1 404	92	71

[a]Pupil and Overall Response Rates represent figures for the mathematics sample With the exception of a few small differences (one to two percent) these rates are identical to the figures for pupils who were assessed in science

[b]Many more schools and pupils are included in the assessment in Canada than in any other population Nine Canadian provinces are included separately in the mathematics assessment at Age 13

TABLE A-4

NUMBER OF SCHOOLS AND PUPILS ASSESSED AND RESPONSE RATES (AGE 9)

	Number of Schools Assessed	Weighted School Response Rate	Number of Pupils Assessed in Mathematics	Number of Pupils Assessed in Science	% Pupil Response Rate[a]	Combined Overall % Response Rate[a]
Canada[b]	797	97	9,365	9,362	95	92
England	89	56	1,071	1,086	94	53
Hungary	144	100	1,632	1,607	94	94
Ireland	126	94	1,261	1,282	97	91
Israel	116	100	1,612	1,627	96	96
Italy, Emilia-Romagna	70	65	1,142	1,157	94	61
Korea	114	100	1,630	1,638	98	98
Portugal	128	89	1,419	1,439	97	86
Scotland	90	62	1,151	1,154	93	58
Slovenia	113	100	1,609	1,593	94	94
Soviet Union	139	98	1,842	1,853	92	84
Spain	110	89	1,624	1,620	95	85
Taiwan	110	100	1,814	1,799	99	99
United States	105	80	1,489	1,464	93	74

[a] Pupil and Overall Response Rates represent figures for the mathematics sample. With the exception of a few small differences (one percent), these rates are identical to the figures for pupils who were assessed in science.

[b] Many more schools and pupils are included in the assessment in Canada than in any other population. Four Canadian provinces are included separately in the mathematics assessment at Age 9.

Appendix B: Achievement Scores and Framework for Assessments In Mathematics And Science

TABLE B-1

AVERAGE PERCENTAGES CORRECT AND STANDARD ERRORS ON MATHEMATIC TEST (AGE 13)

	Total	Male	Female
IAEP Average	58 3 (0 9)		
Brazil Fortaleza	32 4 (0 6)	35 2 (0 9)	30 5 (0 6)
Brazil São Paulo	37 0 (0 8)	37 9 (0 9)	36 2 (0 9)
Canada	62 0 (0 6)	63 0 (0 7)	60 9 (0 6)
China	80 2 (1 0)	81 7 (1 0)	78 5 (1 1)
England	60 6 (2.2)	60 8 (3 0)	60 4 (2.2)
France	64 2 (0 8)	65 5 (0 9)	62 8 (0 9)
Hungary	68 4 (0 8)	68.5 (1 0)	68 3 (0 9)
Ireland	60 5 (0 9)	62 6 (1 2)	58 4 (1 1)
Israel	63 1 (0 8)	64 4 (0 9)	61 8 (1 1)
Italy, Emilia-Romagna	64 0 (0 9)	65 8 (1 1)	62 1 (0 9)
Jordan	40 4 (1 0)	41 4 (1 2)	39 1 (1 9)
Korea	73 4 (0 6)	74 4 (0 9)	72 2 (1 0)
Mozambique	28 3 (0 3)	28 8 (0 5)	27 8 (0 3)
Portugal	48 3 (0 8)	48 9 (1 3)	47 9 (0 9)
Scotland	60 6 (0 9)	60 4 (1 0)	60 8 (1 1)
Slovenia	57 1 (0 8)	58 1 (0 8)	56 1 (1 0)
Soviet Union	70 2 (1 0)	70 0 (1 3)	70 3 (0 9)
Spain	55 4 (0 8)	57 1 (1 1)	53 8 (0 8)
Switzerland	70 8 (1 3)	72 8 (1 5)	68 7 (1 1)
Taiwan	72 7 (0 7)	73 1 (0 9)	72 4 (0 9)
United States	55 3 (1 0)	55 8 (1 1)	54 8 (1 3)

TABLE B-2

TOPIC AND PROCESS AVERAGE PERCENTAGES CORRECT AND STANDARD ERRORS ON MATHEMATICS TEST (AGE 13)

	Numbers and Operations	Measure-ment	Geometry	*Data* Analysis Statistics & Probability	Algebra and Functions	Conceptual Under-standing	Procedural Knowledge	Problem Solving
IAEP Average	61.0 (0.8)	46.9 (1.2)	62.2 (1.2)	69.1 (0.9)	54.2 (1.6)	60.6 (0.8)	58.4 (1.2)	55.9 (0.9)
Brazil, Fortaleza	35.8 (0.7)	20.5 (0.5)	28.6 (0.8)	43.8 (0.8)	32.3 (0.9)	35.3 (0.7)	30.8 (0.8)	31.0 (0.5)
Brazil, São Paulo	40.9 (0.8)	24.1 (0.5)	34.3 (1.5)	49.7 (1.0)	35.6 (1.1)	38.5 (0.9)	36.5 (1.1)	36.0 (0.6)
Canada	65.6 (0.6)	49.9 (0.6)	68.1 (0.7)	76.4 (0.6)	52.7 (0.7)	65.1 (0.6)	61.9 (0.7)	58.9 (0.5)
China	84.9 (0.9)	71.3 (1.5)	80.2 (1.1)	75.4 (1.2)	82.4 (0.9)	81.6 (1.0)	83.0 (0.9)	75.6 (1.2)
England	58.5 (2.0)	51.2 (2.5)	70.3 (2.4)	79.5 (1.8)	54.0 (2.8)	62.0 (2.1)	59.0 (2.6)	60.8 (2.0)
France	65.0 (0.7)	52.7 (1.0)	73.1 (0.8)	79.3 (0.7)	57.0 (1.0)	67.4 (0.7)	65.7 (0.9)	59.3 (0.8)
Hungary	69.4 (0.7)	55.1 (1.0)	73.3 (0.8)	75.9 (0.8)	69.8 (0.9)	69.8 (0.7)	70.8 (0.8)	64.2 (0.8)
Ireland	65.1 (0.8)	49.4 (1.0)	59.9 (1.1)	71.8 (1.0)	55.6 (1.1)	61.5 (0.8)	62.0 (1.2)	57.9 (0.8)
Israel	64.8 (0.7)	47.2 (1.1)	65.8 (1.0)	74.8 (0.8)	64.7 (1.0)	63.8 (0.8)	65.3 (0.9)	59.8 (0.9)
Italy, Emilia-Romagna	63.8 (0.8)	62.8 (1.1)	75.3 (1.0)	71.7 (0.8)	52.6 (1.2)	66.6 (0.8)	62.1 (1.1)	63.3 (0.9)
Jordan	42.8 (1.0)	32.0 (1.0)	43.5 (1.1)	45.7 (1.0)	38.1 (1.3)	44.9 (0.9)	38.5 (1.2)	37.9 (1.0)
Korea	77.4 (0.6)	59.5 (0.9)	77.4 (0.6)	81.2 (0.7)	70.8 (0.8)	78.3 (0.5)	73.4 (0.7)	68.5 (0.7)
Mozambique	33.8 (0.4)	20.1 (0.3)	29.2 (0.5)	35.4 (0.6)	20.5 (0.5)	34.0 (0.4)	22.9 (0.4)	28.2 (0.4)
Portugal	52.1 (0.8)	31.9 (0.7)	49.0 (1.3)	68.6 (1.0)	43.1 (1.1)	51.5 (0.9)	47.1 (1.0)	46.4 (0.7)
Scotland	59.7 (0.8)	51.0 (1.2)	69.6 (0.9)	79.1 (0.8)	52.8 (1.2)	61.8 (0.9)	59.2 (1.0)	60.9 (0.9)
Slovenia	62.2 (0.7)	43.1 (0.9)	63.1 (1.0)	63.6 (0.8)	51.8 (1.0)	58.5 (0.7)	59.0 (0.9)	53.7 (0.8)
Soviet Union	69.2 (1.0)	59.7 (1.1)	77.6 (1.0)	76.1 (1.3)	71.9 (1.1)	70.3 (1.0)	73.2 (1.2)	66.7 (1.0)
Spain	60.1 (0.6)	37.9 (0.8)	60.0 (1.2)	67.7 (0.8)	52.2 (1.2)	58.4 (0.7)	55.8 (0.9)	51.9 (0.8)
Switzerland	73.6 (1.0)	62.0 (1.5)	76.6 (1.3)	81.8 (1.1)	62.7 (1.9)	71.7 (1.1)	69.0 (1.4)	71.9 (1.3)
Taiwan	74.7 (0.6)	63.7 (0.9)	76.6 (0.8)	81.2 (0.6)	69.2 (0.9)	74.7 (0.7)	74.7 (0.7)	68.6 (0.8)
United States	61.0 (1.0)	39.5 (1.0)	54.3 (1.0)	72.2 (1.0)	49.2 (1.6)	57.4 (0.9)	56.0 (1.3)	52.3 (1.0)

TABLE B-3

AVERAGE PERCENTAGES CORRECT AND STANDARD ERRORS ON MATHEMATICS TEST (AGE 9)

	Total	Male	Female
IAEP Average	63 3 (0 9)		
Canada	59 9 (0 5)	59 9 (0 7)	60 0 (0 6)
England	59.5 (1 9)	58 5 (1 5)	60 3 (2 9)
Hungary	68 2 (0 6)	68 2 (0 8)	68 2 (0 8)
Ireland	60 0 (0 8)	59 9 (0 9)	60 1 (1 1)
Israel	64 4 (0 7)	66 0 (0 8)	62 7 (0 9)
Italy, Emilia-Romagna	67 8 (0 9)	69 5 (1 0)	65 9 (1 1)
Korea	74 8 (0 6)	77 2 (0 7)	72 4 (0 8)
Portugal	55 5 (0 9)	56 8 (1 1)	54 2 (1 1)
Scotland	65 7 (0 9)	65 8 (1 1)	65 6 (1 1)
Slovenia	55 8 (0 6)	55 8 (0 7)	55 9 (0 7)
Soviet Union	65 9 (1 3)	66 4 (1 2)	65 4 (1 4)
Spain	61 9 (1 0)	61 9 (1 3)	61 8 (1 1)
Taiwan	68 1 (0 8)	68 4 (0 8)	67 8 (0 9)
United States	58 4 (1 0)	58 7 (1 1)	58 0 (1 2)

TABLE B-4

TOPIC AND PROCESS AVERAGE PERCENTAGES CORRECT AND STANDARD ERRORS ON MATHEMATICS TEST (AGE 9)

	Numbers and Operations	Measure-ment	Geometry	Data Analysis Statistics & Probability	Algebra and Functions	Conceptual Under-standing	Procedural Knowledge	Problem Solving
IAEP Average	61.2 (1.1)	67.2 (0.8)	63.9 (1.0)	67.6 (1.0)	61.8 (1.1)	63.2 (0.9)	66.7 (1.0)	58.5 (1.0)
Canada	55.0 (0.6)	65.4 (0.5)	64.7 (0.6)	72.3 (0.5)	56.4 (0.6)	60.4 (0.5)	61.1 (0.6)	57.4 (0.5)
England	53.6 (2.1)	67.2 (1.6)	67.0 (1.5)	70.4 (1.7)	56.9 (2.1)	60.7 (1.7)	59.2 (2.0)	57.9 (1.9)
Hungary	67.5 (0.7)	71.6 (0.7)	68.6 (0.7)	63.4 (0.8)	72.4 (0.8)	68.2 (0.6)	70.8 (0.7)	64.4 (0.7)
Ireland	58.0 (0.9)	64.2 (0.8)	57.9 (0.9)	65.2 (0.8)	59.4 (1.0)	59.3 (0.8)	63.9 (0.8)	55.5 (0.9)
Israel	63.6 (0.8)	69.9 (0.7)	58.8 (0.9)	63.9 (1.0)	66.8 (0.7)	62.6 (0.8)	68.3 (0.8)	61.6 (0.8)
Italy, Emilia-Romagna	67.3 (0.9)	73.3 (0.9)	64.6 (1.1)	71.1 (0.9)	60.8 (1.3)	67.8 (0.9)	72.5 (0.9)	60.6 (1.1)
Korea	74.6 (0.6)	73.0 (0.8)	75.4 (0.7)	79.3 (0.6)	72.1 (0.7)	75.0 (0.6)	78.7 (0.6)	68.8 (0.6)
Portugal	54.4 (1.1)	58.3 (0.7)	55.6 (1.2)	57.1 (1.0)	54.6 (1.0)	55.7 (0.9)	59.5 (1.1)	49.2 (1.0)
Scotland	62.1 (1.0)	71.3 (0.9)	68.5 (0.8)	73.9 (0.8)	63.1 (1.2)	66.3 (0.8)	67.9 (1.0)	61.8 (0.8)
Slovenia	52.7 (0.6)	62.4 (0.6)	63.1 (0.8)	54.2 (0.8)	57.8 (0.6)	56.3 (0.6)	57.6 (0.6)	52.3 (0.7)
Soviet Union	65.7 (1.3)	71.3 (1.0)	64.4 (1.3)	60.1 (1.5)	67.8 (1.3)	63.0 (1.3)	72.0 (1.2)	61.7 (1.4)
Spain	61.3 (1.1)	60.8 (0.8)	60.1 (1.1)	69.3 (1.1)	58.3 (1.1)	60.8 (1.0)	66.1 (1.0)	57.3 (1.1)
Taiwan	67.1 (0.8)	69.3 (0.8)	69.2 (0.8)	72.8 (0.8)	64.2 (0.8)	68.5 (0.8)	76.1 (0.8)	55.7 (0.8)
United States	54.3 (1.1)	63.2 (1.0)	56.9 (1.0)	72.8 (1.1)	55.3 (1.0)	59.7 (1.0)	59.5 (1.1)	54.5 (1.0)

TABLE B-5

AVERAGE PERCENTAGES CORRECT AND STANDARD ERRORS ON SCIENCE TEST (AGE 13)

	Total	Male	Female
IAEP Average	66 9 (0 5)		
Brazil Fortaleza	46 4 (0 6)	49 1 (0 7)	44 3 (0 8)
Brazil, São Paulo	52 7 (0 6)	56 3 (0 8)	49 6 (0 7)
Canada	68 8 (0 4)	70 5 (0.5)	67 1 (0 4)
China	67 2 (1 1)	69 4 (1.2)	64 8 (1 1)
England	68 7 (1 2)	70 3 (1 6)	67 1 (1 8)
France	68 6 (0 6)	70 7 (0 7)	66 5 (0 7)
Hungary	73 4 (0.5)	75 6 (0 6)	71 4 (0 7)
Ireland	63 3 (0 6)	66 1 (0 9)	60 8 (0 8)
Israel	69 7 (0 7)	71 6 (0 8)	68 0 (0 8)
Italy, Emilia Romagna	69 9 (0 7)	72.2 (0 8)	67 6 (0 8)
Jordan	56 6 (0 7)	57 1 (0 8)	55 9 (1 3)
Korea	77 5 (0 5)	79 6 (0 6)	75 0 (0 7)
Portugal	62 6 (0 8)	65 0 (1 0)	60 3 (0 8)
Scotland	67 9 (0 6)	69 6 (0 7)	66 3 (0 9)
Slovenia	70 3 (0 5)	72.5 (0 7)	68 2 (0 6)
Soviet Union	71 3 (1 0)	72 9 (1 1)	69 6 (1 0)
Spain	67 5 (0 6)	69 2 (0 8)	66 0 (0 7)
Switzerland	73 7 (0 9)	76 4 (1 1)	70 9 (0 8)
Taiwan	75 6 (0 4)	76 3 (0 6)	74 9 (0 6)
United States	67 0 (1 0)	69 4 (1 2)	64 5 (0 9)

TABLE B-6

TOPIC AND PROCESS AVERAGE PERCENTAGES CORRECT AND STANDARD ERRORS ON SCIENCE TEST (AGE 13)

	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science	Knows Science	Uses Science	Integrates Science
IAEP Average	68.0 (0.6)	64.4 (0.6)	66.9 (0.7)	70.9 (0.8)	72.6 (0.6)	65.4 (0.5)	64.9 (0.8)
Brazil, Fortaleza	51.3 (0.7)	42.6 (0.6)	48.6 (0.7)	44.8 (0.9)	55.5 (0.8)	45.4 (0.5)	40.5 (0.8)
Brazil, São Paulo	56.3 (0.8)	48.8 (0.5)	55.8 (0.7)	52.5 (0.8)	60.4 (0.9)	51.9 (0.5)	47.5 (0.7)
Canada	68.5 (0.4)	64.9 (0.4)	67.9 (0.4)	79.0 (0.5)	71.7 (0.4)	66.1 (0.4)	71.0 (0.5)
China	63.8 (1.1)	67.6 (1.1)	70.2 (1.4)	69.7 (1.1)	68.2 (1.1)	67.1 (1.1)	66.6 (1.1)
England	68.2 (1.2)	66.6 (1.2)	65.9 (1.5)	76.5 (1.4)	72.1 (1.2)	66.8 (1.2)	69.0 (1.5)
France	67.5 (0.6)	66.8 (0.6)	66.8 (0.6)	75.7 (0.7)	71.4 (0.6)	66.3 (0.6)	70.1 (0.8)
Hungary	77.3 (0.5)	70.1 (0.6)	72.2 (0.6)	75.3 (0.7)	82.5 (0.5)	71.1 (0.5)	69.9 (0.7)
Ireland	61.0 (0.6)	60.7 (0.7)	65.5 (0.8)	71.4 (0.7)	66.0 (0.7)	62.0 (0.6)	63.4 (0.7)
Israel	65.4 (0.7)	69.8 (0.7)	67.5 (0.8)	78.5 (0.7)	70.5 (0.7)	68.4 (0.6)	71.1 (0.8)
Italy, Emilia-Romagna	71.8 (0.7)	67.0 (0.7)	70.8 (0.7)	72.7 (0.7)	76.7 (0.7)	66.9 (0.7)	69.6 (0.8)
Jordan	58.6 (0.7)	53.8 (0.8)	60.7 (0.9)	56.1 (0.9)	65.3 (0.7)	56.6 (0.8)	49.2 (0.9)
Korea	80.3 (0.5)	75.8 (0.5)	74.8 (0.6)	78.8 (0.6)	83.9 (0.5)	77.2 (0.4)	72.7 (0.6)
Portugal	65.9 (0.8)	58.4 (0.7)	61.1 (0.9)	67.7 (1.2)	69.8 (0.8)	60.9 (0.7)	59.5 (1.1)
Scotland	67.3 (0.7)	65.7 (0.7)	64.1 (0.8)	76.8 (0.7)	72.3 (0.7)	65.8 (0.6)	67.7 (0.8)
Slovenia	73.1 (0.6)	67.3 (0.5)	70.1 (0.6)	72.5 (0.6)	80.2 (0.5)	68.0 (0.5)	66.0 (0.6)
Soviet Union	73.0 (1.0)	70.8 (1.0)	73.0 (0.9)	68.0 (1.2)	78.8 (1.1)	69.8 (0.8)	67.6 (1.3)
Spain	70.3 (0.6)	64.1 (0.7)	68.5 (0.7)	70.0 (0.7)	76.3 (0.7)	65.2 (0.6)	64.3 (0.8)
Switzerland	74.3 (0.9)	70.3 (0.9)	74.5 (0.8)	79.8 (1.0)	77.1 (0.9)	71.6 (0.8)	74.6 (1.1)
Taiwan	77.9 (0.5)	74.8 (0.4)	72.2 (0.5)	76.4 (0.5)	81.4 (0.5)	74.7 (0.4)	72.3 (0.5)
United States	69.1 (1.0)	61.6 (1.1)	67.0 (0.9)	75.6 (1.3)	72.8 (1.0)	65.1 (0.9)	65.4 (1.3)

TABLE B 7

AVERAGE PERCENTAGES CORRECT AND STANDARD ERRORS ON SCIENCE TEST (AGE 9)

	Total	Male	Female
IAEP Average	62 1 (0 5)		
Canada	62 8 (0 4)	63 6 (0 4)	62 0 (0 5)
England	62 9 (0 9)	63 8 (1 3)	62.0 (1.2)
Hungary	62.5 (0.5)	63 4 (0 6)	61 6 (0 6)
Ireland	56 5 (0 7)	58.2 (1 0)	54 8 (0 9)
Israel	61 2 (0 7)	63 0 (0 9)	59 4 (0 7)
Italy Emilia-Romagna	66 9 (0 9)	67 9 (1 0)	65 8 (1 0)
Korea	67 9 (0.5)	70 4 (0 7)	65 1 (0.5)
Portugal	54 8 (0 7)	56 3 (0 9)	53 3 (0 9)
Scotland	62 2 (0 7)	61 9 (0 7)	62.5 (1 0)
Slovenia	57 7 (0.5)	58.3 (0 6)	57 0 (0 6)
Soviet Union	61 5 (1.2)	62 7 (1 4)	60 4 (1 2)
Spain	61 7 (0 7)	63 4 (0 9)	59 7 (0 7)
Taiwan	66 7 (0 5)	68 5 (0 6)	64 6 (0 7)
United States	64 7 (0 9)	65.5 (1 1)	63 8 (0 8)

TABLE B-8

TOPIC AND PROCESS AVERAGE PERCENTAGES CORRECT AND STANDARD ERRORS ON SCIENCE TEST (AGE 9)

	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science	Knows Science	Uses Science	Integrates Science
IAEP Average	63.3 (0.6)	58.6 (0.5)	64.1 (0.7)	63.9 (0.4)	63.9 (0.6)	62.7 (0.5)	56.9 (0.7)
Canada	63.3 (0.4)	57.7 (0.4)	66.8 (0.4)	67.3 (0.5)	63.4 (0.4)	65.3 (0.4)	56.4 (0.4)
England	62.4 (0.9)	60.1 (0.9)	66.3 (1.1)	66.0 (1.1)	64.5 (1.0)	63.6 (0.9)	58.2 (1.0)
Hungary	64.7 (0.6)	56.3 (0.6)	68.2 (0.5)	62.0 (0.6)	66.1 (0.5)	61.1 (0.5)	57.4 (0.7)
Ireland	54.7 (0.8)	53.8 (0.7)	62.9 (0.8)	59.5 (0.8)	57.2 (0.8)	57.4 (0.7)	53.0 (0.8)
Israel	61.4 (0.8)	59.8 (0.6)	60.6 (0.7)	64.1 (0.9)	61.0 (0.8)	63.0 (0.6)	57.7 (0.8)
Italy, Emilia-Romagna	71.3 (0.9)	61.0 (0.9)	66.8 (0.9)	66.9 (1.1)	71.6 (0.9)	66.1 (0.9)	58.2 (1.1)
Korea	69.1 (0.5)	68.2 (0.5)	62.4 (0.6)	70.7 (0.6)	67.3 (0.5)	70.1 (0.5)	64.5 (0.5)
Portugal	58.1 (0.8)	50.0 (0.6)	57.3 (0.9)	52.4 (1.1)	58.4 (0.9)	54.1 (0.7)	48.5 (0.8)
Scotland	61.3 (0.7)	59.1 (0.8)	65.1 (0.7)	67.7 (1.0)	62.5 (0.6)	62.7 (0.7)	60.4 (0.8)
Slovenia	59.4 (0.5)	56.6 (0.5)	58.3 (0.7)	54.1 (0.6)	60.3 (0.5)	57.0 (0.5)	52.9 (0.7)
Soviet Union	63.8 (1.4)	58.1 (0.9)	63.1 (1.4)	60.2 (1.4)	63.9 (1.4)	62.3 (1.1)	54.7 (1.4)
Spain	65.7 (0.7)	54.1 (0.7)	62.7 (0.7)	65.1 (1.0)	66.7 (0.7)	60.3 (0.7)	53.8 (0.8)
Taiwan	65.3 (0.6)	68.1 (0.5)	66.6 (0.7)	67.4 (0.6)	65.3 (0.6)	69.5 (0.6)	63.6 (0.6)
United States	65.2 (0.9)	57.5 (0.8)	70.6 (1.1)	70.7 (1.0)	67.0 (1.0)	65.5 (0.9)	57.9 (0.8)

TABLE B-9

FRAMEWORK FOR ACHIEVEMENT ASSESSMENT IN MATHEMATICS
NUMBER AND PERCENTAGE OF ITEMS ON TEST (AGE 13)

	CONTENT					
	Numbers and Operations	Measure-ment	Geometry	Data Analysis Statistics & Probability	Algebra and Functions	Total (%)
SKILL						
Conceptual Understanding	12	3	5	3	2	25 (33)
Procedural Knowledge	8	3	3	5	7	26 (35)
Problem Solving	7	7	3	1	6	24 (32)
Total (%)	27 (36)	13 (17)	11 (15)	9 (12)	15 (20)	75 (100)

TABLE B-10

FRAMEWORK FOR ACHIEVEMENT ASSESSMENT IN MATHEMATICS
NUMBER AND PERCENTAGE OF ITEMS ON TEST (AGE 9)

	CONTENT					
	Numbers and Operations	Measure-ment	Geometry	Data Analysis Statistics & Probability	Algebra and Functions	Total (%)
SKILL						
Conceptual Understanding	10	4	5	3	2	24 (39)
Procedural Knowledge	15	4	0	3	0	22 (36)
Problem Solving	7	1	1	2	4	15 (25)
Total (%)	32 (52)	9 (15)	6 (10)	8 (13)	6 (10)	61 (100)

TABLE B-11

FRAMEWORK FOR ACHIEVEMENT ASSESSMENT IN SCIENCE:
NUMBER AND PERCENTAGE OF ITEMS ON TEST (AGE 13)

	CONTENT				
	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science	Total (%)
SKILL					
Knows Science	10	4	1	0	15 (23)
Uses Science	6	13	8	4	31 (48)
Integrates Science	3	8	0	7	18 (29)
Total (%)	19 (30)	25 (39)	9 (14)	11 (17)	64 (100)

TABLE B-12

FRAMEWORK FOR ACHIEVEMENT ASSESSMENT IN SCIENCE:
NUMBER AND PERCENTAGE OF ITEMS ON TEST (AGE 9)

	CONTENT				
	Life Sciences	Physical Sciences	Earth and Space Sciences	Nature of Science	Total (%)
SKILL					
Knows Science	17	1	5	1	24 (41)
Uses Science	3	12	4	4	23 (40)
Integrates Science	3	4	1	3	11 (19)
Total (%)	23 (40)	17 (29)	10 (17)	8 (14)	58 (100)

Appendix C: Contextual and Background Variables

TABLE C-1

TIME SPENT IN SCHOOL (AGE 13)

	Average Number of Days Per Year	Average Minutes Instruction Per Day	Average Hours Instruction Per Year	Average Hours Maths Instruction Per Year	Percentage Instructional Time on Maths	Average Hours Science Instruction Per Year	Percentage Instructional Time on Science
Brazil Fortaleza	183	223	680	140	21	76	11
Brazil São Paulo	181	271	817	136	17	107	13
Canada	188	304	953	141	15	98	10
China	251	305	1 276	257	20	277	22
England	192	300	960	122	13	124	13
France	174	370	1,073	133	12	101	9
Hungary	177	223	658	110	17	122	19
Ireland	173	323	931	109	12	92	10
Israel	215	278	996	147	15	130	13
Italy, Emilia Romagna	204	289	983	149	15	94	10
Jordan	191	260	828	115	14	115	14
Korea	222	264	977	132	14	107	11
Mozambique	193	272	875	140	16	–	–
Portugal	172	334	957	119	12	90	9
Scotland	191	324	1 031	134	13	114	11
Slovenia	190	248	785	119	15	179	23
Soviet Union	198	243	802	170	21	255	32
Spain	188	285	893	147	16	118	13
Switzerland	207	305	1,052	173	16	105	10
Taiwan	222	318	1,177	151	13	181	15
United States	178	338	1 003	135	13	138	14

Note -- Mozambique did not participate in the science assessment

TABLE C-2

TIME SPENT IN SCHOOL[a] (AGE 9)

	Number of Days Instruction Per Year		Number of Hours Instruction Per Day		Hours Per Week Maths	Hours Per Week Science	
	176 - 200	More than 200	4 - 5	More than 5	More than 5	Less than 1	1¼ - 2½
Canada	100	0	85	11	32	21	64
England	97	0	86	11	61	5	57
Hungary	72	1	6	1	1	2	92
Ireland	100	0	87	10	42	48	47
Israel	10	90	39	3	7	2	95
Italy, Emilia-Romagna	53	47	8	10	95	3	72
Korea	0	98	5	1	0	0	9
Portugal	4	0	93	5	83	0	16
Scotland	94	4	90	8	72	46	37
Slovenia	96	0	5	0	5	1	71
Soviet Union	16	41	3	1	0	13	87
Spain	37	23	81	16	55	0	25
Taiwan	3	89	55	7	0	0	2
United States	75	2	20	76	40	3	52

[a] Entries in each cell are the percentages of pupils receiving instruction for the specified duration.

TABLE C-3

SCHOOL AND CLASS SIZE (AGE 13)

	Percentage of Pupils in Schools Enrolling 500 - 750 Pupils	Percentage of Pupils in Schools Enrolling More Than 750 Pupils	Percentage of Pupils in Classes Containing More Than 25 Pupils	Average Class Size
Brazil, Fortaleza	6	90	82	32
Brazil, São Paulo	4	94	93	38
Canada	24	30	66	25
China	17	67	99	48
England	22	51	41	22
France	39	24	60	25
Hungary	34	23	57	27
Ireland	36	21	74	27
Israel	32	43	85	32
Italy,Emilia-Romagna	5	0	4	21
Jordan	19	43	68	27
Korea	8	79	100	49
Mozambique	3	95	100	51
Portugal	14	79	68	25
Scotland	30	58	45	24
Slovenia	32	41	60	25
Soviet Union	12	67	80	22
Spain	33	31	75	29
Switzerland	28	10	1	18
Taiwan	1	96	100	44
United States	32	44	40	23

TABLE C-4

SCHOOL AND CLASS SIZE (AGE 9)

	Percentage of Pupils in Schools Enrolling Fewer Than 251 Pupils	Percentage of Pupils in Schools Enrollling 251- 500 Pupils	Percentage of Pupils in Schools Enrolling More Than 500 Pupils	Percentage of Pupils in Classes With More Than 35 Pupils
Canada	18	55	28	1
England	39	53	8	3
Hungary	14	29	57	7
Ireland	46	32	22	24
Israel	10	34	56	27
Italy, Emilia-Romagna	4	29	67	6
Korea	6	7	86	89
Portugal	64	23	13	8
Scotland	39	49	12	1
Slovenia	7	23	69	1
Soviet Union	9	12	79	2
Spain	6	23	71	15
Taiwan	3	10	87	89
United States	12	32	56	0

TABLE C-5

PROBLEMS IN SCHOOL PERCENTAGES OF 13-YEAR OLDS ENROLLED IN SCHOOLS WITH MODERATE OR SERIOUS PROBLEMS REGARDING

	Overcrowding in Classrooms	Shortage of Educational Materials and Equipment	Pupil Absenteeism	Lack of Pupil Discipline	Vandalism of School Property
Brazil Fortaleza	26	57	27	41	48
Brazil, São Paulo	25	65	40	51	59
Canada	37	20	14	11	5
China	42	33	4	14	17
England	32	30	11	14	10
France	55	18	12	25	19
Hungary	40	32	15	32	39
Ireland	40	48	32	13	12
Israel	72	23	9	19	27
Italy, Emilia-Romagna	12	35	8	24	26
Jordan	71	37	21	15	25
Korea	50	49	12	46	17
Mozambique	67	98	57	57	94
Portugal	64	76	35	25	22
Scotland	13	21	24	13	13
Slovenia	68	56	11	31	38
Soviet Union	85	75	29	25	24
Spain	49	41	19	32	18
Switzerland	35	7	4	20	20
Taiwan	37	23	4	9	23
United States	36	10	37	32	25

TABLE C-6

PROBLEMS IN SCHOOL. PERCENTAGES OF 9-YEAR OLDS ENROLLED IN SCHOOLS WITH MODERATE OR SERIOUS PROBLEMS REGARDING:

	Overcrowding in Classrooms	Shortage of Educational Materials and Equipment	Pupil Absenteeism	Lack of Pupil Discipline	Vandalism of School Property
Canada	36	22	6	8	5
England	57	37	7	10	14
Hungary	40	32	16	32	39
Ireland	64	46	6	12	12
Israel	63	24	3	20	12
Italy, Emilia-Romagna	24	70	12	15	31
Korea	69	42	8	52	12
Portugal	24	65	12	16	22
Scotland	42	37	2	11	14
Slovenia	62	49	12	32	31
Soviet Union	80	77	22	19	22
Spain	41	39	13	32	19
Taiwan	37	27	0	2	9
United States	28	16	20	10	5

TABLE C-7

AGE 13 THE TEACHING OF MATHEMATICS PERCENTAGES OF PUPILS

	Streamed by Maths Ability	Taught by Maths Specialists	Who Ever Use Calculator in School	Who Ever Use Computer for School or Homework	Who Never Use Mathematics Objects/ Materials in Class	Tested in Mathematics At Least Once Per Week
Brazil Fortaleza	28	85	4	3	45	56
Brazil São Paulo	14	99	2	4	56	45
Canada	14	43	75	42	60	53
China	4	94	7	6	48	63
England	92	99	90	44	37	28
France	19	94	94	57	36	64
Hungary	0	56	71	31	9	17
Ireland	72	65	25	13	69	19
Israel	77	92	49	59	63	36
Italy, Emilia Romagna	19	15	64	40	39	19
Jordan	8	99	5	5	37	68
Korea	0	96	4	10	64	28
Mozambique	22	100	5	13	18	94
Portugal	5	99	19	7	61	21
Scotland	18	100	82	38	32	17
Slovenia	2	100	46	61	15	28
Soviet Union	29	97	19	6	45	52
Spain	2	87	45	12	30	31
Switzerland	14	32	51	25	30	40
Taiwan	66	99	62	6	37	87
United States	64	96	54	37	51	68

TABLE C-8

AGE 9: THE TEACHING OF MATHEMATICS. PERCENTAGES OF PUPILS:

	Grouped By Ability Within Maths Classes	In Schools Where Calculators Are Not Permitted	In Schools Where At Least 1 Computer Available For Use By Pupils	Who Work With Maths Tools Often In Class
Canada	34	12	98	13
England	53	2	100	18
Hungary	44	23	53	20
Ireland	59	47	57	14
Israel	29	5	88	21
Italy, Emilia-Romagna	23	25	54	18
Korea	41	55	100	11
Portugal	49	29	11	17
Scotland	90	0	97	13
Slovenia	48	23	57	20
Soviet Union	45	11	9	21
Spain	13	40	25	23
Taiwan	6	32	25	30
United States	34	5	96	19

TABLE C-9

AGE 13 THE TEACHING OF SCIENCE PERCENTAGES OF PUPILS

	Streamed by Science Ability	Taught by Science Specialists	In School With One or More Specialized Science Laboratories	Who Never Conduct Experiments in School	Who Never Watch a Science Film/Video in School
Brazil Fortaleza	27	82	14	44	36
Brazil São Paulo	11	99	15	35	40
Canada	7	48	38	13	27
China	2	80	63	29	27
England	49	100	79	2	16
France	10	93	78	20	27
Hungary	0	66	40	31	31
Ireland	34	99	61	27	67
Israel	18	93	54	35	32
Italy Emilia-Romagna	15	8	21	59	27
Jordan	11	94	19	26	35
Korea	1	96	41	35	66
Portugal	5	96	88	48	44
Scotland	2	95	95	3	12
Slovenia	0	95	44	22	34
Soviet Union	21	95	97	13	25
Spain	0	71	34	51	39
Switzerland	15	35	54	36	18
Taiwan	60	100	94	25	43
United States	27	92	54	25	12

TABLE C-10

AGE 9: THE TEACHING OF SCIENCE. PERCENTAGES OF PUPILS:

	Who Never Read Books About Science and Nature in School	Who Never Watch Their Teacher Do Science Experiments	Who Never Do Science Experiments in School
Canada	13	27	27
England	14	15	11
Hungary	9	5	40
Ireland	16	41	50
Israel	14	14	14
Italy, Emilia-Romagna	9	8	50
Korea	12	8	19
Portugal	9	15	22
Scotland	16	25	28
Slovenia	3	13	21
Soviet Union	9	18	44
Spain	6	37	40
Taiwan	3	4	10
United States	9	22	22

TABLE C-11

AGES 13 AND 9 HOMEWORK PERCENTAGES OF PUPILS WHO SPEND SPECIFIED TIME COMPLETING HOMEWORK

	Age 13			Age 9		
	2 Hours or More All Homework Each Day[a]	4 Hours or More Maths Homework Each Week	4 Hours or More Science Homework Each Week	2 Hours or More All Homework Each Day[a]	2 Hours or More Maths Homework Each Week	2 Hours or More Science Homework Each Week
Brazil Fortaleza	49	18	8	–	–	–
Brazil São Paulo	47	16	8	–	–	–
Canada	27	15	4	13	29	20
China	40	37	16	–	–	–
England	30	6	2	10	17	13
France	55	17	1	–	–	–
Hungary	60	11	13	27	50	38
Ireland	65	17	5	17	37	18
Israel	50	17	4	36	45	30
Italy, Emilia Romagna	79	27	2	22	38	29
Jordan	55	14	12	–	–	–
Korea	40	33	9	21	49	31
Mozambique	42	11	–	–	–	–
Portugal	30	9	6	21	41	37
Scotland	15	4	2	5	16	8
Slovenia	28	15	7	15	40	32
Soviet Union	52	33	59	29	48	25
Spain	63	22	12	29	54	49
Switzerland	21	15	1	–	–	–
Taiwan	43	24	10	30	50	41
United States	30	15	7	20	34	22

[a] Average of responses to the homework question from the mathematics and science samples i e (Maths + Science) ÷2

– Did not participate in the survey of this population or subject

TABLE C-12

AGE 13: HOME ENVIRONMENT OF THE PUPILS. PERCENTAGES OF PUPILS WHO:

	Have 4 or More Siblings[a]	Are From Homes With Fewer Than 25 Books[a]	Read For Fun Almost Every Day[a]	Watch TV for 5 Hours or More Each Day[a]	Never Watch TV Programme About Science at Home
Brazil, Fortaleza	33	47	41	21	27
Brazil, São Paulo	16	46	32	19	29
Canada	8	14	37	15	40
China	12	28	28	5	14
England	9	15	39	19	40
France	11	25	40	5	28
Hungary	3	10	44	15	4
Ireland	35	24	41	9	47
Israel	19	10	40	20	19
Italy, Emilia-Romagna	2	23	46	6	18
Jordan	88	50	23	9	10
Korea	20	25	11	11	36
Mozambique	64	55	41	20	–
Portugal	8	32	46	11	21
Scotland	9	25	38	24	48
Slovenia	3	18	43	5	15
Soviet Union	12	12	48	18	33
Spain	11	20	35	11	25
Switzerland	4	16	50	7	27
Taiwan	12	35	18	9	32
United States	17	18	29	21	40

[a] Figures obtained by averaging the percentages separately provided by the mathematics and science samples of pupils.

-- Mozambique did not participate in the science survey.

TABLE C 13

AGE 13 ATTITUDES IN THE HOMES PERCENTAGES OF PUPILS

	Who Have Positive Attitudes to Maths	Whose Parents Want Pupil To Do Well in Maths	Who Receive Help With Maths Homework	Who Have Positive Attitudes to Science	Who Talk With Someone at Home About Science Class	Who Receive Help With Science Homework
Brazil Fortaleza	86	89	46	74	68	39
Brazil, São Paulo	83	82	48	69	65	39
Canada	94	96	69	62	47	47
China	79	81	37	74	80	40
England	91	94	65	66	61	60
France	81	86	53	55	62	44
Hungary	85	93	80	69	75	61
Ireland	88	94	61	57	59	44
Israel	90	97	53	62	56	31
Italy						
Emilia Romagna	86	91	34	73	67	14
Jordan	77	91	43	82	79	40
Korea	71	92	53	27	53	44
Mozambique	88	85	65	–	–	–
Portugal	84	79	27	71	63	37
Scotland	91	95	65	66	60	47
Slovenia	83	87	62	78	84	59
Soviet Union	76	84	32	66	67	26
Spain	89	90	58	78	72	61
Switzerland	85	85	42	59	54	26
Taiwan	79	90	51	51	59	45
United States	90	96	74	57	50	53

– Mozambique did not participate in the science survey

TABLE C-14

AGE 9: HOME ENVIRONMENT OF PUPILS. PERCENTAGES OF PUPILS WHO:

	Have 4 or More Siblings[a]	Are From Homes With Fewer Than 25 Books[a]	Read for Fun Almost Every Day[a]	Watch TV for 5 Hours or More Each Day[a]
Canada	7	20	48	22
England	10	22	50	23
Hungary	3	16	51	16
Ireland	30	27	48	23
Israel	16	15	56	24
Italy, Emilia-Romagna	2	35	51	9
Korea	19	31	25	10
Portugal	9	48	61	19
Scotland	6	23	45	24
Slovenia	3	26	62	9
Soviet Union	22	13	64	18
Spain	11	27	55	19
Taiwan	12	50	31	10
United States	16	23	46	26

[a] Figures obtained by averaging the percentages separately provided by the mathematics and science samples of pupils.

TABLE C-15

AGE 9 ATTITUDES IN THE HOMES PERCENTAGES OF PUPILS WHO BELIEVE THAT

	I Am Good at Maths	My Parents Want Me To Do Well in Maths	I Am Good at Science	My Parents Are Interested In Science
Canada	69	89	60	47
England	49	88	45	47
Hungary	40	88	46	62
Ireland	63	86	39	43
Israel	65	91	64	43
Italy Emilia Romagna	59	91	63	74
Korea	38	86	42	42
Portugal	49	85	51	54
Scotland	55	87	41	46
Slovenia	67	85	63	65
Soviet Union	57	75	58	34
Spain	68	92	67	68
Taiwan	39	90	30	37
United States	71	89	61	42