Education for Life

The Achievements of 15-Year-Olds in Ireland in the Second Cycle of PISA

Summary Report

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Preface

The Programme for International Student Assessment (PISA) is a collaborative project of the member states of the Organisation for Economic Co-operation and Development (OECD). Its purpose is to address the question of how well young people are equipped for future participation in society, in the labour force, as citizens, and as individuals through an assessment of some key skills. As such, its focus moves away from traditional school-based learning towards a more literacy-based approach. PISA runs in three-yearly cycles. In the first cycle (PISA 2000), reading was the main focus of the assessment. While PISA 2000 assessed students in 32 countries/regions (and an additional 11 countries in 2001), the number of countries participating in PISA 2003 is 41, to include all 30 OECD countries and 11 non-OECD (partner) countries. In PISA 2003 mathematics is the key focus and an assessment of cross-curricular problem-solving skills is included for the first time. It is possible to compare outcomes in 2003 on mathematics, reading and science with outcomes in 2000, to give a preliminary indication of changes in achievements over time.

Several reports based on PISA 2000 have been published by the OECD (see OECD, 2001 and http://www.pisa.oecd.org). A national report for Ireland (*Ready For Life? The Literacy Achievements of Irish 15-Year Olds With Comparative International Data*; Shiel, Cosgrove, Sofroniou, & Kelly, 2001) was also published, in full and summary form. A report focusing on reading literacy for teachers and educationalists in Ireland was also published (*A Teacher's Guide to the Reading Literacy Achievements of Irish 15-Year Olds;* Cosgrove, Sofroniou, Kelly, & Shiel, 2003). The present report is the first national publication on PISA 2003 and presents the key findings for Irish 15-year-olds on PISA 2003 in a national context. It will be followed with a full-length report, to be released in the spring of 2005. The publication of this summary report coincides with the OECD's initial report on PISA 2003, which appears in two volumes (*Learning for Tomorrow's World - First Results from PISA 2003* and *Problem Solving for Tomorrow's World - First Measures of Cross-Curricular Skills from PISA 2003*; OECD, 2004a; 2004b).

This report begins by outlining the key features of the PISA survey design (Chapter 1). Next, it describes how student skills in the four assessment domains were measured (Chapter 2). In Chapter 3, achievement outcomes of students in mathematics are described, on both an overall achievement scale, and on subscales representing four mathematical content areas (Space & Shape, Change & Relationships, Quantity, and Uncertainty). Outcomes for 2000 and 2003 are also compared. Chapter 4 presents the achievements of students in reading and science, and also includes comparison with performance in 2000 for these domains. Chapter 5 examines some key student-level and school-level variables that are associated with student achievement in Ireland. Chapter 6 builds on Chapter 5 by examining the associations of a number of school- and student-level variables simultaneously, through the development of multilevel models of achievement in mathematics, reading and science. Chapter 7 explores outcomes on PISA in relation to the Irish Junior Certificate syllabus and examinations, with a particular focus on the content and assessment of mathematics. Chapter 8 describes student performance on the assessment of cross-curricular problem solving. Finally, Chapter 9 summarises findings and draws a number of conclusions and implications.

To help illustrate the nature of the test items encountered by students in PISA 2003, the appendix to this report contains some sample assessment tasks in mathematics and problem solving. A more complete set of sample tasks can be found on http://www.erc.ie/pisa. Items also feature in the initial OECD report for PISA 2003, the PISA 2003 assessment framework document (OECD, 2003) and in the forthcoming full national report.

We would like to acknowledge the contributions of a number of individuals during the implementation of PISA 2003 in Ireland and the production of this report. Firstly, thanks are due to the 145 schools and 3880 students that took part in the assessment in March, 2003. Without their support and assistance, particularly the assistance of the School Contact in each school, the study could not have been carried out. Thanks also to the 27 schools and 734 students who participated in the pilot phase of this survey in March 2002. Outcomes of the pilot were invaluable in assisting in the selection of the final test and questionnaire items, and making refinements to survey procedures.

Thanks are extended to the PISA consortium and OECD Secretariat, particularly Andreas Schleicher, Claudia Tamassia, and Christian Monseur, for assistance and advice in the course of analysing the data for this report. We would also like to acknowledge the advice of Murray Aitkin (University of Newcastle) on nonparametric maximum likelihood estimation applied to the comparison of country mean scores.

Thanks are due to Doreen McMorris (Department of Education and Science), Chair of the PISA national advisory committee, for continued support for our work on PISA, and advice on the content of this report. Thanks also to the other PISA national advisory committee members for their detailed and insightful comments and feedback on drafts of this report: Declan Kennedy (University College, Cork), Bill Lynch (National Council for Curriculum and Assessment), Tom Mullins (University College, Cork), and Elizabeth Oldham (University of Dublin, Trinity College). Thanks to Seán Close (St Patrick's College, Dublin), who recently joined the committee for detailed advice on the content of the report, particularly regarding the interpretation of proficiency levels and student performance in mathematics.

We wish to thank the individuals involved in the rating of the PISA mathematics tasks with respect to the Junior Certificate mathematics syllabus and examinations: John Evans, Elizabeth Oldham, and Peter Tiernan.

Thanks are due to our colleagues in the Educational Research Centre, Mary Rohan, John Coyle, and Stephen McMahon for their continued administrative and technical support, and to Amy Kelly, who contributed to the project as a Research Assistant until May 2004.

Throughout this report, the terms *mathematics*, *reading* and *science* are used to denote the PISA domains of mathematical literacy, reading literacy and scientific literacy. This is consistent with the approach adopted in the international report on PISA (OECD, 2004a).

Chapter 1
PISA 2003: An Overview

The Programme for International Student Assessment (PISA), an international assessment project of the Organisation for Economic Co-operation and Development (OECD), assesses the knowledge and skills of 15-year-olds at three-yearly intervals. The aims of PISA are to generate internationally comparable indicators of student achievement in key aspects of literacy at or near the end of compulsory schooling; to provide a broad context in which countries can interpret the performance of their education systems; to provide an indication of changes in student achievement over time; as well as to focus and motivate educational reform and school improvement. PISA does not aim to provide a direct measure of students' mastery of specific curricular content. Rather, in adopting a 'literacy-based' perspective, key content and learning processes that are deemed important by international experts for the present and future lives of 15-year-olds, and which are embedded in 'real life' problems, are the focus of the assessment.

The first cycle of PISA (PISA 2000), in which 28 OECD countries and four partner (non-OECD) countries participated, was implemented in 2000.[1] Reading literacy was the main focus of the assessment (the 'major domain'; see Table 1.1), while mathematics and science were minor domains. Initial international results were published in *Knowledge and Skills for Life: First Results of PISA 2000* (OECD, 2001). In Ireland, a national report, *Ready for Life? The Literacy Achievements of Irish 15-year Olds* (Shiel, Cosgrove, Sofroniou & Kelly, 2001), provided a detailed analysis of the performance of Irish students in the study. A brief overview of the main outcomes from PISA 2000 is given in the following section.

Table 1.1. Content Domains Across Planned Cycles of PISA (2000-2006)

Year	*Major Domain*	*Minor Domains*	*Additional Areas of Interest**
2000	Reading (141)**	Mathematics (32) Science (35)	Equity and literacy; reading attitudes and habits; students' self-regulated learning
2003	Mathematics (85)	Science (35) Reading (28) Cross-Curricular Problem Solving (19)	Variables associated with performance in mathematical literacy; attitudes to mathematics; educational pathways
2006	Science	Reading Mathematics	Information and communication technologies (ICTs); attitudes to science

* These areas are addressed through the administration of questionnaire items.

** Number of items for each domain in 2000 and 2003 are indicated in brackets.

MAIN OUTCOMES OF PISA 2000

Overall achievements in each of the three assessment domains were scaled to have an OECD mean of 500.0 and a standard deviation of 100.0. In the case of reading, which was the major domain, achievements on three reading subscales were also reported: Retrieve (which

[1] An additional 11 countries participated in PISA in 2001. The outcomes of these countries were published in PISA / UNESCO-UIS (2003).

describes students' ability to retrieve information from different types of texts), Interpret (describing students' ability to form an interpretation of text), and Reflect/Evaluate (detailing students' ability to reflect on, or critically evaluate, texts). The mean score for Ireland on the combined reading literacy scale and three reading literacy subscales were all significantly higher than the corresponding OECD mean scores. Irish students achieved the 5th highest mean score (526.7) out of 27 OECD countries in reading literacy[2], with only one country (Finland) achieving a significantly higher score. The mean scores of students in Ireland on two of the three reading subscales, Retrieve and Interpret (524.3 and 526.5, respectively) were similar to their performance on the combined scale. Again, just one country (Finland) scored significantly higher than Ireland on these subscales. On the third reading subscale, Reflect/Evaluate, Ireland ranked third with a mean of 533.2, and no country had a significantly higher mean score. In mathematics, the mean performance of Irish students (502.9) ranked 15th of 27 OECD countries, and did not differ significantly from the OECD average. The highest scoring country, Japan, achieved a mean score that was 53.7 points higher than Ireland's mean. In science, Ireland ranked 9th overall, achieving a mean score (513.4) that was significantly above the OECD average. Thus, Ireland did better on the science assessment than on mathematics, but less well than on reading literacy.

Associations between performances of students in Ireland in the three domains were quite strong: correlations of .82 between reading and mathematics, .90 for reading and science, and .83 between mathematics and science, were obtained. Achievement outcomes were also related to a number of school-level and student-level variables. In nationally-developed multilevel models of achievement, which allow for the simultaneous evaluation of multiple variables at both the school and student levels, several variables were substantially associated with achievement in all three assessment domains: school sector (secondary, community/comprehensive, or vocational), school designated disadvantaged status, student socioeconomic status, lone-parent status, number of siblings, number of books in the home, early school leaving intent, and completion of homework on time.

FOCUS AND KEY FEATURES OF PISA 2003

In 2003, students in 41 countries participated in the assessment.[3] These included all 30 OECD member countries and 11 non-OECD countries (termed 'partner countries' in PISA) (Figure 1.1) In the 2003 cycle, the primary focus is on mathematics, with reading, science and cross-curricular problem solving included as minor domains (Table 1.1). In this report, 'mathematics' refers to mathematical literacy, and 'science' to scientific literacy. As well as the tests, Student and School Questionnaires were administered.[4] The School Questionnaire, which was completed by principal teachers, asked about school management, organisational and resource variables. In addition, some school-level variables from the Department of Education and Science's school database (such as school designated disadvantaged status) were incorporated into national analyses of the data, as were some variables from the Junior Certificate Examination Database of the State Examinations Commission. The Student Questionnaire sought information on individual student variables (e.g., socioeconomic status, parents' education, and anxiety about mathematics). Some analyses focusing on these variables are presented in the current report and in the initial OECD reports on PISA 2003 (OECD, 2004a, 2004b). Others will be reported in later national and international reports.

[2] The Netherlands was not included in analyses of achievement due to low response rates.

[3] The response rates for the United Kingdom were too low to ensure comparability with other countries, so the report describes the outcomes for Ireland with respect to 39 rather than 40 countries.

[4] Ireland also administered a nationally developed teacher questionnaire for teachers of mathematics, and it is intended to report the outcomes in a later publication.

OECD Countries			Partner Countries
Australia	Iceland	Portugal	Brazil
Austria	Ireland	Slovak Republic*	Macao-China*
Belgium	Italy	Spain	Hong Kong-China
Canada	Japan	Sweden	Indonesia
Czech Republic	Korea (Rep. of)	Switzerland	Latvia
Denmark	Luxembourg	Turkey*	Lichtenstein
Finland	Mexico	United Kingdom	Russian Federation
France	Netherlands	United States	Serbia
Germany	New Zealand		Thailand
Greece	Norway		Tunisia
Hungary	Poland		Uruguay
*New to PISA 2003			

Figure 1.1. Countries Participating in PISA 2003

SAMPLING SCHOOLS AND STUDENTS

The target population in Ireland comprised all 15-year-old students (i.e., those born in 1987) who were in full-time education in mainstream recognised second-level schools in which teaching staff salaries are paid by the Department of Education and Science. School-level exclusions (primary schools with 15-year-olds enrolled, special education schools, private/unrecognised schools and schools on islands) resulted in the exclusion of 1.6% of students. A two-stage stratified sample design was used. First, schools were selected, followed by students within schools. At the first stage, schools in the sampling frame were divided into three strata (groups) according to the total number of 15-year-olds in the school (up to 40 15-year olds enrolled, 41-80, and 81 or more). To achieve a sample size of 5250, as recommended for PISA, 155 schools in Ireland were selected to participate.[5] Within each stratum, schools were selected with probability proportional to size (using school type and gender composition as implicit stratifying variables). Of the schools selected, 139 participated, giving a weighted initial response rate of 90.2%. Four replacement schools also participated, yielding a weighted school-level response rate of 92.8% after replacement.

In the second stage of sampling, the required number of 15-year-old students within each participating school was selected at random (35 students in schools that had 35 or more eligible students, and all students in schools with a number lower than 35). Among selected students, functionally disabled students, students with general learning disabilities, students with specific learning disabilities (dyslexia), and those with limited experience of the test language (English or Irish) were exempted from the assessment. In Ireland, exempted students accounted for 2.9% of students sampled. After refusals, absences and transfer of students to other schools were taken into account, 3880 students participated, yielding a weighted student-level response rate of 82.6% of all eligible students in participating schools. Both school and student response rates were in line with the standards established for PISA 2003 (a response rate of 85% for initially selected schools, and a student-level response rate of 80%).

Ten of the participating schools taught through the medium of the Irish language, or were located in Gaeltacht areas. Administration materials, questionnaires, mathematics and science test items were translated into Irish, and students were given the option of responding in English or Irish.

[5] One selected school contained just one eligible student and was excluded on a *post-hoc* basis.

ADMINISTRATION AND MARKING OF THE ASSESSMENT

The PISA assessment was administered to selected students in their schools by trained test administrators during a two-week period in March 2003. The use of a rotated test design meant that each student was asked to attempt just a portion of the full pool of assessment units and items. Thirteen two-hour test booklets were used. All booklets contained mathematics items, while reading, science and problem solving items appeared in seven of the 13. Items were organised into 30-minute blocks. Each student took one test booklet consisting of four blocks (two hours). A further 45 minutes was available to complete the Student Questionnaire.

Trained quality monitors were employed by the PISA Consortium[6] to independently monitor the testing sessions in 10% of selected schools in each country (14 schools in Ireland). They reported directly to the Consortium on matters such as suitability of the assessment conditions, timing of assessment sessions, and the incidence of disruptions. The reports of these observers for Ireland indicate that the tests and questionnaires were administered in accordance with international guidelines, and that the co-operation of school staff and students was highly satisfactory.

Following the assessment, student responses were scored by trained markers, using marking guides provided by the PISA Consortium. It was a requirement that a subset of test booklets be marked four times and subjected to a homogeneity analysis (which yields an index of the agreement between markers). Inter-rater reliability in Ireland was found to be high and in accordance with values reported for other countries. An inter-country marker reliability study was conducted, in which independent marking of the original booklets was undertaken by Consortium staff. The average country index of agreement for the inter-country reliability study was in the region of 92%, indicating a very satisfactory reliability.

INTERPRETING ACHIEVEMENT SCORES

In this report, reference is made to achievement differences between countries and between groups of students in Ireland. In interpreting these score differences, it is useful to refer to the standard deviations of the achievement scales. The standard deviation gives a measure of how dispersed the scores are around the mean. Given the distribution of scores, a little over two-thirds of students are expected to have an achievement score that is within plus or minus one standard deviation of the mean; 95% of scores fall within plus or minus two standard deviations of the mean. The OECD average standard deviations for all domains are around 100 score points, while those in Ireland are somewhat smaller (see Chapters 3, 4 and 8). In the case of mathematics and reading, score differences can also be interpreted in terms of proficiency levels. For mathematics, six levels of proficiency were identified, and the interval for these is about 62 score points. In reading, five levels have been defined; the interval for these is somewhat wider at 72 score points.

The tables shown in Chapters 3, 4 and 8 show two types of OECD mean. For the *OECD Average*, each OECD country is given equal weight in its computation. The *OECD Total* is the mean one obtains if each participating student is given equal weight so that countries with larger populations contribute proportionately more to this mean. In this report, we use the OECD Average rather than OECD Total in the text.

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[6] PISA was implemented at the international level on behalf of the OECD by a consortium headed by the Australian Council for Educational Research (ACER).

Chapter 2
Assessment Frameworks for PISA 2003

This chapter describes the assessment framework for mathematics, and, in lesser detail, those for reading, science, and problem solving. A fuller description of the assessment frameworks can be found in OECD (2003).

FRAMEWORK FOR MATHEMATICS

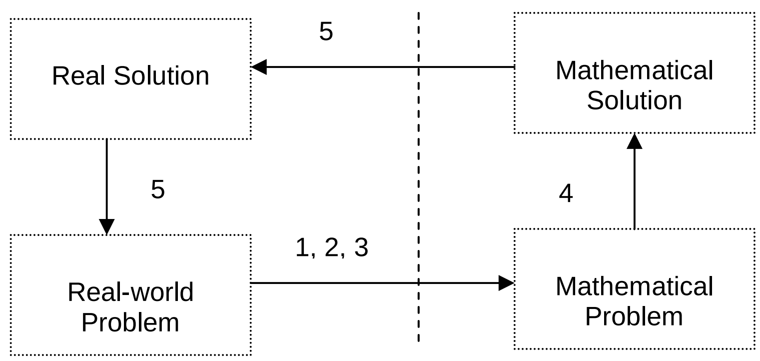
Mathematics in PISA 2003 is concerned with 'the capacities of students to analyse, reason, and communicate ideas effectively as they pose, formulate, solve and interpret mathematical problems in a variety of situations' (OECD, 2003, p. 24). The focus is on 'real-world' problems, though mathematical problems of the traditional kind, which are not always embedded in realistic situations, may also be included. Mathematics in PISA 2003 is defined as:

> an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. (OECD, 2003, p. 24)

The definition and accompanying framework are heavily influenced by the Realistic Mathematics Education movement, which stresses the importance of solving mathematical problems in real-world settings (e.g., Freudenthal, 1973, 1981), and of situated cognition (e.g., Brown, Collins & Duguid, 1989). Central to this approach is the notion of mathematising (Figure 2.1). The process of mathematising involves:

1. Starting with a problem situated in reality;
2. Organising the problem according to mathematical concepts;
3. Gradually 'trimming away the reality' through such processes as making assumptions about which features of the problem are important, and generalising and formalising the problem;
4. Solving the mathematical problem;
5. Making sense of the mathematical solution in terms of the real situation.

Figure 2.1. The Mathematisation Cycle



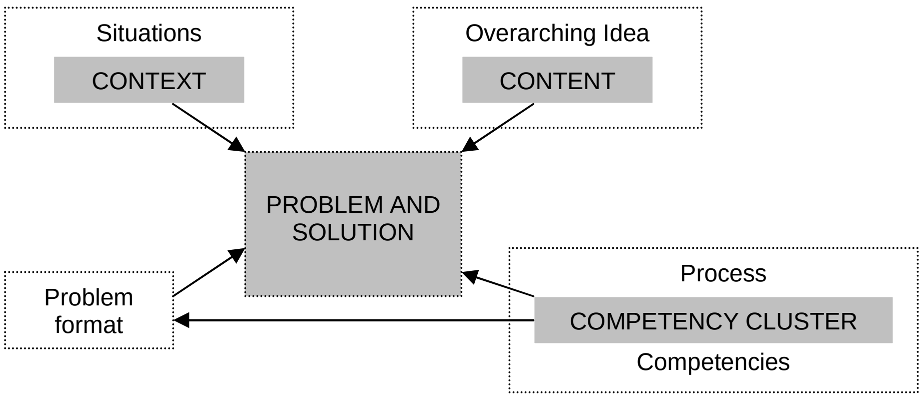
Source: OECD (2003), Figure 1.3, p. 38

The mathematical framework comprises three dimensions: mathematical aspects ('over-arching ideas'), mathematical competencies, and situations (Figure 2.2).

Mathematical Content ─The Four Overarching Ideas

Mathematical content in PISA 2003 encompasses four overarching ideas: Space & Shape, Change & Relationships, Quantity, and Uncertainty. It is acknowledged that these areas are not mutually exclusive, since they include elements of mathematics curricula, such as arithmetic, measurement, geometry, algebra, and probability and statistics. In PISA 2003, a total of 85 items or tasks was presented to students. Of these, 23 (27.1%) are categorised as Quantity, 20 (23.5%) as Space & Shape, 22 (25.9%) as Change & Relationships, and 20 (23.5%) as Uncertainty. In PISA 2000, just two of the four overarching ideas (Space & Shape, and Change & Relationships) were assessed. Thus, PISA 2003 assesses a broader range of mathematical content than PISA 2000, while including a subset of items that were also administered in 2000.

Figure 2.2. The Components of Mathematics in PISA 2003



Source: OECD 2003, Figure 1.2, p 30.

Mathematical Competencies and Competency Clusters

The ability to solve mathematical problems situated in real-life contexts requires that students apply their mathematical skills and competencies to the process of mathematisation. PISA identifies three broad competency clusters: the Reproduction cluster, the Connections cluster, and the Reflection cluster. These are assumed to form a hierarchy, with problems in the Reflection cluster being most difficult to solve. Each mathematical problem in PISA is classified according to the cluster that best describes the competencies that the student is required to draw on to solve the problem. Items are distributed across the competency clusters with 26 items (30.6%) belonging to the Reproduction cluster, 40 (47.1%) to the Connections cluster, and 19 (22.4%) to the Reflection cluster.

Mathematical Situations

The ability to use mathematics in a variety of situations is viewed as being an important part of mathematics. PISA identifies four situation-types in which it is believed that students encounter mathematics in their everyday lives: personal (18 or 21.2% of items), educational/occupational (21 or 24.7%), public (29 or 34.1%), and scientific (17 or 20.0%). While situation indicates the part of the student's world to which the problem belongs, context reflects the specific setting within that situation. The framework distinguishes between intra-and extra-mathematical contexts. The former refers to questions that do not move outside the mathematical realm, while the latter are found in questions that go beyond a mathematical context, and require students to interpret and extract relevant information.

FRAMEWORK FOR READING LITERACY

The reading literacy assessment in PISA 2003 does not measure whether students are technically able to read. Rather, assuming that they can, it attempts to assess the ability of students to understand and reflect on a wide range of written materials, in different situations. Reading literacy is defined as:

> understanding, using and reflecting on written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society. (OECD, 2003, p. 15)

The definition draws attention to higher-order reading comprehension skills including using and reflecting on texts. Reference to participation in society emphasises the role of reading literacy in economic, political, cultural and social life, and reading in a variety of contexts. In operationalising this definition, reading literacy is defined in terms of three dimensions: the content or structure of texts (continuous, such as narrative and descriptive, and non-continuous, such as tables, charts and forms); the processes that need to be performed (retrieval, interpretation, and critical reflection/evaluation); and the situation in which knowledge and skills are drawn on or applied (personal, public, occupational, and educational). This framework is the same as that used in PISA 2000. All 28 PISA 2003 reading literacy items were used in the PISA 2000 assessment.

FRAMEWORK FOR SCIENCE

In PISA 2003, science is defined as:

> the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions, in order to understand and help make decisions about the natural world and the changes made to it through human activity. (OECD, 2003, p. 133)

PISA science is concerned with the capacity of students to draw appropriate and guarded conclusions from evidence and information given to them, to criticise the claims made by others on the basis of the evidence, and to distinguish opinion from evidence-based statements. The PISA science framework includes three dimensions: scientific knowledge or concepts; scientific processes; and scientific areas of application (situations). Concepts are selected from the four major fields of physics, chemistry, biological science, and Earth and space science. The selection of concepts is based on three criteria: the relevance of the concept to everyday life; the likely relevance of the concept in the next decade and beyond; and whether the knowledge can be combined with selected scientific processes.

The PISA framework distinguishes between three major scientific processes: describing, explaining and predicting scientific phenomena; understanding scientific investigation; and interpreting scientific evidence and conclusions. The three broad situations in which individuals apply scientific processes are identified as science in life and health, science in Earth and environment, and science in technology. Science was a minor domain in both PISA 2000 and PISA 2003; it will be the major domain in 2006. The PISA 2003 assessment of science used 25 items that also appeared in PISA 2000, as well as 10 new items.

FRAMEWORK FOR PROBLEM SOLVING

Reflecting its attempts to measure competencies that cut across a range of subject domains, PISA developed an assessment of cross-curricular problem solving for 2003. The assessment, which is not expected to be included in future PISA cycles, was given the status of a minor domain. Although there is disagreement in the literature on a definition of cross-curricular problem solving, it is generally acknowledged that the major focus should be on the solver's ability to analyse the nature of a problem, search for, or construct a solution, and finally communicate the results. With this in mind, problem solving in PISA 2003 is defined as:

> an individual's capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the literacy domains or curricular areas that might be applicable are not within a single domain of mathematics, science or reading. (OECD, 2003, p. 156)

The problem-solving framework is organised according to the type of problem encountered, the processes involved in solving a problem, and the situations involved. The assessment comprises 19 items which are categorised according to three problem types: decision-making (7 items, 36.8%); systems analysis and design (7 items, 36.8%), and trouble shooting (5 items, 26.3%). It is argued that 'the three… problem types provide the generic structures within which problem-solving processes can be assessed' (OECD, 2003, p. 160).

The six processes that are assumed to be most closely related to the three problem types encountered in PISA problem-solving items are: understanding the problem, characterising the problem, representing the problem, solving the problem, reflecting on the solution, and communicating the problem solution. There is no implied hierarchy, and not all six processes are necessarily involved in solving every problem. The problems in PISA are embedded in real-life situations (personal life, work and leisure, community and society) and approach the notion of 'life skills'.

ITEM TYPES

In PISA 2003 mathematics, 20.0% of items were simple multiple-choice, 12.9% complex multiple-choice (such as a series of yes/no questions), 42.4% short response/closed constructed response, and 24.7% open constructed response. Partial credit was available for partially correct responses for 10 of the open constructed response items. Double-digit coding, which entails scoring items for both correctness and error patterns, was used for nine of these items.

In reading literacy, 32.1% of items were simple multiple-choice, 3.6% complex multiple-choice, 28.6% short response/closed constructed response, and 35.7% open constructed response. In science, the item types were simple multiple-choice (37.1%), complex multiple-choice (20.0%), short response (2.9%), and open constructed response (40.0%). Almost two-fifths (36.8%) of items in the problem solving framework were multiple-choice, 47.4% open constructed response, and 15.8% closed constructed response (none was short response in format).

Chapter 3
Achievement Outcomes in Mathematics

In this chapter, performance on the PISA 2003 assessment of mathematics is reported with reference to the combined (overall) mathematics scale, and its four subscales: Space & Shape, Change & Relationships, Quantity, and Uncertainty.

DESCRIPTION OF THE MATHEMATICS SCALES AND PROFICIENCY LEVELS

The scaling of PISA achievement data uses Item Response Theory (IRT), which has the advantage of placing both student achievement and item difficulty on the same metric. In 2003, the combined mathematics scale was set to have an OECD mean score of 500.0 and a standard deviation of 100.0, using random samples of 500 students drawn from each participating OECD country. Separate subscales were developed for each of the four mathematics subdomains. These have OECD mean scores and standard deviations that are close to, but not exactly, 500 and 100, respectively.

To represent degrees of proficiency along the combined mathematics scale and the four subscales, each was divided into six levels. The identification of the six levels was based on a detailed consideration of the types of skills students would be likely to need to answer each mathematics item. On the combined mathematics scale, students who achieve at Level 6, the highest level, are likely to complete the most difficult PISA mathematics tasks successfully, including those requiring modelling of complex problem situations and advanced reasoning. In contrast, students who achieve at Level 1, the lowest level, are likely to succeed only on the more basic mathematics tasks, in contexts where all relevant information is present and the questions are clearly defined. Between these two extremes, the likely proficiency of students progresses from basic to moderate to proficient.

Some students were unable to demonstrate proficiency on Level 1 tasks. These students fall into the category 'below Level 1'. They may lack the basic mathematical skills to progress through the education system, and are likely to be at risk in the transition from education to work, and in their future educational and occupational outcomes.

LINKING STUDENT PERFORMANCE TO THE DIFFICULTY OF ITEMS

Figure 3.1 on the following page illustrates the proficiency levels on the PISA combined mathematics scale with reference to both student ability and item difficulty. The figure shows the cut-points (boundaries) for each level, the scores of Irish students at various points on the scale, and the item difficulties of five questions in the mathematics domain. For example, the second item from the unit 'Number Cubes' (503.5) has an item difficulty around the Irish student mean (502.8). The second item from the unit 'Exports' has an item difficulty (565.0) that corresponds closely to the Irish score at the 75th percentile (561.9). Appendix 1 provides a description of some of these items. Readers are also referred to http://www.erc.ie/pisa where more sample items from PISA 2003 can be seen.

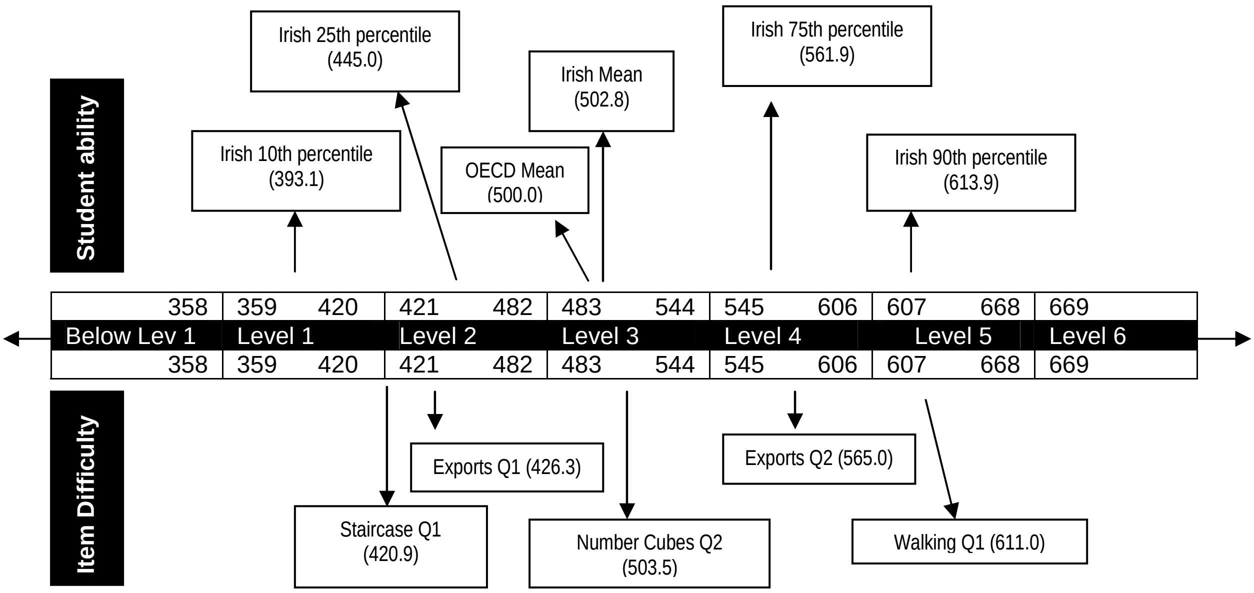


Figure 3.1. The PISA 2003 Combined Mathematics Scale: Cut-points for Proficiency Levels, Scores of Students in Ireland at Key Markers, and Difficulties of Selected Items

COMPARISON OF PERFORMANCE ON THE COMBINED MATHEMATICS SCALE

Ireland achieved a mean score (502.8) on the combined mathematics scale that is not significantly different[7] from the overall OECD mean (489.0) (see Table 3.1). The Irish mean merits a ranking of 17th out of 29 OECD countries (95% confidence interval[8] for Ireland's ranking = 14th to 19th) and a ranking of 20th out of 40 OECD and partner countries (95% confidence interval for Ireland's ranking = 16th to 21st). Ireland's mean score is not significantly different from those of eight countries (the Czech Repbublic, Denmark, France, Sweden, Austria, Germany, the Slovak Republic, and Norway), and is significantly lower than those of 10 OECD countries, including Finland, Korea, the Netherlands, Japan, Canada, Australia, and New Zealand. Ten OECD countries (including Poland, Hungary, Spain, and the USA) achieved significantly lower mean scores.

Countries tend to cluster on the combined mathematics scale at upper and middle rankings, while there is more variation in the mean scores at the lower end of the rankings. Further, it can be observed that 194.4 score points separate the top and bottom countries. However, there is far more variation in achievement within individual countries as evidenced in the large standard deviations in some countries, including Belgium and Germany. Ireland's standard deviation (85.3) is comparatively small.

COMPARISON OF PERFORMANCE IN COMBINED MATHEMATICS USING THE NONPARAMETRIC MAXIMUM LIKELIHOOD METHOD

Table 3.1 summarises multiple comparisons for 40 countries. The Bonferroni method, with an alpha-level of 0.05 across all 39 comparisons, results in per-comparison alpha of 0.0013 (0.05/39). This leads to conservative estimates, especially when the number of comparisons

[7] Statistical significance was evaluated at the .05 level. Adjustments were made for the number of comparisons involving Ireland and OECD countries (28 comparisons), or Ireland and all participating countries (39 comparisons), where appropriate.

[8] Ranking mean scores from samples rather than entire populations introduces sampling and measurement error and the 95% confidence intervals take this into account.

is large. Another way to make these comparisons is to use nonparametric maximum likelihood estimation to fit a form of latent class model to classify the countries into a number of empirically distinguishable performance groupings (Aitkin, Francis & Hinde, in press). The number of groups equals the maximum number of discrete masspoints found and correspond to the fitted probability distribution. Each masspoint has a mean score associated with it, as well as a proportion which is the probability of an unknown country from this population falling into that grouping. Using this method, countries are grouped if their posterior probabilities of belonging to a common masspoint are >= 0.95 (a convenient convention). Borderline values are between 0.90 and 0.95.

In comparison to the Bonferroni method, additional information is obtained from the data using the nonparametric maximum likelihood method. Data for the combined mathematics scores are grouped into six distinct groups. Ireland falls into the second grouping (which has a score of 504.6), along with France, Sweden, Austria, Germany, the Slovak Republic, and Norway.

Table 3.1. Mean Achievement Scores and Standard Deviations on Combined Mathematics – OECD and Partner Countries

	Mean	*(SE)*	*SD*	*(SE)*	*OECD Diff*		*Mean*	*(SE)*	*SD*	*(SE)*	*OECD Diff*
Hong Kong-China	550.4	(4.54)	100.2	(3.01)	▲	Norway	495.2	(2.38)	92.0	(1.15)	▼
Finland	544.3	(1.87)	83.7	(1.08)	▲	Luxembourg	493.2	(0.97)	91.9	(0.95)	▼
Korea	542.2	(3.24)	92.4	(2.14)	▲	Poland	490.2	(2.50)	90.2	(1.34)	▼
Netherlands	537.8	(3.13)	92.5	(2.33)	▲	Hungary	490.0	(2.84)	93.5	(1.96)	▼
Liechtenstein	535.8	(4.12)	99.1	(4.43)	▲	Spain	485.1	(2.41)	88.5	(1.26)	▼
Japan	534.1	(4.02)	100.5	(2.75)	▲	*Latvia*	483.4	(3.69)	87.9	(1.66)	▼
Canada	532.5	(1.82)	87.1	(0.97)	▲	United States	482.9	(2.95)	95.2	(1.29)	▼
Belgium	529.3	(2.29)	109.9	(1.78)	▲	*Russian Federation*	468.4	(4.20)	92.3	(1.93)	▼
Macao-China	527.3	(2.89)	86.9	(2.41)	▲	Portugal	466.0	(3.40)	87.6	(1.66)	▼
Switzerland	526.6	(3.38)	98.4	(2.05)	▲	Italy	465.7	(3.08)	95.7	(1.87)	▼
Australia	524.3	(2.15)	95.4	(1.50)	▲	Greece	444.9	(3.90)	93.8	(1.76)	▼
New Zealand	523.5	(2.26)	98.3	(1.17)	▲	*Serbia & Montenegro*	436.9	(3.75)	84.7	(1.55)	▼
Czech Republic	516.5	(3.55)	95.9	(1.87)	▲	Turkey	423.4	(6.74)	104.7	(5.34)	▼
Iceland	515.1	(1.42)	90.4	(1.21)	▲	*Uruguay*	422.2	(3.29)	99.7	(1.60)	▼
Denmark	514.3	(2.74)	91.3	(1.44)	▲	*Thailand*	417.0	(3.00)	82.0	(1.79)	▼
France	510.8	(2.50)	91.7	(1.80)	▲	Mexico	385.2	(3.64)	85.4	(1.85)	▼
Sweden	509.0	(2.56)	94.7	(1.79)	▲	*Indonesia*	360.2	(3.91)	80.5	(2.06)	▼
Austria	505.6	(3.27)	93.1	(1.67)	o	*Tunisia*	358.7	(2.54)	82.0	(1.95)	▼
Germany	503.0	(3.32)	102.6	(1.77)	o	*Brazil*	356.0	(4.83)	99.7	(2.95)	▼
Ireland	**502.8**	**(2.45)**	**85.3**	**(1.26)**	o	**OECD Total**	**489.0**	**(1.07)**	**103.6**	**(0.74)**	
Slovak Republic	498.2	(3.35)	93.3	(2.32)	o	**OECD Average**	**500.0**	**(0.63)**	**100.0**	**(0.43)**	

■	Mean achievement significantly higher than Ireland	Above OECD average	▲
□	Mean achievement not significantly different from Ireland	At OECD average	o
▒	Mean achievement significantly lower than Ireland	Below OECD average	▼

Note. OECD countries are in regular font; partner countries are in italics. SD = Standard deviation; SE = Standard error.
The column "OECD Diff" indicates whether each country scores at, significantly above, or significantly below the OECD average (p < .05), using Bonferroni-adjustments with an overall alpha-level of .05.

PERFORMANCE ON THE MATHEMATICS PROFICIENCY LEVELS

An examination of the distribution of Irish students across proficiency levels on the combined mathematics scale (Table 3.2) shows that the percentage of students who are at, or below, Level 1 is lower than the OECD average (16.8% compared to 21.4%). However, fewer

Irish students attain Levels 5 and 6 (11.3% compared to 14.6%). Thus, Ireland's moderate performance may be attributed to the comparatively low performance of high achievers rather than to the weak performance of low achievers.

Table 3.2. Descriptions of Proficiency Levels on Combined Mathematics Scale, and Percentages of Students Achieving Each Level – Ireland and OECD Average

Level (Cut-point)	*Brief Description* – Students at this level are likely to be able to complete tasks that involve:	*Ireland* %	*Ireland* (SE)	*OECD* %	*OECD* (SE)
Level 6 (above 668.7)	*Evaluating, generalising and utilising information from mathematical investigations/modelling of complex problem situations.* One or more of: connecting different information sources and representations and translating among them; demonstrating advanced mathematical thinking and reasoning; applying insights along with a mastery of formal mathematical operations and relationships to develop new approaches for problem-solving; formulating and precisely communicating actions and reflections regarding findings, interpretations, arguments, and their appropriateness to the original situations.	2.2	(0.33)	4.0	(0.10)
Level 5 (606.6 to 668.7)	*Developing and working with mathematical models of complex situations.* One or more of: identifying constraints and specifying assumptions of models; selecting, analysing and evaluating problem-solving strategies; working strategically using well-developed and systematic reasoning skills; linking and translating multiple representations; reflecting on actions, arguments and forming insights; formulating and communicating interpretations, arguments and reasoning.	9.1	(0.76)	10.6	(0.13)
Level 4 (544.4 to 606.5)	*Working with mathematical models of complex concrete situations.* One or more of: identifying model constraints or making assumptions about the model; selecting and integrating different representations, linking them to aspects of real-world situations; utilising well-developed skills; reasoning flexibly, with some insight; constructing and communicating explanations based on interpretations and arguments.	20.2	(1.06)	19.1	(0.17)
Level 3 (482.4 to 544.3)	*Familiar contexts that usually require multiple steps for solution.* One or more of: sequential decision-making; selecting and applying simple problem-solving strategies; interpreting, linking and using representations based on different information sources; reasoning about and reflecting on representations; writing short communications reporting reasoning, interpretations, and results.	28.0	(0.82)	23.7	(0.18)
Level 2 (420.4 to 482.3)	*Simple contexts that require no more than direct inference.* One or more of: interpreting and identifying relevant information from a single source; linking text and visual mode or making use of a single representational mode; using basic algorithms, formulae, procedures, or conventions; demonstrating direct reasoning and making literal interpretations of results.	23.6	(0.83)	21.1	(0.15)
Level 1 (358.3 to 420.3)	*Clearly defined tasks with familiar contexts where all relevant information is present and no inference is required.* One or more of the following: identifying or interpreting relevant information; implementing routine procedures or actions in explicit situations, understanding and using simple concepts and facts.	12.1	(0.84)	13.2	(0.16)
Below Level 1 (less than 358.3)	Has a less than 50% chance of responding correctly to Level 1 tasks. Mathematics skills not assessed by PISA.	4.7	(0.57)	8.2	(0.17)
	Total	100		100	

*N (Ireland) = 3880. **Denotes OECD average percent.

Note. Students at a particular level have at least a 50% chance of correctly answering all items at that level.

PERFORMANCE ON THE MATHEMATICS SUBSCALES

As indicated earlier, mathematics subscales were formed, based on the four major content areas ('over-arching ideas'): Space & Shape, Change & Relationships, Quantity, and Uncertainty. The OECD mean scores on these subscales vary slightly from the mean of 500.0 that was set for the overall combined mathematics scale.

The mean performance of Irish students on Space & Shape (476.2) is significantly below the OECD mean score of 496.3, and is lower than the Irish mean score for the combined scale. Ireland ranks 27th of 40 countries overall (95% confidence interval for Ireland's ranking = 24th to 30th), 23rd of 29 OECD countries (95% confidence interval for Ireland's ranking = 20th to 25th). The Irish mean is significantly lower than that of 22 countries (20 OECD countries), the same as seven countries (five OECD countries), and significantly higher than 10 countries (four OECD countries).

The mean performance of Irish students on the Change & Relationships subscale (506.0) is significantly above the OECD mean score of 498.8. Ireland ranks 18th of 40 countries overall (95% confidence interval for Ireland's ranking = 14th to 20th), and 15th of 29 OECD countries (95% confidence interval for Ireland's ranking = 11th to 17th). The Irish mean is significantly lower than that of 12 countries (10 OECD countries), the same as that of nine countries (eight OECD countries), and significantly higher than that of 18 countries (10 OECD countries).

Ireland's mean performance on the Quantity subscale (501.7) is not significantly different from the OECD average (500.7). Ireland ranks 21st of 40 countries on the subscale (95% confidence interval for Ireland's ranking = 19th to 24th), and 18th of 29 OECD countries (95% confidence interval for Ireland's ranking = 16th to 21st). Fifteen countries (12 of the 29 OECD countries) have a score that is significantly higher than that of Ireland; the mean scores of 10 OECD countries do not differ from that of Ireland; and the mean scores of 14 countries (six OECD countries) are significantly lower.

Ireland's mean score of 517.2 on the Uncertainty subscale is significantly above the OECD average of 502.0. Ireland ranks 13th out of 40 countries on this subscale (95% confidence interval for Ireland's ranking = 11th to 17th), and 10th of 29 OECD countries (95% confidence interval for Ireland's ranking = 9th to 14th). Nine countries (seven OECD countries) have a mean score that is significantly higher than Ireland's, eight countries (seven OECD countries) have mean scores that do not differ from Ireland's, and 22 countries (14 OECD countries) have mean scores that are significantly lower.

PERFORMANCE ON THE PROFICIENCY LEVELS OF THE MATHEMATICS SUBSCALES

Table 3.3 shows the percentages of Irish students at each proficiency level of the mathematics subscales, compared to the OECD average percentages. The overall weak performance of Irish students on Space & Shape is evident in the distribution across proficiency levels. For example, 27.6% of Irish students (compared with an OECD average of 24.8%) score at or below Level 1, and over half of Irish students (53.0%) score at or below Level 2 (compared to an OECD average of 45.2%). At the upper end of the scale, just under 9% of Irish students reached Levels 5 or 6, compared to almost twice this percentage (16.2%) for the OECD average. Comparing the percentages for Ireland for the combined scale and the Space & Shape subscale, the difference is marked at the lower end where 40.4% are at or below Level 2 on the combined scale compared to 53.0% on the subscale. The performance of students in Ireland on the Change & Relationships subscale is similar to that for the combined scale. About 16% of students (compared with 23.2% across the OECD) are at or below Level 1 and

38.9% at or below Level 2 (compared with 43.0% across the OECD). Almost 13% of Irish students (compared with an OECD average of about 16%) are at Levels 5 and 6.

The distribution of performance on the Quantity subscale is characterised by a lower percentage of students at Level 1 and below compared with the OECD average (17.9% compared to 21.3%). The percentage of Irish students at Levels 5 and 6 (11.7%) is also below the OECD average (15.0%), but is similar to the percentage of students at Levels 5 or 6 on the combined scale (11.3%). Consistent with Ireland's high average performance on the Uncertainty subscale, proportionately more Irish students (16.4%) attain Levels 5 and 6 (compared to an OECD average of 14.6%). Furthermore, 13.8% of Irish students (compared to an OECD average of 20.7%) score at or below Level 1.

Table 3.3. Percentages of Students Achieving Each Proficiency Level on the Mathematics Subscales - Ireland and OECD Average

	<Level 1		Level 1		Level 2		Level 3		Level 4		Level 5		Level 6	
Subscale	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Ireland														
Space & Shape	10.7	(0.78)	16.9	(1.15)	25.4	(0.87)	23.0	(1.02)	15.4	(0.77)	6.8	(0.64)	1.8	(0.24)
Change & Relation.	5.1	(0.51)	11.2	(0.86)	22.6	(0.84)	27.0	(1.07)	21.6	(0.85)	10.2	(0.63)	2.3	(0.35)
Quantity	5.6	(0.57)	12.3	(0.85)	23.0	(1.00)	26.9	(1.06)	20.6	(0.84)	9.5	(0.62)	2.2	(0.36)
Uncertainty	3.6	(0.45)	10.2	(0.74)	21.2	(0.86)	26.5	(0.93)	22.0	(0.93)	12.4	(0.72)	4.0	(0.39)
OECD														
Space & Shape	10.6	(0.19)	14.2	(0.16)	20.4	(0.14)	21.5	(0.16)	17.2	(0.15)	10.4	(0.11)	5.8	(0.10)
Change & Relation.	10.2	(0.19)	13.0	(0.15)	19.8	(0.14)	22.0	(0.19)	18.5	(0.20)	11.1	(0.13)	5.3	(0.11)
Quantity	8.8	(0.18)	12.5	(0.15)	20.1	(0.15)	23.7	(0.21)	19.9	(0.17)	11.0	(0.11)	4.0	(0.09)
Uncertainty	7.4	(0.15)	13.3	(0.17)	21.5	(0.16)	23.8	(0.17)	19.2	(0.17)	10.6	(0.14)	4.2	(0.10)

PERFORMANCE IN MATHEMATICS IN PISA 2000 COMPARED TO 2003

It is not possible to compare achievements on the combined mathematics scale in 2000 and 2003 since the 2000 assessment included items on only two subscales. However, performance can be compared for Space & Shape and for Change & Relationships since these were common to both PISA 2000 and PISA 2003. Achievement data for these two subscales in PISA 2003 were scaled using the item parameter estimates from PISA 2000 for the set of items common to both assessments for the purposes of comparing achievement in the two years.

On the Space & Shape subscale, there are no significant differences between the OECD mean scores in 2000 and 2003, or between OECD average scores at six percentile points (5th, 10th, 25th, 75th, 90th and 95th). Eight countries (four OECD countries and four partner countries) registered a significant increase in mean score (Belgium, the Czech Republic, Italy and Poland; and Brazil, Indonesia, Latvia, and Thailand) while two OECD countries (Iceland and Mexico) showed a significant decrease. There is no change at any point in the performance of Irish students.

On the Change & Relationships subscale, the OECD country average score is significantly higher in 2003, while significant increases are observed at five of the six percentile points of interest. In 13 countries, 10 of these being OECD countries including Belgium, Canada, the Czech Republic, Finland, Korea, Poland and Spain, there is a significant increase in mean performance. In one OECD partner country (Thailand) there is a significant decrease, and there is no change for 18 countries (15 OECD countries), including Ireland.

Chapter 4

Achievement Outcomes in Reading Literacy and and Science

ACHIEVEMENT IN READING LITERACY

Description of the Reading Literacy Scales

The assessment of reading literacy in PISA 2003, now a minor domain, used 28 of the test items from 2000, when it was the main assessment domain. The items were selected with reference to the difficulty of items and the framework, to ensure that the proportions of items in the three reading process areas (Retrieve, Interpret, Reflect/Evaluate) were similar in both 2000 and 2003. In PISA 2000, performance was reported on a combined reading literacy scale and on three subscales, while results for 2003 are reported on a combined scale only. As in 2000, performance in 2003 is also reported in terms of proficiency levels on the combined scale.

Description of the Reading Literacy Proficiency Levels

The combined reading literacy scale was divided into five levels of proficiency using the same cut-points (boundaries) that had been used in 2000 (see Table 4.1). Students who achieve at Level 5 (the highest level) are capable of completing the most complex reading tasks on the PISA assessment, such as working with dense text, and making high-level inferences. The scale is unbounded at the upper level, which implies that some students may be capable of even more complex reading tasks than those assessed in PISA. In contrast, students who achieve at Level 1, the lowest level, are most likely to succeed only on the more basic reading tasks developed for PISA, such as locating a single piece of information in an elementary level text. Levels 1 to 5 represent an increase in the reading skills of students, from basic, to moderately complex, to difficult, to very complex.

As in mathematics, some students were unable to demonstrate proficiency on the easiest of the PISA reading tasks (their pattern of responses indicated that they would not be expected to successfully solve half of the tasks drawn from Level 1). These students fall into the category 'below Level 1'. Such students are likely to have serious difficulties in applying what reading skills they do have to advance and extend their knowledge, and may be at risk in the longer term in their educational and occupational careers, as well as in their personal development.

Figure 4.1 illustrates the proficiency levels on the PISA reading literacy scale with reference to both student ability and item difficulty. The figure shows the cut-points for each level, the scores of Irish students at various points on the scale, and the item difficulties of five reading questions. For example, the second item from the unit 'Labour' has an item difficulty (631.1) a little above the Irish 90th percentile (622.1). The first item from the unit 'Labour' and the second item from the unit 'Gift' have item difficulties (476.7 and 447.5, respectively) that are close to the Irish 25th percentile (460.2). For a fuller description of these and other items, readers are referred to http://www.erc.ie/pisa.

Table 4.1. Brief Descriptions of Proficiency Levels on the Combined Reading Literacy Scale, and Percentages of Students Achieving Each Level – Ireland and OECD Average

Level (Cut-point)	*Brief Description* – Students at this level are likely to be able to:	*Ireland** %	*Ireland** *(SE)*	*OECD*** %	*OECD*** *(SE)*
Level 5 (above 625.6)	Complete the most complex PISA reading tasks, including managing information that is difficult to locate in complex texts; evaluate texts critically; and draw on specialised information.	9.3	(0.71)	8.3	(0.12)
Level 4 (552.9 to 625.5)	Complete difficult reading tasks, such as locating embedded information, constructing meaning from nuances of language, and critically evaluating a text.	26.2	(1.19)	21.3	(0.18)
Level 3 (480.2 to 552.8)	Complete reading tasks of moderate complexity, including locating multiple pieces of information, drawing links between different parts of a text, and relating text information to familiar everyday knowledge.	32.4	(1.26)	28.7	(0.19)
Level 2 (407.5 to 480.1)	Complete basic reading tasks, including locating one or more pieces of information which may require meeting multiple criteria, making low-level inferences of various types, and using some outside knowledge to understand text.	21.2	(1.20)	22.8	(0.18)
Level 1 (334.8 to 407.4)	Complete the most basic PISA reading tasks, such as locating a single piece of information, identifying the main theme of a text, and making a simple connection with everyday knowledge.	8.3	(0.66)	12.4	(0.16)
Below Level 1 (less than 334.8)	Has a less than 50% chance of responding correctly to Level 1 tasks. Reading abilities not assessed by PISA.	2.7	(0.48)	6.7	(0.14)
	Total	100		100	

*N (Ireland) = 3880. **Denotes OECD average percent.
Note. Students at a particular level have at least a 50% chance of correctly answering all items at that level.

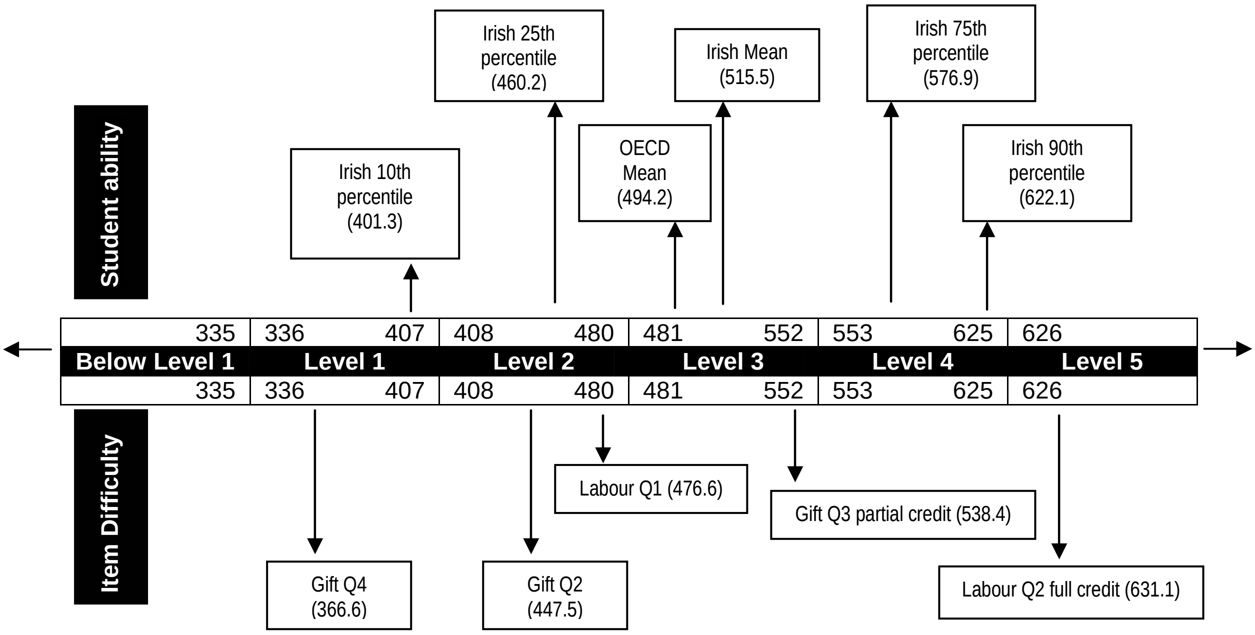


Figure 4.1. The PISA 2003 Reading Literacy Scale: Cut-points for Proficiency Levels, Scores of Students in Ireland at Key Markers, and Difficulties of Selected Items

Overall Performance on the Reading Literacy Scale

Ireland achieved a mean score of 515.5 on the reading literacy scale (Table 4.2). This is significantly higher than the OECD country mean of 494.2 (see footnote 7, page 10 for a brief description of statistical significance). Ireland's ranking in reading literacy is 7th out of 40 countries (95% confidence interval for Ireland's ranking = 5th to 11th), and 6th out of 29 OECD countries (95% confidence interval for Ireland's ranking = 5th to 9th). Just three countries have mean scores that are significantly higher than Ireland's (Finland, Korea, and Canada).

Twenty-nine countries (21 OECD countries) have a mean score that is significantly lower than Ireland's mean score. Australia, New Zealand, Sweden, the Netherlands and Belgium, and partner countries Liechtenstein and Hong Kong-China have mean scores that are not significantly different from Ireland's. As with mathematics, country means are more clustered at the upper than at the lower end of the distribution. The low standard deviation for Ireland (86.5 compared to an OECD average of 100.2) indicates a relatively narrow dispersion of achievement. This stands in contrast to countries such as New Zealand and Belgium, which have mean scores that do not differ from Ireland's, but which have standard deviations that are larger.

Table 4.2. Mean Achievement Scores and Standard Deviations on the Combined Reading Literacy Scale – OECD and Partner Countries

	Mean	*(SE)*	*SD*	*(SE)*	*OECD Diff*		*Mean*	*(SE)*	*SD*	*(SE)*	*OECD Diff*
Finland	543.5	(1.64)	81.0	(1.13)	▲	Austria	490.7	(3.76)	103.1	(2.26)	o
Korea	534.1	(3.09)	82.6	(2.03)	▲	*Latvia*	490.6	(3.67)	90.4	(1.75)	o
Canada	527.9	(1.75)	88.5	(0.93)	▲	Czech Republic	488.5	(3.46)	95.5	(2.39)	o
Australia	525.4	(2.13)	97.4	(1.52)	▲	Hungary	481.9	(2.47)	92.0	(1.82)	▼
Liechtenstein	525.1	(3.58)	89.8	(3.35)	▲	Spain	480.5	(2.60)	95.4	(1.48)	▼
New Zealand	521.6	(2.46)	104.6	(1.46)	▲	Luxembourg	479.4	(1.48)	99.7	(1.03)	▼
Ireland	**515.5**	**(2.63)**	**86.5**	**(1.75)**	▲	Portugal	477.6	(3.73)	92.7	(2.13)	▼
Sweden	514.3	(2.42)	95.6	(1.91)	▲	Italy	475.7	(3.04)	100.7	(2.16)	▼
Netherlands	513.1	(2.85)	84.8	(2.05)	▲	Greece	472.3	(4.10)	104.5	(1.95)	▼
Hong Kong - China	509.5	(3.69)	84.8	(2.74)	▲	Slovak Republic	469.2	(3.12)	92.5	(2.03)	▼
Belgium	507.0	(2.58)	110.0	(2.14)	▲	*Russian Federation*	442.2	(3.94)	93.3	(1.76)	▼
Norway	499.7	(2.78)	102.5	(1.81)	o	Turkey	441.0	(5.79)	95.3	(4.11)	▼
Switzerland	499.1	(3.28)	94.8	(1.90)	o	*Uruguay*	434.1	(3.43)	121.5	(2.01)	▼
Japan	498.1	(3.92)	105.5	(2.53)	o	Thailand	419.9	(2.81)	78.1	(1.50)	▼
Macao - China	497.6	(2.16)	66.9	(1.86)	o	*Serbia and Montenegro*	411.7	(3.56)	81.5	(1.63)	▼
Poland	496.6	(2.88)	95.9	(1.76)	o	*Brazil*	402.8	(4.58)	111.3	(2.30)	▼
France	496.2	(2.68)	97.0	(2.17)	o	Mexico	399.7	(4.09)	95.1	(1.93)	▼
United States	495.2	(3.22)	101.2	(1.44)	o	*Indonesia*	381.6	(3.38)	76.3	(1.79)	▼
Denmark	492.3	(2.82)	88.3	(1.75)	o	*Tunisia*	374.6	(2.81)	95.7	(1.78)	▼
Iceland	491.7	(1.56)	98.3	(1.37)	o	**OECD Total**	**487.7**	**(1.18)**	**103.8**	**(0.66)**	
Germany	491.4	(3.39)	109.1	(2.25)	o	**OECD Average**	**494.2**	**(0.64)**	**100.2**	**(0.39)**	

(black) Mean achievement significantly higher than Ireland	Above OECD average ▲
(white) Mean achievement not significantly different from Ireland	At OECD average o
(grey) Mean achievement significantly lower than Ireland	Below OECD average ▼

Note. OECD countries are in regular font; partner countries are in italics. SD = Standard deviation; SE = Standard error.
The column "OECD Diff" indicates whether each country scores at, significantly above, or significantly below the OECD average ($p < .05$), using Bonferroni-adjustments with an overall alpha-level of .05.

Using the nonparametric maximum likelihood method (see Chapter 3 for a description) country mean achievements are grouped into 10 distinct groups. Ireland falls into the third grouping (which has a score of 511.5) along with Sweden, the Netherlands, Hong Kong-China and Belgium.

Overall Performance on the Reading Literacy Levels of Proficiency

Proportionately fewer students in Ireland scored at or below Level 1 on the combined reading literacy scale (11.0% compared to the OECD average of 19.1%), and slightly more scored at Levels 4 and 5 (35.5% compared to an average of 29.6% across the OECD; Table 4.1). The relatively strong performance of Irish students is due more to the comparatively high performance of low achievers rather than the high performance of high achievers. It is of concern, nonetheless, that 2.7% of Irish students failed to demonstrate even the most basic reading literacy skills assessed in PISA and that a further 8.3% scored at the most basic level (Level 1).

Performance in Reading Literacy in PISA 2000 Compared to 2003

The OECD average scores at seven key percentile points on the reading literacy scale are similar in 2000 and 2003. Three countries (Latvia, Liechtenstein, and Poland) registered a significant increase in mean performance. The mean performance of nine countries, including Ireland, along with Austria, Hong Kong-China, Iceland, Italy, Japan, Mexico, the Russian Federation, and Spain decreased significantly and there was no change for 20 countries. Ireland's mean score dropped by 11.2 points. The scores of Irish students at the 75th, 90th, and 95th percentiles also decreased significantly. Therefore, even though Ireland's overall mean performance was comparatively high in both 2000 and 2003, overall performance, as well as performance of higher achievers, was poorer in 2003.

ACHIEVEMENT IN SCIENCE

Description of the Science Scale

The science scale measured students' ability to describe, explain and predict scientific phenomena, to understand and interpret scientific evidence, and to draw conclusions. Three major areas of science were assessed: Life & Health, Earth & Environment, and Technology.

Interpreting Scores on the Science Scale

As science was a minor assessment domain in PISA 2000 and PISA 2003, sufficient information was not available about student achievement to develop proficiency levels similar to those developed for mathematics and reading. However, it was possible to generate a description of the skills associated with different points along the scale.

Towards the top of the science scale (around 690 points), students demonstrated ability to complete the following tasks:

- create or use conceptual models to make predictions or give explanations;
- analyse scientific investigations in relation to experimental design;
- use data as evidence to evaluate alternative viewpoints;
- communicate scientific arguments and descriptions in detail.

At an intermediate point on the scale (around 550 points), students showed that they could

- use scientific concepts to make predictions or give explanations;
- recognise questions that can be answered by scientific investigation;
- select relevant information from competing data or chains of reasoning in drawing or evaluating conclusions.

Towards the lower end of the scale (around 400 score points), students could

- recall simple scientific factual knowledge;
- use common science knowledge in drawing or evaluating conclusions.

Figure 4.2 shows the relationship between Irish student proficiency and item difficulty for science through a selection of the sample items and key performance benchmarks. For example, the second item from the unit 'Semmelweis' has an item difficulty (494.9) a little below the Irish student mean (505.4). The first item from the unit 'Semmelweis' has an item difficulty for a partially correct response (625.7) that corresponds to the 90th percentile for Ireland (624.5). These and other sample items can be seen at http://www.erc.ie/pisa.

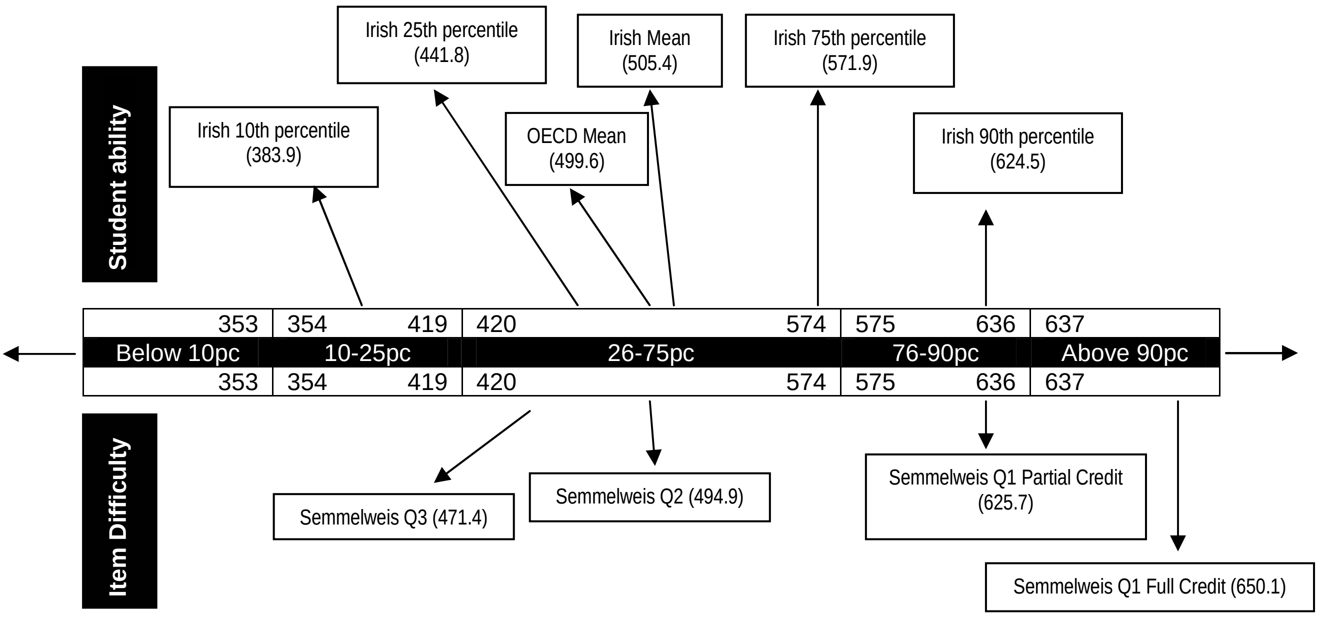


Figure 4.2. The PISA 2003 Science Scale: Cut-points for Key OECD Percentile Intervals, Scores of Students in Ireland at Key Markers, and Difficulties of Selected Items

Overall Performance on the Science Scale

Ireland achieved a mean score of 505.4 in science (Table 4.3). Although just 6 points higher than the OECD average, the difference is statistically significant. Ireland's ranking in science is 16th of 40 countries (95% confidence interval for Ireland's ranking = 12th to 20th), and 13th out of 29 OECD countries (95% confidence interval for Ireland's ranking = 9th to 16th). The mean scores of 11 countries (eight OECD countries) are significantly higher than that of Ireland, while Ireland's mean score does not differ significantly from the scores of eight countries (all OECD countries) and is significantly higher than those of 20 countries (11 OECD countries). Countries with mean scores that are significantly higher than Ireland's include Finland, Japan, Korea, Australia and New Zealand. The highest scoring countries, Finland and Japan, have mean scores that are about 42 points higher than that of Ireland. The difference between the highest and lowest scoring country is 163.5 points.

The standard deviation for Ireland (93.0) is lower than the OECD average (109.0), indicating a comparatively narrow range of achievement scores which was also observed for mathematics and reading. In contrast, the standard deviations in science for countries, such as Italy and Germany, are considerably larger (107.8 and 111.4, respectively).

Table 4.3. *Mean Achievement Scores and Standard Deviations on the Science Scale – OECD and Partner Countries*

	Mean	*(SE)*	*SD*	*(SE)*	*OECD Diff*		*Mean*	*(SE)*	*SD*	*(SE)*	*OECD Diff*
Finland	548.2	(1.92)	90.8	(1.05)	▲	United States	491.3	(3.08)	101.6	(1.34)	▼
Japan	547.6	(4.14)	109.4	(2.71)	▲	Austria	491.0	(3.44)	97.0	(1.51)	▼
Hong Kong - China	539.5	(4.26)	94.1	(2.78)	▲	*Russian Federation*	489.3	(4.14)	99.8	(1.49)	▼
Korea	538.4	(3.54)	100.5	(2.16)	▲	*Latvia*	489.1	(3.89)	92.7	(1.48)	▼
Liechtenstein	525.2	(4.33)	103.5	(4.35)	▲	Spain	487.1	(2.61)	100.2	(1.51)	▼
Australia	525.1	(2.10)	101.8	(1.53)	▲	Italy	486.5	(3.13)	107.8	(2.02)	▼
Macao - China	524.7	(3.03)	87.9	(3.04)	▲	Norway	484.2	(2.87)	103.8	(1.82)	▼
Netherlands	524.4	(3.15)	98.5	(2.17)	▲	Luxembourg	482.8	(1.50)	102.8	(1.13)	▼
Czech Republic	523.3	(3.38)	100.6	(1.69)	▲	Greece	481.0	(3.82)	100.6	(1.65)	▼
New Zealand	520.9	(2.35)	104.0	(1.39)	▲	Denmark	475.2	(2.97)	101.8	(1.66)	▼
Canada	518.7	(2.02)	99.1	(1.05)	▲	Portugal	467.7	(3.46)	93.4	(1.74)	▼
Switzerland	513.0	(3.69)	107.5	(1.85)	▲	*Uruguay*	438.4	(2.90)	109.1	(1.83)	▼
France	511.2	(2.99)	110.8	(2.17)	▲	*Serbia and Montenegro*	436.4	(3.50)	82.7	(1.61)	▼
Belgium	508.8	(2.48)	107.4	(1.82)	▲	*Turkey*	434.2	(5.89)	95.9	(4.71)	▼
Sweden	506.1	(2.72)	106.8	(1.81)	▲	*Thailand*	429.1	(2.70)	81.3	(1.60)	▼
Ireland	**505.4**	**(2.69)**	**93.0**	**(1.33)**	▲	Mexico	404.9	(3.49)	86.7	(2.20)	▼
Hungary	503.3	(2.77)	97.3	(1.99)	o	*Indonesia*	395.0	(3.21)	68.0	(1.87)	▼
Germany	502.3	(3.64)	111.4	(2.15)	o	*Brazil*	389.6	(4.35)	98.3	(2.63)	▼
Poland	497.8	(2.86)	102.4	(1.38)	o	*Tunisia*	384.7	(2.56)	87.3	(1.84)	▼
Slovak Republic	494.9	(3.71)	102.2	(3.11)	o	**OECD Total**	**495.7**	**(1.07)**	**109.0**	**(0.69)**	
Iceland	494.7	(1.47)	95.6	(1.43)	▼	**OECD Average**	**499.6**	**(0.60)**	**105.5**	**(0.37)**	

Mean achievement significantly higher than Ireland (black shading)
Mean achievement not significantly different from Ireland (no shading)
Mean achievement significantly lower than Ireland (grey shading)

Above OECD average ▲
At OECD average o
Below OECD average ▼

Note. OECD countries are in regular font; partner countries are in italics. SD = Standard deviation; SE = Standard error.
The column "OECD Diff" indicates whether each country scores at, significantly above, or significantly below the OECD average ($p < .05$), using Bonferroni-adjustments with an overall alpha-level of .05.

Using the nonparametric maximum likelihood method (see the description in Chapter 3), country mean achievements fall into seven distinct groups. Ireland lies in the third grouping (which has a score of 505.0), along with Belgium, Sweden, Hungary and Poland.

Performance on the Science Scale in 2000 and 2003

Comparing the mean performance in 2000 and 2003, as well as the performance on a number of percentile points for the science scale, neither the OECD overall average score nor OECD average scores at the 25th and 75th percentiles changed. However, a significant decrease at the 5th and 10th percentiles and a significant increase at the 90th and 95th percentiles are in evidence, indicating a wider range of achievement in 2003 than in 2000. In 12 countries (including Belgium, Czech Republic, Finland, France, Germany, Poland, and Switzerland) there was a significant increase in mean science achievement, while in five countries (Austria, Canada, Korea, Mexico, and Norway) there was a significant decrease in mean science achievement. There is no change at any point in the distribution for Ireland.

Chapter 5

Student- and School-Level Associations With Achievement in Combined Mathematics, Reading and Science in PISA 2003

In this chapter, associations between a range of explanatory variables and student achievement in mathematics, reading and science are examined. Explanatory variables include both student- and school-level characteristics. The analyses examine associations between pairs of variables – a single explanatory variable and a response variable (for example, between gender and achievement). Hence, direct relationships between variables cannot be inferred. In Chapter 6, more complex multilevel regression analyses are presented, which seek to explain variance between and within schools by examining the simultaneous impact of a number of student and school variables on achievement.

OVERVIEW OF STUDENT- AND SCHOOL-LEVEL VARIABLES

A range of student and school characteristics are considered in this chapter. At the student level, data are largely obtained from the Student Questionnaire, which was administered to all participating students in PISA 2003. At the school level, data are obtained from the School Questionnaire (completed by principal teachers of participating schools), from the Post-Primary Database of the Department of Education and Science, and the Junior Certificate Examination Database of the State Examinations Commission. A few of the Student and School Questionnaire items were administered to students and principals in Ireland only; the remainder were used in all participating countries. Additional variables are considered in the forthcoming national report for Ireland and the OECD reports on PISA 2003 (OECD, 2004a, 2004b).[9] The variables reported have been selected on the basis of policy relevance and associations with achievement. Two variables reported at the school level (school economic, social and cultural status; disciplinary climate) were collected at the student level. In both instances data were aggregated to the school level and then disaggregated back to the student level (i.e., each student was assigned the mean score for his or her school).

STUDENT CHARACTERISTICS AND ACHIEVEMENT

Student Gender

Gender Differences in Mean Scores. Male students in Ireland achieved a mean score in combined mathematics that was 14.8 points (one-sixth of a standard deviation) higher than that of females. In contrast, females achieved a mean score in reading that was 29.0 points (one-third of a standard deviation) higher than the mean score of males. Both of these differences are statistically significant. The small difference between the mean scores of males and females in science (2.0 scale score points in favour of males) is not statistically significant. These gender differences are similar to the corresponding OECD average score differences and are consistent with the pattern of gender differences found in the majority of participating countries. Irish male students significantly outperformed females on all mathematics subscales. The gender difference in Ireland is greatest for the Space & Shape subscale (25.5 points; just over a quarter of a standard deviation) and smallest for the Quantity subscale (8.9 points; about one-tenth of a standard deviation). The gender difference for the Change & Relationships subscale is 12.6 points and for the Uncertainty

[9] The full range of variables gathered or derived in the course of the survey can be found in the PISA 2003 Database. This is available, together with supporting documentation, at http://www.pisa.oecd.org

subscale it is 15.5 points (both in the region of one-sixth of a standard deviation). These gender differences are a little higher than the OECD average differences: for Space & Shape, the OECD average gender difference is 15.6 points; for Quantity it is only 6.4 points; for Change & Relationships it is 9.6 points and for Uncertainty it is 10.5 points.

Comparison of Gender Differences in PISA 2000 and PISA 2003. In PISA 2000, a significant gender difference in favour of Irish females was found for reading (28.7 score points or three-tenths of a standard deviation), while males significantly outperformed females in mathematics (by 12.9 points or one-sixth of a standard deviation). There was no significant gender difference for performance on science in PISA 2000 (6.2 scale points, or less than one-tenth of a standard deviation in favour of males). Hence, the data indicate that the pattern of gender differences in the overall performance of Irish students is similar for PISA 2000 and PISA 2003.

Student Nationality

The population of Irish 15-year-olds is relatively homogeneous: 95.0% of students and their parents were born in Ireland. Native status is not related to performance outcomes. This contrasts with the findings for many OECD countries (e.g., Sweden and France) where non-native students have significantly lower mean achievement scores. In Ireland, maintaining this relatively high equality of student achievement outcomes will require careful monitoring, as the proportion of non-national students enrolled in second-level schools is likely to increase in the next few years (see Eurydice, 2004).

Student Socioeconomic Status (SES) and Home Background

Parental Occupation. Students whose parents[10] have occupations in the upper third of the occupation distribution in Ireland have a mean score in mathematics (535.7) that is about three-quarters of a standard deviation above the mean score of students in the bottom third (473.5). The magnitude of the advantage accrued by high-SES students is about the same across all three domains. On average across OECD countries, the achievement score increase is 33.7 points per standard deviation on the SES scale. In Ireland, the score increase is slightly smaller (27.4 points), indicating slightly less disparity between the achievements of high and low SES students than is the case in OECD countries generally.

Economic, Social and Cultural Status. Parental occupation, parental education, and indicators of home educational resources were combined to form a global composite of economic, social and cultural status (ESCS). The difference in mean scores of students in Ireland with low and high ESCS scores is 76.9 points (around nine-tenths of a standard deviation). The score difference in mathematics corresponding to a one standard deviation increase on the scale is slightly smaller in Ireland (38.6 points) compared to the average across OECD countries (45.9 points).

Family Composition. The 15.1% of Irish students who lived in a lone-parent family had significantly lower mean scores than students from dual-parent families in all three domains. The difference in scores in combined mathematics between the two groups, is 33.6 score points (around two-fifths of a standard deviation), the third highest across all participating countries. The number of siblings was also related to student performance – students with no siblings (mean of 501.2), three (499.1), or four or more (483.0) siblings, performed less well on average than students with one (521.8) or two (512.3) siblings.

Home Educational Resources. Students with high levels of home educational resources (a desk, a quiet place for study and books to help with school work) scored 44.0 score points (about

[10] Throughout this report, 'parent' refers to parent or guardian. Students were instructed to respond to the questionnaire with this in mind.

half a standard deviation) higher in combined mathematics than students with one or none of these resources. Furthermore, students with high numbers of books in the home (500 or more) scored 106.9 score points (one and a quarter standard deviations) higher in reading than students with very few or no books (10 books or less).

Student Academic Characteristics and Behaviour

Early School-Leaving Intent. About one-fifth of students (20.2%) reported that they intended to leave school prior to completion of the Leaving Certificate. These students scored significantly lower in all three domains, by about one standard deviation (75.1 score points in combined mathematics, 85.9 points in reading and 86.1 points in science) than students who intended to complete a Leaving Certificate programme. The percentage of students in 2003 reporting the intention to leave school was higher in 2003 than in 2000 (14.0%).

Current Grade (Year) Level. Students' current grade level was also related to achievement. Students in Second year, one year below the modal grade level, had mean scores on all three domains that were about one standard deviation lower (e.g., 85.5 score points in combined mathematics) than students in Third year. Students in Fourth year had mean scores in all three domains that were about three-fifths of a standard deviation higher than those in Third year (e.g., 50.6 score points in combined mathematics). Students in Fifth year had mean scores that were between those of students in Third and Fourth year in all three domains (e.g., in combined mathematics, 22.8 points higher than Third years; 27.8 points lower than Fourth years). The interpretation of associations between grade level and achievement is not straightforward. For example, in some schools Transition Year (Fourth year) is optional or unavailable.

Syllabus Level of Junior Certificate Mathematics, English and Science. The achievements in PISA of students taking Junior Certificate mathematics, English and science at each syllabus level were examined. A mean score difference of just over one standard deviation in all three domains was found between students taking the corresponding subject at Higher and Ordinary levels (93.9 score points in mathematics, 99.1 points in reading and 103.8 points in science). In the case of mathematics and English, a mean score difference for PISA mathematics and PISA reading literacy of around one standard deviation was found between students taking the Junior Certificate at Ordinary and Foundation levels (83.7 points in combined mathematics, and 93.3 points in reading). In the case of science (an optional subject at Junior Certificate level taken by 90.1% of the students that participated in PISA 2003), the mean difference between students taking the subject at Ordinary level and those not taking the subject is only 8.5 score points (less than one-tenth of standard deviation) and is not statistically significant. Comparing all students who studied science with those who did not, a significant score difference of 59.7 points (two-thirds of a standard deviation) in favour of those taking the subject was found.

Absenteeism, Homework and Study. Student absenteeism (as indicated by the number of days missed in the fortnight prior to the PISA assessment) was associated with achievement. Across all three domains, students who did not miss days scored about two-thirds of a standard deviation higher (e.g., 49.7 score points in combined mathematics) than students who missed three or more days, and approximately one-quarter of a standard deviation higher (e.g., 19.6 score points in combined mathematics) than students who missed one or two days. Overall time spent on homework and study each week showed positive associations with achievement. A difference of 38.8 score points in combined mathematics (about one-third of a standard deviation) between the achievement of students reporting high and low amounts of time on homework was found, in favour of the high group.

Calculator Usage During the PISA Assessment. Students were asked whether they had used a calculator during the PISA assessment. A majority (78.0%) said they had used a calculator. Students using a calculator had a significantly higher mean score than those that did not (a score difference of 20.3 score points, or one-quarter of a standard deviation). Calculator usage appears to have increased since PISA 2000 where just 24.2% of students reported using a calculator. Note that the revised Junior Certificate mathematics syllabus, examined for the first time in 2003, now permits calculator usage during the examination. In interpreting this finding, it should be borne in mind that 12.3% of students did not respond to the question.

Attitudes Towards Mathematics

Self-Efficacy in Mathematics. Students were asked to rate their confidence at completing a variety of mathematics tasks. Responses were combined to create a self-efficacy scale with an OECD average of 0.0 and standard deviation of 1.0. Gender differences on this measure are significant in all participating countries, with males having a mean score around one-third of a standard deviation (0.34 units) higher than females on average across the OECD. The gender difference in Ireland (0.28; three-tenths of a standard deviation) is similar to the OECD average. The score difference on the combined mathematics scale for Irish students reporting low and high self-efficacy is 108.5 points (one and a quarter standard deviations) in favour of the latter group. Given that the self-efficacy measure is based on students' ratings of their own confidence in completing mathematics tasks, it may also be an indication of current mathematics performance.

Anxiety About Mathematics. Students reported their levels of anxiety in dealing with mathematics in various contexts. An anxiety scale was created in a similar manner to the self-efficacy one with a mean of 0.0 and standard deviation of 1.0. In all participating countries except two, gender differences are significant, with females reporting higher levels of anxiety than males. An OECD average gender difference of 0.28 units (close to three-tenths of a standard deviation) was observed. In Ireland, the difference was 0.27, close to the OECD average. Irish students reporting high levels of anxiety (i.e., those in the top third of the distribution of anxiety scores) had a mathematics score (468.1) that is four-fifths of a standard deviation lower than the score (536.8) of those in the bottom third.

SCHOOL CHARACTERISTICS AND ACHIEVEMENT

School Sector. Significant differences in achievement were found between the vocational, secondary and community/comprehensive sectors, with the largest differences (about half a standard deviation in the three assessment domains, e.g., 40.1 score points in mathematics) between vocational and secondary schools. Differences are similar to those observed in 2000.

Junior Certificate Examination Fee Waiver Entitlement. The achievements of students in schools with high, medium and low percentages of students entitled to a fee waiver for the Junior Certificate Examination (an indicator of school-level SES) differed significantly. For example, students in schools with a low rate of fee waiver scored 59.8 points (seven-tenths of a standard deviation) higher on combined mathematics than students in schools with a high rate of fee waiver.

Disciplinary Climate. Students were asked about their perceptions of the disciplinary climate in their mathematics class. Their responses were then aggregated to the school level, and each student was assigned the mean disciplinary climate score for his or her school. Students in schools with a low (poor) disciplinary climate score in mathematics classes achieved a mean combined mathematics score that is 43.7 points (about half a standard deviation) lower than students in schools with a high climate score. Climate appears to be independent of SES composition; its correlation with the percent of students entitled to a fee waiver for the Junior Certificate Examination is weak (–.06).

Chapter 6

Explanatory Models of Performance in Ireland on Combined Mathematics, Reading and Science in PISA 2003

In this chapter, associations between achievement and several school-level and student-level variables are examined simultaneously. Summaries of three models of achievement (in combined mathematics, reading literacy and science) are presented. The models in this chapter allow for an assessment of the contribution of individual student- and school-level variables to achievement, when adjusting for other variables in each model. This reduces the likelihood of making incorrect inferences, which may arise when only one variable at a time is considered in relation to achievement.

BETWEEN-SCHOOL DIFFERENCES IN ACHIEVEMENT OUTCOMES

The extent to which schools are similar varies across countries, reflecting at least in part the selectivity of the school system. A useful way to examine this is to partition total variation in achievement into variation between schools and variation within schools. The proportion between schools is usually referred to as the intra-cluster correlation (ICC) and, expressed as a percentage, gives an indication of how homogenous schools are within a given system.

The ICC of Ireland for combined mathematics (16.7%) is the eighth lowest among the 30 OECD countries and 39 participating countries for which data are available,[11] indicating a comparatively homogenous school system. This value is close to the values for Canada, New Zealand, Spain, and partner country Macao-China. In some of the Scandinavian countries, notably Iceland, Finland, and Norway, the ICC is very low (less than 10%). In contrast, the ICC exceeds 50% in eight countries (Belgium, Italy, Germany, Austria, Japan, Turkey, Hungary, and the Netherlands), indicating greater heterogeneity amongst schools. The ICC for Ireland for reading literacy (22.5%) is a little higher, yielding a ranking of 10th, while in science, it is almost identical to combined mathematics (16.2%), giving a ranking of 8th, where a ranking of 1 represents the lowest ICC. These comparatively low ICCs are consistent with those for Ireland in PISA 2000.

MODEL FOR COMBINED MATHEMATICS

The final model for combined mathematics included eight student-level variables: gender, socioeconomic status, lone-parent status, number of siblings, books in the home, home educational resources, frequency of absence from school, and grade level. An interaction between books in the home and frequency of absence was found (whereby the rate of increase in achievement corresponding to increasing numbers of books was larger for students with no absences compared to those with higher absence rates). Just two school-level variables were required in the final model for combined mathematics: disciplinary climate in mathematics classes and the percentage of students in the school in receipt of a fee waiver[12] for the Junior Certificate Examination. Two other school-level variables, school size and school sector, were not significant in the presence of the other variables and so were dropped from the final model.

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[11] Data for this indicator were not available for Brazil at the time of writing.

[12] The fee waiver for the Junior Certificate Examination is based on low-income status indicated by possession of a medical card.

Contributions of Student-Level Variables to Achievement

The final model suggested a deficit of 24.2 points (three-tenths of a standard deviation) for female students compared to males, after adjusting for other variables. Student socioeconomic status (SES), as indicated by parental occupation, was also significant, with a difference of 28.6 points (around one-third of a standard deviation) between the scores of high- and low-SES students. The interaction between the books in the home and absence from school indicates that the strength of the relationship between the former and achievement varies with the level of absence. For example, students with no absences in the fortnight prior to the PISA assessment and 500 or more books at home had a mean score that was 69.4 points higher (about four-fifths of a standard deviation) than those with no absences and 10 books or fewer. Students with three or more absences and 500 or more books had gains of 42.4 points (half a standard deviation) compared to students with three or more absences and 10 books or fewer. Students with low educational resources (those who had one or none of: access to a desk, a quiet place for study, books to help with school work) had an expected score that was 11.2 points (about one-eighth of a standard deviation) below that of students who had all three educational resources. The difference between students from lone-parent and dual-parent families is 15.7 points (one-sixth of a standard deviation) in favour of the latter group. Number of siblings also maintained a significant association in the presence of the other variables in the model, e.g., a deficit of 17.8 points (one-fifth of a standard deviation) was found between students with four or more siblings compared to students with one sibling. The grade level that a student was in at the time of the PISA assessment was also related to achievement. For example, students in Second year had a combined mathematics score that was 59.2 points (about seven-tenths of a standard deviation) lower than students in Third year (the modal grade) on average.

Contributions of School-Level Variables to Achievement

For the disciplinary climate variable, the difference between students in schools in the middle compared to the higher group is 25.5 points (one-third of a standard deviation), while the score difference between students in the low and high groups is 52.1 points (about three-fifths of a standard deviation). The corresponding deficits for the fee waiver variable are 12.2 and 26.5 points (just under one-sixth and one-third of a standard deviation, respectively).

Proportion of Achievement in Combined Mathematics Explained by the Model

Student-level variables (and interactions) alone explained 62.3% of the variation in achievement between schools, and 26.9% of the variation within schools (i.e., at the student and class level). When the school-level variables were included, the final model explained 78.8% of between-school variation and 29.6% of the variation within schools.

MODELS FOR READING LITERACY AND SCIENCE

The final models for reading and science were broadly similar to the model for combined mathematics in the variables that were retained and the strength of their associations with achievement. However, there were three exceptions. First, the direction and size of the gender difference varied. The final model for reading indicated a significant gender difference in favour of females, who score 21.5 points (one-quarter of a standard deviation) higher than males, after adjusting for other variables in the model. The gender difference in the final model of science of 7.6 points (just under one-tenth of a standard deviation) favoured males. Second, unlike the model for mathematics, there were no significant interactions between variables in the models for either reading and science. Third, in the case of science, an additional variable was included: whether or not the student studied science for the Junior Certificate. Students who did not study science had a fitted contribution that was 38.2 points (two-fifths of a standard deviation) lower on the PISA science scale than those who did.

The final model of reading explained 81.4% of variation at the school level, and 35.4% at the individual (student and class) level. The final model of science explained 80.2% of between-school variation, and 31.2% of within-school variation.

IMPLICATIONS OF THE MODELS

Similarity of the Three Models

The final models for PISA 2003 are more similar than those reported for PISA 2000 (Shiel et al., 2001). Reasons for this merit further exploration as there were differences in the way student scores were scaled in the two studies. In 2000, only students who attempted items corresponding to a particular minor domain were assigned a score for that domain. In 2003, scores were imputed (inferred via statistical methods) for all students in each minor domain, regardless of whether or not they had attempted items in a given domain. The presence of imputed scores for such students may have impacted on the modelling process and the results.

Gender Differences

Significant gender differences are present in all three final models, favouring males for combined mathematics and science, and females for reading literacy. These are of a similar magnitude in the case of combined mathematics and reading, while the value for science is smaller (having changed from non-significant, when originally fitted separately, to significant when fitted with other variables in the model). These findings add to discussions of gender differences, since they remain significant even in the presence of 9 or 10 other student- and school-level variables.

Study of Science at Junior Certificate

The inclusion of information about whether or not each student studied science for the Junior Certificate showed a significant difference in favour of those who did. However, further investigation of the association of this variable with mathematics and reading suggests that it may be acting as a proxy for low achievement since similar achievement differences are also found for these two PISA domains. As 9.9% of Irish students who participated in PISA did not study science, it may be asked if this segment of the population would not benefit in the future from having encountered an element of applied science in their post-primary school curriculum.

Grade Level

Substantial differences corresponding to grade level were also found. However, such differences are difficult to interpret for reasons already noted in Chapter 5. Given that students can be above or below the modal grade level (Third year) for a variety of reasons, and because not all students take the Transition Year Programme, the parameter estimates for grade level cannot be viewed as reflecting a simple progression through four grades.

School-Level Variables in the Models

The impact of SES at the individual level, found in PISA 2000, is confirmed in 2003 with the addition of a useful school-level deprivation context measure that is easily collected and of policy relevance, namely the percentage of students entitled to a Junior Certificate

Examination fee waiver. This is a more refined measure than the Department of Education and Science's dichotomous school designated disadvantaged status. The former reflects the more continuous relationship of the SES density of students in the school context to achievement. It is also notable that, in contrast to PISA 2000, school sector does not appear in any of the final models for 2003. This suggests that the current model better explains the achievement differences across secondary, vocational and community/comprehensive schools. The disciplinary climate in mathematics variable appears to provide a useful measure of disciplinary climate for all three domains. It is more closely tied to management practice than the percent fee waiver variable, which reflects more the average SES of the school and which might be viewed as less under the control of schools than disciplinary climate.

Contextual Effects

A high proportion of the achievement variation between schools was explained by the student-level variables when fitted alone (e.g., 62.3% for combined mathematics). This indicates a considerable variation in school performance due to differences in student composition (see Hox, 2002). School-level variables explained significant amounts of between-school variation, over and above those recorded at the student level. This illustrates the contextual effect of the school-level SES-related variable in relation to achievement, in the presence of the other variables in the model.

Chapter 7
Curriculum and Assessment in Ireland and Performance on PISA 2003

This chapter examines (i) the relationship between performance in mathematics, English and science on the Junior Certificate Examination and performance on PISA 2003, (ii) the content overlap between PISA mathematics and Junior Certificate mathematics, (iii) the relationship between the expected familiarity of students with items in the PISA 2003 mathematics assessment and their performance on PISA 2003 mathematics, and (iv) the distribution of proficiency levels for students at each syllabus level in mathematics and English.[13]

PERFORMANCE ON PISA AND THE JUNIOR CERTIFICATE EXAMINATION

Junior Certificate Mathematics Syllabus and Examination

The Junior Certificate mathematics syllabus was revised in 2000 and examined for the first time in 2003. Its structure has not changed substantially, but calculators were permitted in the examination for the first time in 2003. A comparison of the Junior Certificate mathematics examination papers[14] and the PISA mathematics assessment suggests substantial differences in the focus and style of the two assessments. In the Junior Certificate, questions are usually presented in a purely mathematical, abstract context, almost always with little or no redundant information. The Junior Certificate Examination in mathematics emphasises rigorous technical language and notation. In the PISA assessment, questions are often embedded in rich real-life contexts, accompanied by texts and diagrams. In PISA, students are often required to discriminate between necessary and redundant information, as well as actually formulate the problem in mathematical terms, in order to solve it. Compared to the Junior Certificate Examination for mathematics, students are more frequently required in PISA to explain or justify their working out and conclusions.

Junior Certificate Performance Scale

To make direct comparisons between performance on PISA and performance on the Junior Certificate Examinations, the Junior Certificate Examination grades of all students, regardless of the level at which they took the examination, were placed on the same scale. The resulting 12-point Junior Certificate Performance Scale (JCPS) in the case of English and mathematics has a three-grade overlap between examination levels (Higher, Ordinary and Foundation). Because there is no Foundation level the case of science, a 9-point scale was used ranging from 4 (F, Ordinary level) to 12 (A, Higher level).

The majority of students participating in PISA 2003 took the Junior Certificate Examination in 2002 (34.3% of the PISA cohort) or in 2003 (59.6%); a further 6.1% of students took the examination in another year and are not included in these analyses. Junior Certificate results for English and mathematics are available for 93.9% of students with PISA mathematics and reading literacy scores. For Junior Certificate science, they are available for 82.5% of students

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[13] Readers wishing to obtain a broader understanding about issues concerning the curriculum in Ireland are referred to Oldham (2001, 2002) and Lyons, Lynch, Close, Sheerin and Boland (2003) (mathematics), Mullins (2000) and Mullins and Killeen (1989) (English), and Cosgrove, Shiel and Kennedy (2002) and the *Report of the Task Force on the Physical Sciences* (2002) (science).

[14] Examination papers are available at http://www.examinations.ie

who participated in the PISA assessment of science. The percentage is lower for science because it is an optional subject for the Junior Certificate.

Relationship Between Performance in PISA 2003 and the Junior Certificate Examination

The correlations between students' JCPS scores and their performance on PISA, for the three subject domains, and for the mathematics subscales, suggests a moderate relationship in all cases, with the correlations exceeding .65. The correlation between PISA combined mathematics and the JCPS for mathematics is the highest at .75. Turning to the mathematics subscales, the correlation between performance on Junior Certificate mathematics and the Space & Shape subscale is weakest at .68, while it is around .74 for the other mathematics subscales and JCPS mathematics. The correlations between JCPS mathematics, English and science and the respective PISA domains are similar to those reported for PISA 2000. Correlations between performance on the three PISA 2003 domains are somewhat higher than those between PISA and the Junior Certificate subjects, ranging from .80 (PISA mathematics and PISA reading) to .85 (PISA science and PISA reading).

ANALYSES OF PISA 2003 MATHEMATICS WITH REFERENCE TO JUNIOR CERTIFICATE MATHEMATICS

The framework for the analyses presented here focuses on the expected familiarity of Third year students with each PISA mathematics item, distinguishing between the three syllabus levels and three aspects of the items (underlying concept, context of application and item format). In addition to these familiarity ratings, conducted by three individuals who are highly experienced in the Irish mathematics curriculum, those items which were rated by them as somewhat or very familiar in terms of the concepts assessed were further classified into the Junior Certificate topic area(s) in which each one would best fit.

Location of PISA 2003 Mathematics Items in Junior Certificate Mathematics Topic Areas

A cross-tabulation of PISA mathematics items by Junior Certificate mathematics topic areas indicates that, in the case of Higher level, 28.6% of PISA items were rated as 'not familiar' in terms of the mathematical concepts assessed. The corresponding percentages for Ordinary and Foundation levels are 33.0% and 49.4%, respectively.[15] The Junior Certificate mathematics topic areas of sets, geometry, and trigonometry are not assessed at all by the PISA mathematics items. The cross-tabulation also suggests that the bulk of PISA mathematics items which *are* somewhat familiar to Irish students are located in the Junior Certificate mathematics topic areas of applied arithmetic and measurement (25.8% to 33.0% of items, depending on syllabus level), statistics (14.6% to 19.8%) and number systems (8.8% to 9.9%). The cross-tabulation indicates that few PISA mathematics items fall into the Junior Certificate topic areas of algebra (1.1% to 5.5% of items, depending on syllabus level), and functions and graphs (no items to 4.4% of items).

Item-Level Curriculum Familiarity Ratings

The specific mathematical concepts underlying the majority of PISA items in the case of Higher (69.4%) and Ordinary (64.7%) levels were rated as somewhat or very familiar, while just under half of the items in the case of Foundation level (48.3%) were rated as somewhat or very familiar. In contrast, the context in which the mathematics problem was presented

[15] Note that these percentages are based on ratings which, in the case of six items at Higher and Ordinary level and four at Foundation level, fell into two Junior Certificate mathematics topic areas.

(e.g., the extent to which it was embedded in a real-life setting) was rated unfamiliar for the majority of items at all three syllabus levels (65.9% at Higher level, 70.6% at Ordinary level, and 80.0% at Foundation level). Item formats were also judged to be largely unfamiliar to Irish students, at least in the context of Junior Certificate mathematics (62.4% were rated unfamiliar at Higher level, 72.9% at Ordinary level and 83.5% at Foundation level). These ratings are very similar to those obtained in PISA 2000, despite the expansion of the assessment domain to include two additional mathematics content areas (Quantity and Uncertainty) and changes to the Junior Certificate mathematics syllabus since 2000.

Ratings were examined for each PISA mathematics subscale area (Space & Shape, Change & Relationships, Quantity, and Uncertainty) separately. Results suggest that students are familiar with most of the items on the Change & Relationships and Quantity subscales, moderately familiar with items on the Space & Shape subscale, and less familiar with the items on the Uncertainty subscale. One might expect that this pattern of ratings would be reflected in students' actual achievements on the four subscales, but this is not the case. Irish students scored significantly below the OECD average on the Space & Shape subscale, significantly above the average on the Change & Relationships and Uncertainty subscales, and around the average on the Quantity subscale. Of course, a measure of the relative familiarity of other participating countries with the mathematics items would be needed in order to gain a better understanding of this pattern of results in an international context.

A comparison of familiarity with concept across the three mathematical processes assessed in PISA (Reproduction, Connections and Reflection) suggests that, at all levels, students were most familiar with Reproduction items and least familiar with Reflection items, which is consistent with the types of questions students usually encounter on the Junior Certificate examination papers for mathematics.

Student-Level Analyses

Taking into account both the mathematics syllabus level at which the student had taken (or was to take) the Junior Certificate Examination, as well as the particular set of mathematics items attempted, student-level familiarity scales were computed for each of three aspects (concept, context, and format).

The resulting student-level scales are empirically as well as logically interdependent. The intercorrelations among the curriculum familiarity scales at the student level are all in excess of .60. Given the inter-relatedness of the scales, a single global curriculum familiarity scale incorporating all three aspects was created. The global curriculum familiarity scale correlated .32 with combined mathematics achievement. Considering the three aspect scales separately, the correlation between concept familiarity and mathematics achievement of .37 is the highest; item format correlates .28 with achievement and that for context of application is the lowest at .21. As in PISA 2000, these findings suggest that concept familiarity is most strongly predictive of success on an item.

THE DISTRIBUTION OF STUDENTS AT VARIOUS JUNIOR CERTIFICATE SYLLABUS LEVELS ON PISA MATHEMATICS AND READING PROFICIENCY LEVELS

Junior Certificate Mathematics and PISA 2003 Combined Mathematics

There is a marked difference in the levels of proficiency on the combined mathematics scale demonstrated by students taking Junior Certificate mathematics at the three syllabus levels (Table 7.1). One-third of Foundation level students have a mean score below Level 1. A further two-fifths of this group (38.5%) score at Level 1, and 22.5% at Level 2. Just under 6%

of Irish students taking Foundation level surpass Level 2. No student taking Foundation level demonstrated a proficiency higher than Level 3. At Ordinary level, 21.9% of students are at or below Level 1, and close to two-fifths (36.2%) are at Level 2. Only around two-fifths of Ordinary level students (41.9%) have a mean score at Level 3 or higher and just 1.6% group have a mean score at Level 5 or 6. At Higher syllabus level, few students score at or below Level 1 (1.5%), although 10.5% are at or below Level 2. Close to one-quarter of Higher level students (24.9%) have a mean score at the highest proficiency levels (Level 5 or 6).

Given that the OECD has identified proficiency Level 2 on the combined mathematics scale as the minimum level required for successful participation in further education and more generally (OECD, 2004a), these findings may be of concern, particularly with respect to the performance of around one-fifth of Ordinary level students.

Table 7.1. Percent of Irish Students at Each Combined Mathematics Proficiency Level Cross-Classified by Junior Certificate Mathematics Syllabus Level

	Below Level 1		*Level 1*		*Level 2*		*Level 3*		*Level 4*		*Level 5*		*Level 6*	
	%	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*
Higher	0.3	0.16	1.2	0.33	9.0	1.09	28.8	1.26	35.8	1.52	19.7	1.39	5.2	0.76
Ordinary	4.1	0.70	17.8	1.26	36.2	1.27	30.4	1.30	9.9	0.90	1.5	0.38	0.1	0.11
Foundation	33.4	4.05	38.5	4.18	22.5	3.35	5.5	1.83	0.0	0.00	0.0	0.00	0.0	0.00

Note. Total number of Irish students = 3880. N Higher = 1651, N Ordinary = 1941, N Foundation = 265, N Missing syllabus level = 24.

Junior Certificate English and PISA 2003 Reading Literacy

There are large differences in the distribution of students across proficiency levels, depending on the syllabus level taken for Junior Certificate English. For example, 77.5% of Foundation level students score at or below Level 1, and none score above Level 3. At Ordinary level, 27.1% of students score at or below Level 1, while just 7.3% demonstrated the more advanced reading proficiencies associated with Levels 4 and 5. In contrast, almost half of the Higher syllabus level students (48.4%) scored at Level 4 or 5, and very few (2.3%) at or below Level 1.

There are some differences in the distribution of performance across reading proficiency levels when one compares these for each syllabus level for 2000 and 2003. For example, while the low reading standards of Foundation level students in 2003 remain a cause for some concern, the percentage at or below Level 1 appears to have reduced since 2000 (from 90.0% to 77.5%). However, in the absence of further data points over time, and given the large standard errors and very small sample size corresponding to these percentages, one cannot say with any confidence that this represents a real change in standards at Foundation level. In contrast, the lower percentage of Higher level students scoring at Level 4 or 5 in 2003 (48.4%) compared to 2000 (55.3%) is consistent with the significant decrease in achievement in reading literacy in 2003 at the mean and the upper end of the achievement distribution noted in Chapter 4.

Chapter 8
Achievement Outcomes in Problem Solving

OVERVIEW OF THE PROBLEM-SOLVING FRAMEWORK

In addition to assessing the major domain of combined mathematics, and the minor domains of reading and science, PISA 2003 assessed performance in a third minor domain, cross-curricular problem solving. As indicated in Chapter 2, the problem-solving assessment was designed to measure students' ability to solve real-life problems in contexts that were different from those used to assess mathematics, reading and science. The assessment incorporated three problem types: decision making (where students make decisions under specified constraints), system analysis and design (where students evaluate and design systems), and trouble-shooting (where students identify why a device is malfunctioning, based on a set of symptoms). Nineteen problem-solving items in units consisting of two to three tasks were presented, and some students were asked to attempt either nine or ten items, while other students were not asked to attempt any.[16] An example of these tasks may be found in Appendix 1, together with the item scale value (at OECD Level), OECD average percent-correct score and percent-correct score for Irish students. Figure 8.1 illustrates the location of selected items on the PISA problem-solving scale. More sample items are available at http://www.erc.ie/pisa.

ACHIEVEMENT IN PROBLEM SOLVING

Overall Performance on the Problem-Solving Scale

Performance on the PISA assessment of cross-curricular problem solving was reported on a single scale with an OECD country average of 500.0 and a standard deviation of 100.0. As in the other PISA minor domains, scores were imputed (inferred using statistical methods) for students who were not asked to attempt the problem-solving items. Irish students ranked 21st of 40 countries (95% confidence interval for Ireland's ranking = 20th to 22nd) and 18th of 29 OECD countries (95% confidence interval for Ireland's ranking = 17th to 19th), achieving a mean score (498.5) that was not significantly different from the OECD country average (see footnote 7, page 10 for a brief description of statistical significance). Sixteen countries achieved significantly higher mean scores than Ireland, including 13 OECD countries (Table 8.1). The four highest-scoring countries, Korea (mean of 550.4), Hong Kong-China (547.9), Finland (547.6) and Japan (547.3) achieved mean scores that were not significantly different from one another. However, students in these countries had mean scores that were about 50 points higher than the mean score of Irish students. The standard deviation for Ireland (79.6) was the lowest among OECD countries, although the standard deviations for Finland (82.0), and Iceland (84.8) were close to Ireland's. A low standard deviation indicates a relatively narrow spread of performance in a country.

When nonparametric maximum likelihood estimation was employed to group countries on the basis of their overall performance (see Chapter 3 for a description of this method), five groups were identified. Ireland, along with Hungary, had a masspoint between the second and third groupings of countries. The second grouping (which has a score of 517.9) included countries such as Switzerland, the Netherlands, France and Germany, while the third (which has a score of 481.5) included Norway, Spain, Portugal and Italy.

[16] Problem-solving items appeared in 7 of the 13 test booklets.

Table 8.1. Mean Achievement Scores, Standard Errors and Standard Deviations on the Cross-Curricular Problem Solving Scale – OECD and Partner Countries

	Mean	*(SE)*	*SD*	*(SE)*	*OECD Diff*		*Mean*	*(SE)*	*SD*	*(SE)*	*OECD Diff*
Korea	550.4	(3.06)	86.4	(1.95)	▲	Luxembourg	493.66	(1.36)	91.6	(1.03)	▼
Hong Kong-China	547.9	(4.18)	97.2	(2.90)	▲	Slovak Republic	491.8	(3.38)	92.8	(2.39)	▼
Finland	547.6	(1.86)	82.0	(1.15)	▲	Norway	489.8	(2.60)	98.8	(1.65)	▼
Japan	547.3	(4.05)	104.9	(2.72)	▲	Poland	486.6	(2.78)	90.4	(1.68)	▼
New Zealand	532.8	(2.17)	95.7	(1.24)	▲	*Latvia*	482.5	(3.90)	92.1	(1.75)	▼
Macao-China	532.4	(2.53)	81.3	(2.55)	▲	Spain	482.2	(2.73)	93.6	(1.25)	▼
Australia	529.8	(1.98)	91.4	(1.35)	▲	*Russian Federation*	478.6	(4.59)	98.5	(2.11)	▼
Liechtenstein	529.5	(3.95)	92.7	(4.21)	▲	United States	477.3	(3.13)	98.1	(1.29)	▼
Canada	529.3	(1.74)	88.4	(0.93)	▲	Portugal	469.8	(3.87)	92.5	(2.11)	▼
Belgium	525.3	(2.20)	103.9	(1.52)	▲	Italy	469.5	(3.10)	102.2	(2.14)	▼
Switzerland	521.3	(3.05)	94.0	(1.88)	▲	Greece	448.5	(3.97)	98.8	(1.67)	▼
Netherlands	520.2	(2.95)	89.4	(2.03)	▲	*Thailand*	425.0	(2.72)	82.0	(1.59)	▼
France	519.2	(2.67)	92.9	(2.08)	▲	*Serbia and Montenegro*	420.2	(3.32)	85.8	(1.56)	▼
Denmark	516.8	(2.54)	87.3	(1.51)	▲	*Uruguay*	410.7	(3.68)	111.7	(1.93)	▼
Czech Republic	516.4	(3.42)	92.9	(1.92)	▲	Turkey	407.5	(6.03)	96.7	(4.43)	▼
Germany	513.4	(3.24)	94.8	(1.75)	▲	Mexico	384.4	(4.30)	96.1	(2.01)	▼
Sweden	508.6	(2.44)	88.4	(1.58)	▲	*Brazil*	370.9	(4.80)	100.2	(2.60)	▼
Austria	506.1	(3.18)	90.0	(1.71)	o	*Indonesia*	361.4	(3.29)	73.3	(1.74)	▼
Iceland	504.7	(1.38)	84.8	(1.15)	▲	*Tunisia*	344.7	(2.11)	79.5	(1.42)	▼
Hungary	501.1	(2.86)	94.1	(2.03)	o	**OECD Total**	**489.7**	**(1.15)**	**106.4**	**(0.79)**	
Ireland	**498.5**	**(2.34)**	**79.6**	**(1.35)**	**o**	**OECD Average**	**500.0**	**(0.64)**	**100.0**	**(0.45)**	

Mean achievement significantly higher than Ireland	Above OECD average ▲
Mean achievement not significantly different from Ireland	At OECD average o
Mean achievement significantly lower than Ireland	Below OECD average ▼

Note. OECD countries are in regular font; partner countries are in italics. SD = Standard deviation; SE = Standard error.
The column "OECD Diff" indicates whether each country scores at, significantly above, or significantly below the OECD average ($p < .05$), using Bonferroni-adjustments with an overall alpha-level of .05.

Performance At Key Markers

Performance on PISA problem solving can also be examined with reference to the scores achieved by students in Ireland and in other countries at key markers. Figure 8.1 shows the scores of Irish students scoring at the 10th, 25th, 75th and 90th percentile ranks. For example, the score corresponding to the 10th percentile in Ireland is 394.6. Irish students at the 75th, 90th and 95th percentile ranks achieved scores that were lower than the corresponding OECD country average scores. In contrast, scores of students in Ireland at the 5th, 10th and 25th percentile ranks were higher. This distribution is similar to the pattern of Irish student achievement in the other three domains, particularly mathematics and science.

Proficiency Levels

As in combined mathematics and reading, PISA established proficiency levels for problem solving. Four intervals were identified: Levels 3, 2, 1 and below Level 1. Just 12.3% of Irish students achieved Level 3 (the highest level) compared to the OECD country average of 18.2% (Table 8.2). Students at Level 3 can typically deal with a large number of constraints, able to organise and monitor their thinking while developing solutions. Just under two-fifths (38.3%) of students in Ireland achieved scores at Level 2, compared to the OECD country average of 34.2%. Students at Level 2 can apply analytic reasoning processes to solve problems requiring decision-making skills. Almost 37% of students in Ireland achieved scores at Level 1 compared to the OECD country average of 30.4%. These students are basic problem solvers who can deal with a single data source containing well-defined information. Just 12.5% achieved scores below Level 1, in compared to the OECD country average of 17.3%.

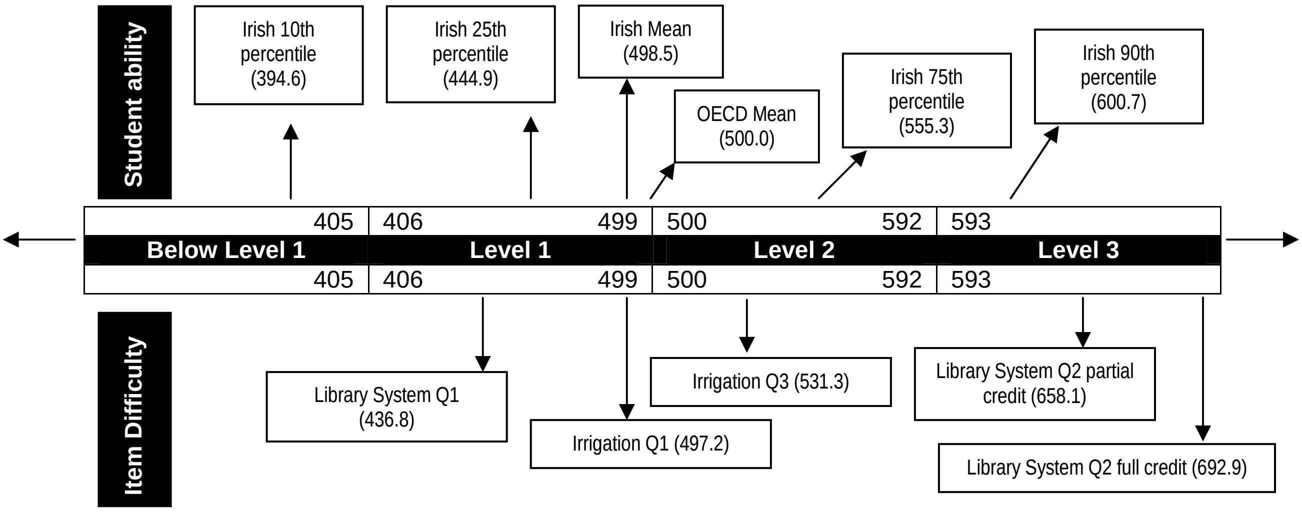

Figure 8.1. The PISA 2003 Problem Solving Scale: Cut-points for Proficiency Levels, Scores of Students in Ireland at Key Markers, and Difficulties of Selected Items

Table 8.2. Task Descriptions of Proficiency Levels on the Problem-Solving Scale, and Percentages of Students Achieving Each Level – Ireland and OECD Average

Level (Cut-point)	*Brief Description* - Students at this level are likely to be able to:	*Ireland** %	*Ireland** (SE)	*OECD*** %	*OECD*** (SE)
Level 3 (above 592.5)	*"Reflective, communicative problem solvers"*: Approach multi-faceted problems systematically, construct their own representations; deal with a large number of interrelated conditions and constraints; organise and monitor their thinking while developing solutions; verify their solution; address problems successfully; and communicate their solutions clearly.	12.3	(0.76)	18.2	(0.18)
Level 2 (498.9 to 592.4)	*"Reasoning, decision-making problem solvers"*: Apply various types of reasoning (inductive deductive, and combinatorial) to analyse situations and solve problems among well-defined alternatives; combine and synthesise information and representations from a variety of sources; and draw inferences based on two or more sources of information.	38.3	(1.05)	34.2	(0.23)
Level 1 (405.3 to 498.8)	*"Basic problem solvers"*: Solve problems that deal with a single data source containing discrete, well-defined information; understand, locate and retrieve information the major features of a problem; may transform information to present the problem differently, or apply information to check a limited number of well-defined conditions.	36.9	(1.17)	30.4	(0.20)
Below Level 1 (less than 405.2)	*"Weak or emergent problem solvers"*: Have a less than 50% chance of responding correctly to Level 1 tasks.	12.5	(0.91)	17.3	(0.25)
	Total	100		100	

*N (Ireland) = 3880. **Denotes OECD average percent.

Note. Students at a particular level have at least a 50% chance of correctly answering all items at that level.

BETWEEN-SCHOOL DIFFERENCES IN PROBLEM-SOLVING

A comparison of the proportion of total variation between schools in achievement in combined mathematics, reading and science suggests that the Irish system is comparatively homogenous; i.e., schools do not differ much with respect to achievement (Chapter 6). The same is true of the between-school differences in problem solving, with just 15.7% of total variation in problem solving lying between schools, compared to an OECD average of 31.6% (country range of between-school variation = 3.0% to 57.6%).

ASSOCIATIONS BETWEEN PERFORMANCE IN PROBLEM SOLVING AND IN OTHER PISA DOMAINS

The performance of Irish students in PISA problem solving was remarkably similar to their performance on the combined mathematics scale. In both instances, students achieved mean scores that were not significantly different from the corresponding OECD country averages. Moreover, there was a strong correlation (.90) between combined mathematics and problem solving, although the problem solving items had been designed so that students would only require the most basic mathematical knowledge. Correlations between problems solving and the other PISA domains were marginally weaker (.85 for both reading and science).

ASSOCIATIONS BETWEEN STUDENT- AND SCHOOL-LEVEL VARIABLES AND PROBLEM SOLVING

An analysis of the association between a range of student-level variables and performance on problem solving produced findings highly similar to those reported for a range of variables and combined mathematics in Chapter 5. Hence, they are not reproduced here. The variables comprise socioeconomic status, home educational resources, books in the home, lone-parent status, absenteeism, grade level, study of science for the Junior Certificate, mathematics self-efficacy, and anxiety about mathematics. However, unlike the case of combined mathematics, but similar to most participating countries, there was no significant gender difference in performance in problem solving, either for overall mean scores (where the mean score difference in Ireland was just half a score point), or for scores at key percentile points. At the school level, the associations of school sector, fee waiver entitlement for the Junior Certificate Examination, and disciplinary climate, with achievement in problem solving were also highly similar to those reported for combined mathematics in Chapter 5, and are not reproduced here either.

Chapter 9

Key Findings, Implications and a Look Ahead to 2006

The key findings of PISA 2003 are presented in this chapter with particular reference to Ireland. A set of implications arising from the outcomes is given. The chapter concludes with a look ahead to 2006.

KEY FINDINGS

Overview of PISA 2003

The second cycle of the Programme for International Student Assessment (PISA 2003) which took place in 30 OECD countries and 11 non-OECD (partner) countries[17], involved the assessment of students' knowledge and skills in four domains: mathematics (major domain), reading literacy, science and cross-curricular problem solving (minor domains). Students' performance was scaled using item response theory to have an OECD mean of around 500 and standard deviation of 100 (which varies slightly depending on the domain). In the case of mathematics, achievements on four subscales are also considered. Performance scales were also divided into proficiency levels for mathematics (6 levels), reading (5 levels) and problem solving (3 levels). Changes in performance in mathematics, reading, and science between 2000 and 2003 are considered.

Combined Mathematics

Irish students achieved a mean score of 502.8 on the combined mathematics scale, which is not significantly different[18] from the overall OECD mean of 500.0. The Irish mean ranks 20th out of 40 participating countries (95% confidence interval of Ireland's ranking = 16th to 21st) and 17th out of 29 OECD countries (95% confidence interval = 14th to 19th).[19] Ireland's mean score is not significantly different from those of eight countries, and is significantly lower than those of 10 OECD countries. Ten OECD countries achieved significantly lower mean scores than the Irish mean. The percentage of students who are at or below proficiency Level 1 (the lowest level, where students demonstrate only basic mathematics skills such as routine computation) is below the OECD average (16.8% compared to 21.4%), indicating comparatively strong performance at the lower end of the achievement distribution. However, just 11.3% of students in Ireland compared to 14.6% on average in the OECD attain Levels 5 and 6 (the highest levels, where students demonstrate advanced mathematics skills such as model building, generalisation and insight). The standard deviation for Ireland (85.3) is smaller than the OECD average (100.0), indicating a narrower dispersion in achievement in Ireland.

Mathematical Subscales

The mean performance of Irish students on the Space & Shape subscale (476.2) is significantly below the OECD mean score of 496.3. Mean performance on the Change & Relationships subscale (506.0) is significantly above the OECD mean score of 498.8 (though

[17] The United Kingdom participated but its response rates were too low to ensure reliable achievement estimates, hence comparisons are made here for 29 rather than 30 OECD countries.

[18] Statistical significance was evaluated at the .05 level, adjusting for the number of comparisons involving Ireland and OECD countries (28 comparisons), or Ireland and all participating countries (39 comparisons), where appropriate.

[19] There is sampling and measurement error associated with country rankings and they are only an indication of the relative position of each country with respect to the other. For this reason, the confidence intervals associated with Ireland's rankings are provided.

the difference is not large). Ireland's mean score of 517.2 on the Uncertainty subscale is significantly above the OECD average of 502.0. Its performance on the Quantity subscale, 501.7, is not significantly different from the OECD average of 500.7.

Reading Literacy

Students in Ireland achieved a mean score of 515.5 on the reading literacy scale, which is significantly higher than the OECD country mean of 494.2. Ireland's ranking in reading literacy is 7th out of 40 countries (95% confidence interval of Ireland's ranking = 5th to 11th) and 6th out of 29 OECD countries (95% confidence interval = 5th to 9th). Three countries (Finland, Korea, and Canada) have mean scores that are significantly higher than Ireland's. Twenty-nine countries (21 OECD countries) have a mean score that is significantly lower. The low standard deviation associated with the mean score for Ireland (86.5 compared to an OECD average of 100.2) indicates a relatively narrow dispersion of achievement. Proportionately fewer students in Ireland scored at or below Level 1 compared to the OCED average (11.0% and 19.7%, respectively). Level 1 is associated with basic reading skills such as retrieval of explicit information from a simple text, while skills of students below Level 1 are not measured by PISA. The percentage of Irish students (35.5%), scoring at Level 4 or 5 (where reading skills are more advanced and students deal with complex texts in a critical manner) was above the OECD average (29.6%).

Science

Students in Ireland achieved a score in science (505.4) that was marginally, but statistically significantly, higher than the OECD average (499.6). Ireland's ranking in science is 16th out of 40 countries (95% confidence interval of Ireland's ranking = 12th to 20th) and 13th out of 29 OECD countries (95% confidence interval = 9th to 16th). The mean scores of 11 countries (8 OECD countries) are significantly higher than that of Ireland, while Ireland's mean score does not differ significantly from the scores of eight countries (all OECD countries) and is significantly higher than those of 20 countries (11 OECD countries). In relative terms, Ireland's performance in science is somewhat better than in mathematics, but poorer than in reading literacy. Because it was a minor domain in 2003, proficiency levels for science were not developed.

Problem Solving

The mean score of Irish students (498.5) does not differ from the OECD average (500.0). Ireland ranks 21st out of 40 countries (95% confidence interval of Ireland's ranking = 20th to 22nd) and 18th out of 29 OECD countries (95% confidence interval = 17th to 19th). The mean scores of 17 countries are significantly higher than that of Ireland, and those of 16 countries are significantly lower. The standard deviation for Ireland (79.6) is once again smaller than the OECD average (100.0). Comparatively more students in Ireland perform at or below proficiency Level 1 (basic or emergent level; 49.4% compared to 47.7% across the OECD) and just 12.3% (compared to 18.2% across the OECD) score at Level 3 (the highest level, where reflective and communicative problem solving skills are evident).

Performance in PISA 2000 compared to 2003

Mathematics. Performance on the two subscales common to PISA 2000 and 2003 (Space & Shape and Change & Relationships) were compared. There was no change in the Irish mean performance on the Space & Shape subscale or at any of the percentile points examined (5th, 10th, 25th, 75th, 90th and 95th), as was the case in the majority of participating countries. There was an overall increase in OECD mean performance in the Change & Relationships subscale, and at five key percentile points. However, for Ireland there was no change. Caution is warranted in interpreting these findings as they represent only two points in time.

Reading Literacy. There was no change in the average OECD score, or at scores at any of six percentile points, between 2000 and 2003. The scores of students in Ireland are lower in 2003 than in 2000 at the mean and the 75th, 90th, and 95th percentile points. Performance at the lower end of the scale did not change.

Science. Similar to reading, there was no change in the OECD average score between 2000 and 2003. However, scores at the lower percentiles were lower in 2003 than in 2000 on average across the OECD, and scores at the upper percentiles were higher in 2003. The mean score of Ireland for science did not change, nor did scores at any of the six percentile points examined.

Student-Level Variables Associated With Achievement

Student Gender. Irish male students achieved a mean score in combined mathematics that was 14.8 points (one-sixth of a standard deviation) higher than that of females. In reading, Irish males scored 29.0 points (about three-tenths of a standard deviation) below females. A gender difference in science achievement favouring males in the region of one-tenth of a standard deviation, or 7.6 points was significant, but only after adjusting for the contributions of a range of student and school variables.[20]

Student Socioeconomic Status, Home and School Background. A series of multilevel models revealed that the contribution of a number of variables to achievement was very similar for mathematics, reading and science. Apart from student gender, variables that retained a significant association with achievement after adjusting for the other variables in the model were: socioeconomic status, lone-parent/dual-parent family status, number of siblings, books in the home, home educational resources, absenteeism, and grade (year) level.

School Socioeconomic Status and Disciplinary Climate. After adjusting for student-level variables in the models, school socioeconomic status (as measured by the percentage of students in the school entitled to a fee waiver for the Junior Certificate Examination) and disciplinary climate were significantly associated with achievement. Further, the fee waiver and disciplinary climate variables are not related.

School-Level Variables Associated With Achievement

When the effects of three school-level variables were examined simultaneously with one another, and with a number of student-level variables, it was found that school sector (whether secondary, community/comprehensive, or vocational) was no longer associated with achievement in mathematics, reading, or science. In contrast, disciplinary climate and school-level SES (as indicated by the percent of students entitled to fee waiver for the Junior Certificate Examination) both maintained significant associations with achievement in the three domains.

Between- and Within-school Variance in Achievement

Relative to other countries, between- school variation in the achievements of Irish students was low (16.7% in mathematics, 22.5% in reading, and 16.2% in science). This can be interpreted as indicating that, compared to most other OECD countries, schools in Ireland are similar to one another in terms of average achievement.

[20] The variables included in computing the adjusted gender difference are student SES, family size and structure, books in the home, educational climate, grade level, absenteeism, study of science for the Junior Certificate, and the school variables disciplinary climate and percent with Junior Certificate fee waiver. These estimates are from models constructed by the Irish national centre.

IMPLICATIONS

In this section, implications arising from the outcomes of PISA 2003 in Ireland are presented. Almost half relate specifically to mathematics as it was the major assessment domain in PISA 2003. The others address reading, science, cross-curricular problem solving, as well as school- and student-level variables associated with achievement.

Mathematics

1. *Overall performance in mathematics.* The overall mean score of students in Ireland, although not significantly different from the OECD country average, is lower than the mean score of students in a number of European countries, including Finland, Belgium, Switzerland and the Czech Republic. This suggests a need to question whether current standards in mathematics are adequate, and whether they meet current and future needs. In doing so, it should be recognised that, although the stated aims of PISA mathematics and of the Junior Certificate Mathematics syllabus are broadly similar, there are substantial differences in the underlying philosophies[21], in mathematical content, in assessment, and in implications for teaching and learning.

2. *Performance on the mathematics subdomains (subscales).* On two mathematics subdomains, Uncertainty, and Change & Relationships, students in Ireland achieved mean scores that were significantly higher than the corresponding OECD country average scores. Ireland's mean score on Quantity was not significantly different from the OECD country average. The weakest subdomain for students in Ireland was Space & Shape, where performance was significantly below the OECD country average. In all four subdomains, mean scores for Ireland were well below those of the highest-scoring countries. The performance of students in Ireland in Space & Shape may reflect differences between the focus on spatial reasoning and visual geometry in PISA, and the emphasis on deductive, logical geometry in the Junior Certificate syllabus/examination. Indeed, none of the Space & Shape items in PISA was identified by individuals experienced in the mathematics curriculum of Ireland as an element of the syllabus in geometry (see 8 and 9, below).

3. *Distribution of achievement in mathematics.* The standard deviation around the mean score of students in Ireland on combined mathematics (85.3) was among the lowest in the OECD – well below the country average standard deviation (100.0). A low standard deviation indicates a narrow dispersion of achievement scores, and can be interpreted as evidence of an equitable distribution of achievement outcomes in a country, though countries with narrow dispersions may have high or low overall achievement.

4. *Performance of high achievers in mathematics.* The relatively low performance of higher-achieving students in mathematics in Ireland is noteworthy, as students scoring at the 75th, 90th and 95th percentiles achieved scores that were significantly below the corresponding OECD country average scores. This suggests that any forthcoming review of mathematics at post-primary level should include a consideration of these outcomes, with a view to identifying ways in which performance of high achievers might be enhanced. It is likely that enhancement could be enabled within the structure of existing syllabi/examinations, by providing opportunities for higher-achieving students to demonstrate their abilities on problems that are more strongly embedded in real-life contexts, and recognising their achievements on such work. In addition, wider access to opportunities at Senior Cycle level that would engage higher-achieving students in more in-depth application and problem solving around mathematical concepts they have acquired, while rewarding them academically for doing so, might merit consideration.

[21] The framework for PISA mathematics is grounded in the Realistic Mathematics Education movement.

5. *Performance of low achievers in mathematics.* The observations that 16.8% of all students in Ireland, and 21.9% of students taking the Junior Certificate mathematics examination at Ordinary level, score at or below Level 1 on the PISA mathematics proficiency scale, are matters of concern. It would be worth investigating if the performance of lower-achieving students could be enhanced by providing them with learning experiences in which conceptual understanding is more strongly emphasised, and relationships between mathematics knowledge and real-life applications are more obvious.

6. *Gender differences in mathematics.* Male students in Ireland achieved a mean score on combined mathematics that was significantly higher (by 14.8 points, or one-sixth of a standard deviation) than that of females. Gender differences favouring males were also observed on the four mathematics subdomains, with the largest occurring for Space & Shape scale (25.5 score points; over a quarter of a standard deviation). These differences contrast with those found for all students taking the Junior Certificate mathematics examination in 2003, where females outperform males by about one-half of a grade (one-sixth of a standard deviation). Further investigation of these differences might consider associations between gender and performance on different problem types (including those that call for spatial reasoning), as well as the differing risk-levels that male and female students may adopt in responding to PISA-type problems in a low-stakes assessment context.

7. *Self-efficacy in mathematics and anxiety about mathematics.* Similar to other participating countries, male students in Ireland reported higher self-efficacy in mathematics (confidence in their ability to solve mathematics problems) and lower anxiety about mathematics than females. However, interpretation of the associations of these variables with achievement in mathematics is complex as the data on self-efficacy are based on students' ratings of their confidence in their ability to solve specific mathematics items, and the questionnaire items on self-efficacy and anxiety were administered immediately after students had completed the PISA mathematics assessment. Since self-efficacy and anxiety may affect and be affected by students' current mathematics performance, they may be outcomes of schooling rather than explanatory variables.

8. *Concepts underlying PISA and Junior Certificate Mathematics.* The test curriculum rating project conducted in conjunction with the Irish analysis of PISA 2003 showed that students in Ireland were expected to be very familiar or familiar with the mathematical concepts underlying between 48.3% and 69.4% of PISA items (depending on the syllabus level taken). This suggests that any future review of mathematics at post-primary level should consider if important mathematical content is being omitted. Again, any debate around the differences between PISA and Junior Certificate mathematics would need to recognise that there are important elements of the Junior Certificate mathematics syllabus that are not assessed by PISA (e.g., sets, geometry and trigonometry), that some PISA concepts (e.g., probability) only appear on mathematics syllabi at Senior Cycle level and that students may acquire mathematical concepts outside of mathematics classes.

9. *Context in PISA and Junior Certificate mathematics items.* The test curriculum rating project showed that students in Ireland were expected to be very familiar or familiar with just 20.0% to 34.1% of the contexts in which PISA mathematics items were embedded. Any forthcoming review of mathematics at post-primary level might consider whether greater attention should be paid to interpreting and solving mathematics problems embedded in realistic contexts across different mathematics topics (described as 'horizontal mathematisation' in Realistic Mathematics Education), and how the teaching and assessment of mathematics might be affected by such a change.

10. *Between-school variation in achievement in mathematics.* In Ireland, just 16.7% of the variation in mathematics achievement is attributable to differences between schools. This indicates

that, relative to many other countries, schools tend to be more alike in mathematics achievement. This may be partly attributed to relatively homogeneous composition of the school-going population in Ireland. Most 15-year olds progress through the educational system with minimal grade repetition, and, unlike their counterparts in a number of countries, do not choose between academic and vocational programmes at an early stage.

11. *Implementation of the revised Junior Certificate mathematics syllabus.* The finding that the mean mathematics performance of students in Ireland in 2000 and 2003 is not significantly different may suggest that the revised Junior Certificate mathematics syllabus (implemented in 2000, for first examination in 2003) has not yet had the expected impact, even though it is intended that there is a stronger emphasis on relational understanding and problem solving than before. A comparison of the PISA mathematics items and items presented on the revised Junior Certificate mathematics examination papers indicate large differences in the manner in which mathematics is presented; perhaps the intended increase in emphasis on relational understanding and problem solving is not yet sufficiently evident in what is actually assessed in Junior Certificate mathematics. However, implementation may take longer than three years to have a significant impact on achievement. The increased use of calculators by students in Ireland in PISA 2003 provides some evidence of implementation.

Reading

12. *Overall performance in reading.* Just three countries in PISA 2003 (Finland, Korea and Canada) had significantly higher mean scores in reading than Ireland, while Ireland's mean score was well above the OECD country average. This indicates that, despite having a slightly lower mean score than in 2000, Ireland is still among the highest-performing countries in PISA reading literacy.

13. P*erformance in reading in 2000 and 2003.* Reading is the only PISA domain in which a difference in the performance of students in Ireland was observed between 2000 and 2003. The mean score was significantly lower in 2003 than in 2000, while the scores of students at the 75th, 90th and 95th percentile points in Ireland were also significantly lower. No differences were observed in the performance of students in Ireland scoring at the 5th, 10th or 25th percentiles. It is recommended that caution be exercised in any interpretation of these changes until additional data, gathered over a longer period of time, become available.

14. *Gender differences in reading.* Female students in Ireland achieved a mean score in PISA reading that was 29.0 points (one-third of a standard deviation) higher than that of males. The difference in favour of female students in PISA on the Junior Certificate Examination was almost one grade point (two-fifths of a standard deviation). There is a need to further examine the combination of variables corresponding to gender differences in English / reading on both PISA and the Junior Certificate, including socioeconomic status, motivation to read, and reading habits, before interventions can be designed to align the performance of males and females (a challenge faced by most countries participating in PISA).

15. *Low achievers in reading.* In both 2000 and 2003, approximately 11% of students in Ireland achieved at or below Level 1 in reading. Although lower than the OECD country average percentage in both years, the finding suggests that progress in reducing the proportion of students in schools who have reading difficulties has been limited. Given the importance of reading for the personal development of individuals, as well as for their educational and occupational opportunities, carefully monitored programmes targeted at schools and individuals should continue to be developed and implemented, with the objective of reducing the proportion of students with reading difficulties in the system.

Science

16. *Overall performance on science.* The mean score of Irish students in PISA 2003 science was significantly higher than the OECD country average, though the gap between Ireland's mean score and those of the highest-scoring countries (Finland, Japan, Hong-Kong China, and Korea) was considerable. More detailed information on performance in science will become available in 2006, when science becomes a major assessment domain in PISA.

17. *Study of science.* As in PISA 2000, students in PISA 2003 who reported that they did not study science as a subject for the Junior Certificate Examination (5.2% of males, 14.6% of females, 9.9% of all students) achieved a mean score that was lower by 69.7 points (four-fifths of a standard deviation) than that of students taking science as a subject. Although students not taking science also performed less well in mathematics and reading than those who did take the subject, it would seem important that all First-year students, and especially females, are well informed about the benefits of choosing science as a subject (for example, by providing short 'taster' courses in science). It would also seem important to make efforts to develop the scientific knowledge of all Junior Cycle students, although it may not be necessary for all of them to take the science in the Junior Certificate Examination to accomplish this.

18. *Gender differences in science.* Whereas the mean scores of male and female students in PISA science are not significantly different when looked at in isolation, a significant difference of 7.6 points (just under one-tenth of a standard deviation) in favour of male students was observed when the contributions of a range of factors performance were considered simultaneously. This finding differs from the finding relating to science in the Junior Certificate Examination. Females taking the examination in 2003 scored about half a grade point (a quarter of a standard deviation) higher. This difference should be examined further to ascertain if it arises for methodological (e.g., the use of simulated scores for pupils who did not take the PISA science assessment) or other reasons.

19. *Performance of high achievers in science.* Although overall performance on PISA science was significantly above the OECD country average, Irish students scoring at the 90th and 95th percentiles achieved scores that were significantly below the corresponding OECD country averages. This is consistent with the comparatively low performance of higher achievers in mathematics, and with the decline in performance among higher achievers in reading between 2000 and 2003. It further reinforces the need to investigate ways to extend the knowledge and skills of the highest performers in schools in Ireland.

Cross-Curricular Problem Solving

20. *Overall performance on cross-curricular problem solving.* The mean score of Irish students on cross-curricular problem solving was not significantly different from the OECD country average. As in mathematics, the scores of Irish students at the 75th, 90th and 95th percentiles were below the corresponding OECD country average scores, while those at the 5th, 10th and 25th percentiles were above the corresponding OECD average scores.

21. *Problem solving and combined mathematics.* There are quite strong correlations among the four domains assessed in PISA 2003. The correlation between problem solving and combined mathematics for students in Ireland is .90, indicating that a large amount of variation in each assessment is shared. This is noteworthy, since it was intended that the two assessments would be distinct from one another, at least in terms of underlying content. The strong correlation between mathematics and problem solving suggests that, despite differences in content, they may share some of the same underlying cognitive processes.

School-Level Variables

22. *School socioeconomic status and performance.* The multilevel models of achievement in mathematics, reading and science highlight the contributions of individual- and school-level socioeconomic status to achievement. The level of disadvantage associated with the school that a student attends (based on the percentage of students who are entitled to a Junior Certificate Examination fee waiver) was found to have a significant association with achievement in combined mathematics, reading and science, even after adjusting for other school and student variables, including student socioeconomic status. This finding justifies current efforts to address low achievement in schools with large numbers of disadvantaged students.

23. *School disciplinary climate and performance.* After adjusting for the effects of other school- and student-level variables, students in schools with a high positive average disciplinary climate (as rated by the students themselves) had higher expected mean scores in all assessment domains than their counterparts with medium and low levels. Further, the correlation between school-level socioeconomic status and disciplinary climate is weak, indicating that school disciplinary climate is independent of school socioeconomic status. These findings suggest that the nature of the disciplinary climate in mathematics lessons might be examined further, to ascertain if there are ways in which learning environments could be better structured to support student learning. It would also be useful to ascertain why school-level disciplinary climate in mathematics also explains achievement in reading and science.

Student-Level Variables

24. *Lone-parent status and performance.* Even after adjusting for other relevant variables, lone-parent status made a negative contribution to achievement in combined mathematics, reading and science (e.g., 15.7 points or one-sixth of a standard deviation for mathematics). This indicates that students in lone-parent families are particularly at risk of low achievement, and might be the focus of interventions that take their needs and the needs of their parents into account. The finding that the achievement gap in mathematics between students in lone-parent and dual-parent families is larger than that of Ireland in only two countries in PISA 2003 suggests that students in lone-parent families in Ireland may be particularly at risk in comparative terms.

25. *Absenteeism and performance.* The multilevel models of achievement reinforce the benefits of regular attendance at school. Student attendance was significantly related to achievement in reading and science. In mathematics, there was an interaction between attendance and the index of books in the home. Students who were absent for three or more days and who had few books in the home had the lowest fitted scores.

26. *Home educational processes and performance.* In addition to confirming the effects of student socioeconomic status on achievement, the multilevel models of achievement reported here confirm the contribution of the number of books in a student's home and the availability of home educational resources to achievement in reading, mathematics and science. While these variables can be interpreted as measures of the educational environment in the home, it would be useful to unpack them further, with a view to identifying specific ways in which parents might be encouraged to support their children's learning at home.

LOOKING AHEAD TO PISA 2006

The next PISA assessment is scheduled to take place in 2006. The assessment offers important opportunities to extend knowledge about the performance of 15-year-olds in Ireland and in other countries. First, it will offer a second opportunity to examine changes in achievement in mathematics, reading and science, allowing for more confident interpretations to be drawn, as methodologies become more refined. Second, science will become the major focus of the assessment, allowing an in-depth examination of students' achievements across a wider range of content areas than has been possible in either 2000 or 2003, together with the opportunity to describe student achievements along proficiency levels similar to those which already exist for mathematics and reading. It will also allow for comparisons of student performance along a number of distinct science themes. Third, PISA 2006 coincides with the first examination of the revised Junior Certificate science syllabus and will be particularly useful in aiding the exploration of issues surrounding its implementation. To this end, a detailed investigation of the revised curriculum compared to PISA, similar to the one that was carried out for mathematics, is planned, while it is also planned to ask teachers about syllabus implementation. Fourth, an international optional computer-based assessment of science may be implemented in some participating countries, including Ireland. It is envisaged that the computer-based assessment will add value to the paper-and-pencil assessment by allowing for the assessment of skills in a more dynamic and interactive environment. However, the success of the computer-based assessment and the form it will take for 2006 will only be decided following the analysis of the pilot data after the field trial in March 2005. Finally, the inclusion of attitudinal items, which assess student interest in science, their support for scientific research, and their sense of responsibility towards environmental and other concerns in the test booklets alongside the test items, will represent a novel way of assessing attitudes to science. However, as with the computer-based assessment, the final design of these items has yet to be decided.

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Appendix 1

Sample Tasks, Texts, and Item Statistics for Mathematics and Problem Solving

INTERPRETING THE TABLES IN APPENDIX 1

Sample tasks and items for mathematics and problem solving have been adapted from the OECD's initial reports for PISA 2003 (OECD, 2004a, 2004b). For reasons of space, the layout has been compacted somewhat and is not identical to that which students were presented with in the test booklets. For each item, the information under 'PISA Item Difficulty' gives the IRT scale score that represents the location of the item on the relevant achievement scale (in terms of average performance of a fixed number of students drawn from each OECD country). Both scales have a mean of 500.0 and a standard deviation of 100.0. Item difficulties are also reported in terms of the proficiency levels at which they are located.

Additional item statistics are presented in this appendix, including the OECD percentage correct score and the weighted percentage of Irish students providing a correct response, the percentages giving an incorrect response, and the percentages not responding.

The reader is referred to the item maps in Chapter 3 (Figure 3.1), Chapter 4 (Figures 4.1 and 4.2) and Chapter 8 (Figure 8.1) for examples of where items are located along the student achievement and proficiency scales.

Example Interpretation

In the sample mathematics item Exports Question 1, the item difficulty across OECD countries is 426.3 points. Therefore, the item is located about three-quarters of a standard deviation below the OECD mean of 500.0. Further, since the item is between 420.1 and 482.4 on the combined mathematics scale, the item is at proficiency Level 2. The OECD average percentage correct for the item is 78.7%, while, in Ireland it is higher at 85.4%. The OECD average 'missingness' for the item is 7.5%, while in Ireland it is lower, at 1.8%.

FURTHER SAMPLE TASKS

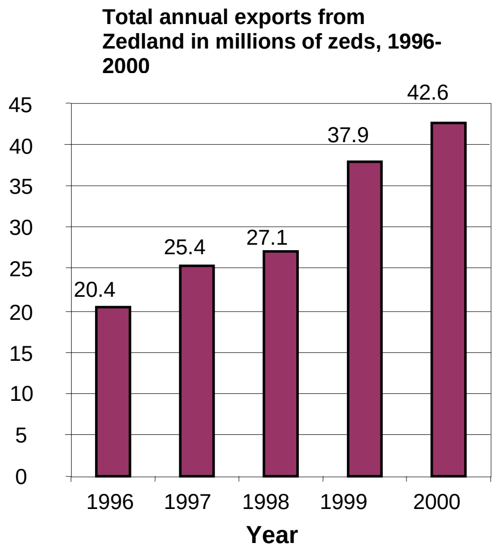
As no new items for reading or science were released following the PISA 2003 assessment, sample items for these domains were drawn from a pool of items released following the 2000 assessment. A more detailed and comprehensive appendix, which includes a larger number of sample items from all four domains, is available at http://www.erc.ie/pisa and readers are also referred to OECD (2001), Shiel et al. (2001) and Cosgrove et al. (2003).

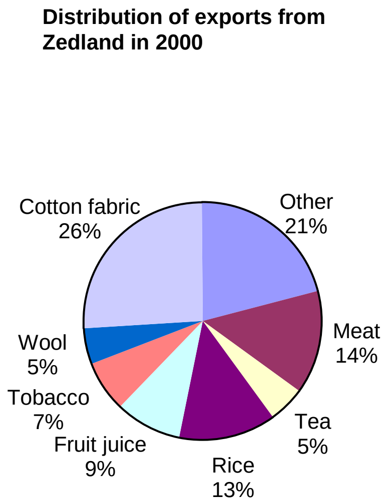
MATHEMATICS

UNIT: EXPORTS

Context: *Public.*

The graphics below show information about exports from Zedland, a country that uses zeds as its currency.





EXPORTS QUESTION 1 *(Item Code: M438Q01)*

Domain: *Uncertainty*. **Item type**: *Closed constructed response.*

What was the total value (in millions of zeds) of exports from Zedland in 1998?

Key: *Full credit*: 27.1 million zeds or 27 100 000 zeds or 27.1 (unit not required), accept also rounding to 27; *no credit*: Other responses.
Process: *Reproduction*. Follow the written instructions, decide which of the two graphs is relevant, and locate the correct information in that graph.

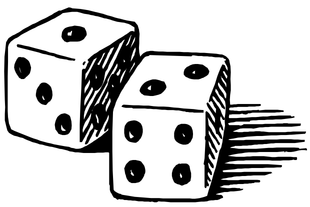
PISA Item Difficulty
Scale score
426.3
Level
2

Item statistics	% OECD	% Ireland
Correct	78.7	85.4
Incorrect	13.8	12.8
Missing	7.5	1.8
Total	100	100

UNIT: NUMBER CUBES

Context: *Personal.*

On the right, there is a picture of two dice. Dice are special number cubes for which the following rule applies: The total number of dots on two opposite faces is always seven. You can make a simple number cube by cutting, folding and gluing cardboard. This can be done in many ways.

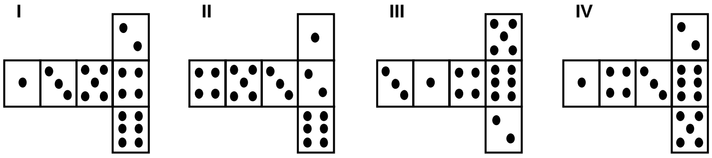


NUMBER CUBES QUESTION 2 *(Item Code: M555Q02)*

Domain: *Space & Shape.* **Item type**: *Complex multiple choice.*

In the figure below you can see four cuttings that can be used to make cubes, with dots on the sides.

Which of the following shapes can be folded together to form a cube that obeys the rule that the sum of opposite faces is 7? For each shape, circle either "Yes" or "No" in the table below.



Shape	Obeys the rule that the sum of opposite faces is 7?
I	Yes / No
II	Yes / No
III	Yes / No
IV	Yes / No

Key: *Full credit*: No, yes, yes, and no, in that order; *no credit*: Other responses, missing.
Process: *Connections.* Encode and interpret 2-dimensional objects, interpret the connected 3-dimensional object, and check certain basic computational relations.

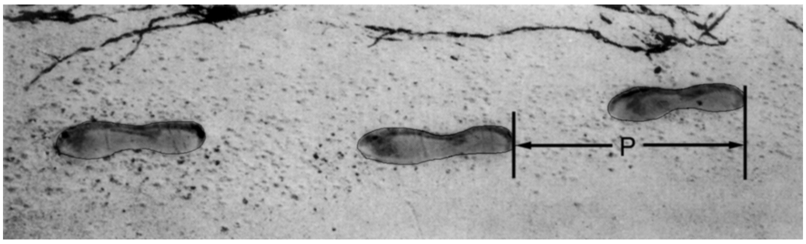
PISA Item Difficulty
Scale score
503.5
Level
3

Item statistics	% OECD	% Ireland
Fully correct	63.0	57.4
Incorrect	34.7	40.9
Missing	2.3	1.7
Total	100	100

N. corr. responses	% OECD	% Ireland
0	2.7	3.1
1	7.2	8.9
2	8.9	8.2
3	16.0	20.7
4	63.0	57.4
Missing	2.3	1.7

UNIT: WALKING

Context: *Personal.*



The picture shows the footprints of a man walking. The pace length P is the distance between the rear of two consecutive footprints. For men, the formula $n/P = 140$ gives an approximate relationship between n and P where n = number of steps per minute and P = pace length in metres.

WALKING QUESTION 1 *(Item Code: M124Q01)*

Domain: *Change & Relationships.* **Item type**: *Open constructed response.*

If the formula applies to Mark's walking and Mark takes 70 steps per minute, what is Mark's pace length? Show your work.

Key: *Full credit*: 0.5 m or 50 cm, ½ (unit not required). $70/p = 140$, $70 = 140p$, $p = 0.5$. $70/140$; *no credit*: Other responses, missing.
Process: *Reproduction.* Reflect on and realise the embedded mathematics, solve the problem successfully through substitution in a simple formula, and carry out a routine formula.

PISA Item Difficulty
Scale score
611.0
Level
5

Item statistics	% OECD	% Ireland
Correct	36.3	22.9
Incorrect	42.7	62.8
Missing	21.0	14.3
Total	100	100

PROBLEM SOLVING

UNIT: IRRIGATION

Problem type: *Trouble shooting.*

Below is a diagram of a system of irrigation channels for watering sections of crops. The gates A to H can be opened and closed to let the water go where it is needed. When a gate is closed no water can pass through it.

This is a problem about finding a gate which is stuck closed, preventing water from flowing through the system of channels.

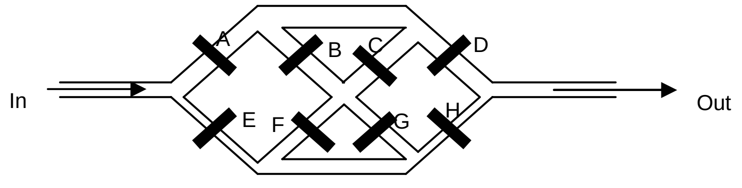


Figure 1: A system of irrigation channels

Michael notices that the water is not always going where it is supposed to. He thinks that one of the gates is stuck closed, so that when it is switched to "open", it does not open.

IRRIGATION QUESTION 1 *(Item Code: X603Q01)*

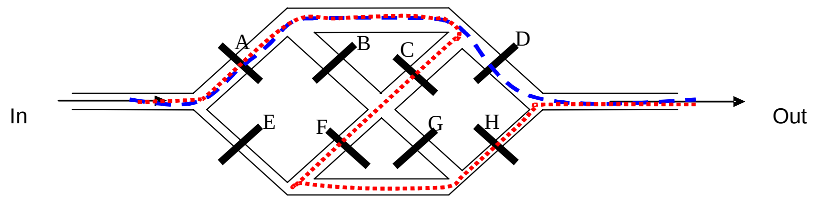
Item type: *Open constructed response.*

Michael uses the settings given in Table 1 to test the gates.

Table 1: Gate Settings

A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Open	Closed	Open	Open	Closed	Open	Closed	Open

When the gates are set as shown in Table 1, **on the diagram below** draw all the possible paths for the flow of water. Assume that all gates are working according to the settings.



Key: *Full credit:* Flow paths as shown above: Ignore any indications of the directions of flow; the response could be shown in the diagram provided, or in figure 1, or in words, or with arrows; *no credit:* Other responses, missing.
Process: Not classified by process.

PISA Item Difficulty
Scale score
497.2
Level
1

Item statistics	% OECD	% Ireland
Correct	47.1	45.9
Incorrect	50.2	52.3
Missing	2.7	1.8
Total	100	100