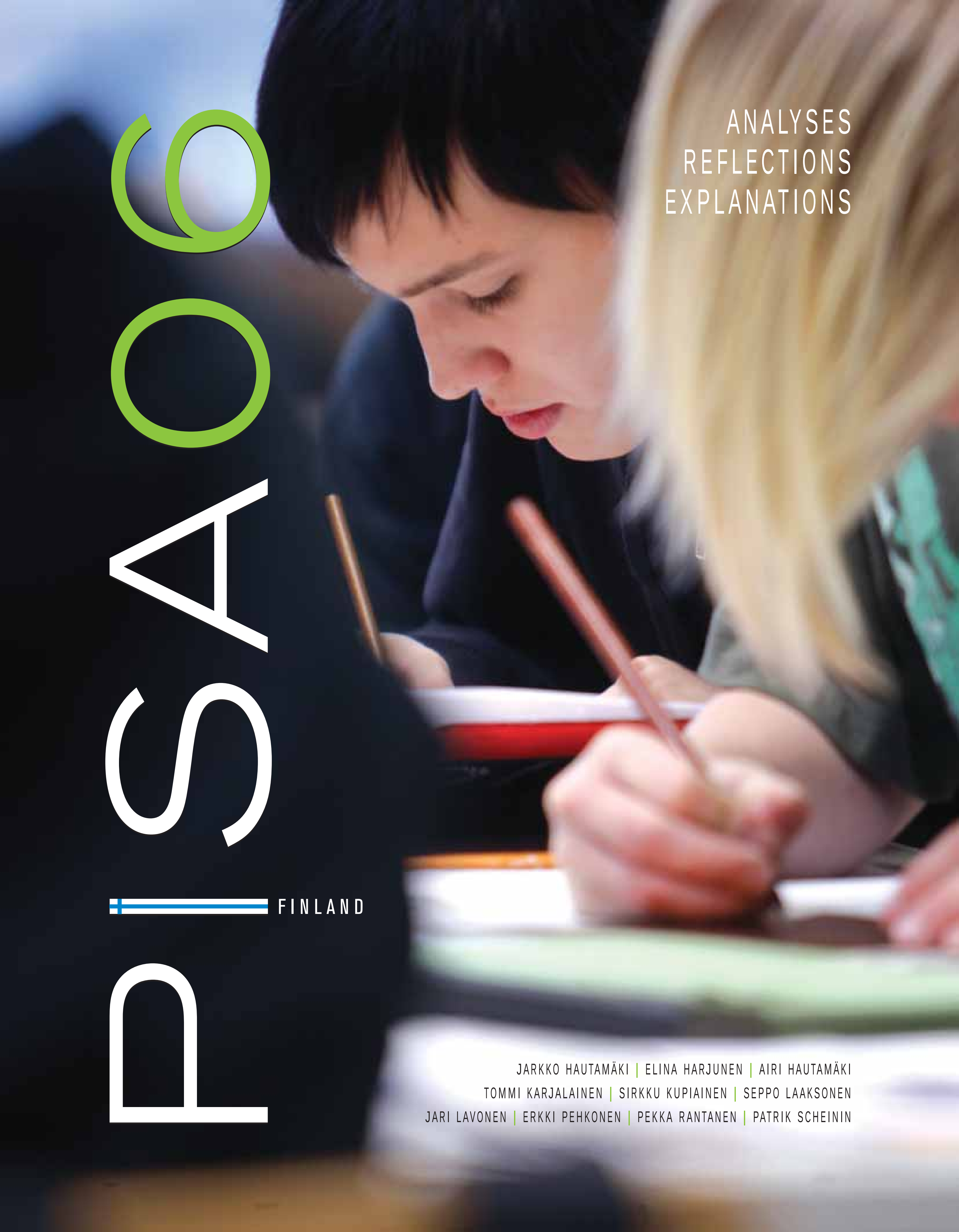

PISA06

FINLAND

ANALYSES
REFLECTIONS
EXPLANATIONS

JARKKO HAUTAMÄKI | ELINA HARJUNEN | AIRI HAUTAMÄKI
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PISA06 FINLAND

ANALYSES, REFLECTIONS AND EXPLANATIONS

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with Irmeli Halinen and Ritva Jakku-Sihvonen

OECD PISA

Opetusministeriö
Undervisningsministeriet
Ministry of Education
Ministère de l'Education

UNIVERSITY OF HELSINKI

CENTRE FOR
EDUCATIONAL ASSESSMENT

Foreword

Sari Sarkomaa
Minister of Education and Science

PISA 2006 Finland - analyses, reflections and explanations provides an introduction to the Finnish educational system. The intention is to open up the Finnish educational system for those who wish to understand what OECD's Programme for International Student Assessment (PISA) tells about Finnish schooling. How can the data be used for educational debates, and for interpreting the Finnish results?

The foundations for Finnish comprehensive school were laid with great expectations. The Programme for International Student Assessment can be used as an international tool for testing these underpinnings. It turns out that several different pathways to achieving good results can be depicted. The real issue deals with which measures and ideologies to accept: how should student variation be treated and mastered, within unified or parallel systems of schooling? This issue has a moral aspect, which has been recognised at the core of Finnish educational policy in comprehensive education. We call it, in Finland, education for all, and have established a unified and comprehensive schooling system to benefit person, family, country and mankind.

Finland has taken part in all three PISA cycles, in 2000, in 2003 and, latest, in 2006. Finland has, indeed, participated with honour and glory. Finland was taken with surprise in 2001, when the results of the first cycle appeared, we were waiting with excitement for 2003 results, and we were almost sure in 2006 that the results would not be bad. And they were not! The outcomes were good and even excellent. Due to this chain of good results, cycle after cycle, an interest toward Finland has increased. Experts of schooling have visited Finland to learn how education can be also organised. We have been happy to show, but slow to know all the reasons. But, again happily, these visitors have also shown the importance of sharing views and experiences. Understanding a foreign country deepens the understanding of one's own system, which is a necessary condition for exchanging ideas, experiences and results.

It is in compulsory schooling that young people gain the attitudes, knowledge and skills for subsequent learning. This is why it is our aim to develop basic education to meet the needs of different learners and to redouble our efforts to enhance children's and young people's well-being. Important means to this end are the teacher's time for the pupil and cooperation with parents, the school community and the children's immediate community.

We must turn our eyes forwards and see to the prerequisites of quality education and to its development also in the future. It is no exaggeration to say that the future of Finland is created through innovative teaching in basic and early childhood education. Basic education has been a Finnish success story. Holding on to this success story and taking it forward is one of my most important tasks as Minister of Education and Science. Prospects for maintaining our position at the top are good: education is greatly valued in Finland and we have highly educated, competent and motivated teachers. Investment in knowledge, education and culture is the best futures policy. To economise on education now would be to undermine Finland's future opportunities, because in the school tomorrow is here today.

Schooling is a social innovation with a long history and an important future. I hope that this book will be found useful for people wanting to know educational solutions in Europe and in the world, in a time when schooling is evermore important. Finnish education is a part of the Finnish national innovation system, which, I believe, will be found functional also in the future, when Finland is facing the demands of the future knowledge society.

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Finland did very well in the PISA 2006 assessment.

But how to explain an outlier?

1
PISA Results from 2000 through 2006

In Chapter 1 we present a number of the PISA outcomes. However, very little interpretation is given here, as explanations are given in later chapters. The purpose of this chapter is to give a summary of the results so as to provide the reader with a sound basis on which to understand the further chapters. The sources for the tables and figures are the two published OECD PISA 2006 books (OECD 2007a, 2007b). Some of the information is repeated in chapters devoted to the results in science, math and reading.

Trends in PISA from the Finnish perspective

Finland's PISA achievements from 2000 through 2006 are presented in Table 1.1.

More detailed summaries of results are presented in waves: first, by using a set of Finland and OECD means, second, by presenting from all three PISA assessments the five best countries' mean scores, and then finally, by presenting the mean results of all OECD countries for all three PISA assessments.

In Table 1.2, we present PISA results from 2000 through 2006 in the three major proficiency areas of mathematics, reading and science for Finland and OECD. Also change scores (2006 – 2000) are calculated.

A complementary way is to look at the best performing countries through all the three measurement occasions. The best five countries throughout years 2000 – 2006 are presented in Table 1.3 Finland is highlighted in bold.

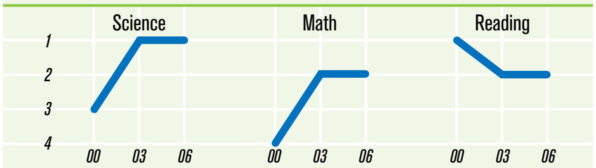
The third presentation is given in Figures 1.1–1.3 (1 for science, 2 for mathematics and 3 for reading). The comparability of the different PISA assessment scores are taken into account. For science, the previous PISA 2000 and PISA 2003 are not comparable to scores of PISA 2006 science, due to a low number of anchor items. For mathematics, the years 2003 and 2006 can be compared. For reading, all three measuring occasions can be used for comparisons. Only OECD countries which took part in the first assessment are included in these figures.

It can be clearly seen that the Finnish results are very good and that the Finnish comprehensive school is performing well.

Excellence

Pisa results are presented in several ways in the major reports (OECD 2007a, 2007b). In this section we present the results, first, by using PISA proficiency levels in science, math and reading, and, second, by using percentiles. The descriptions of the proficiency level and percentiles will be repeated in chapters devoted to PISA science (Chapter 5), PISA mathematics (Chapter 6) and PISA reading (Chapter 7).

T 1.1 | Relative standing of Finland in PISA2000, PISA2003 and PISA2006



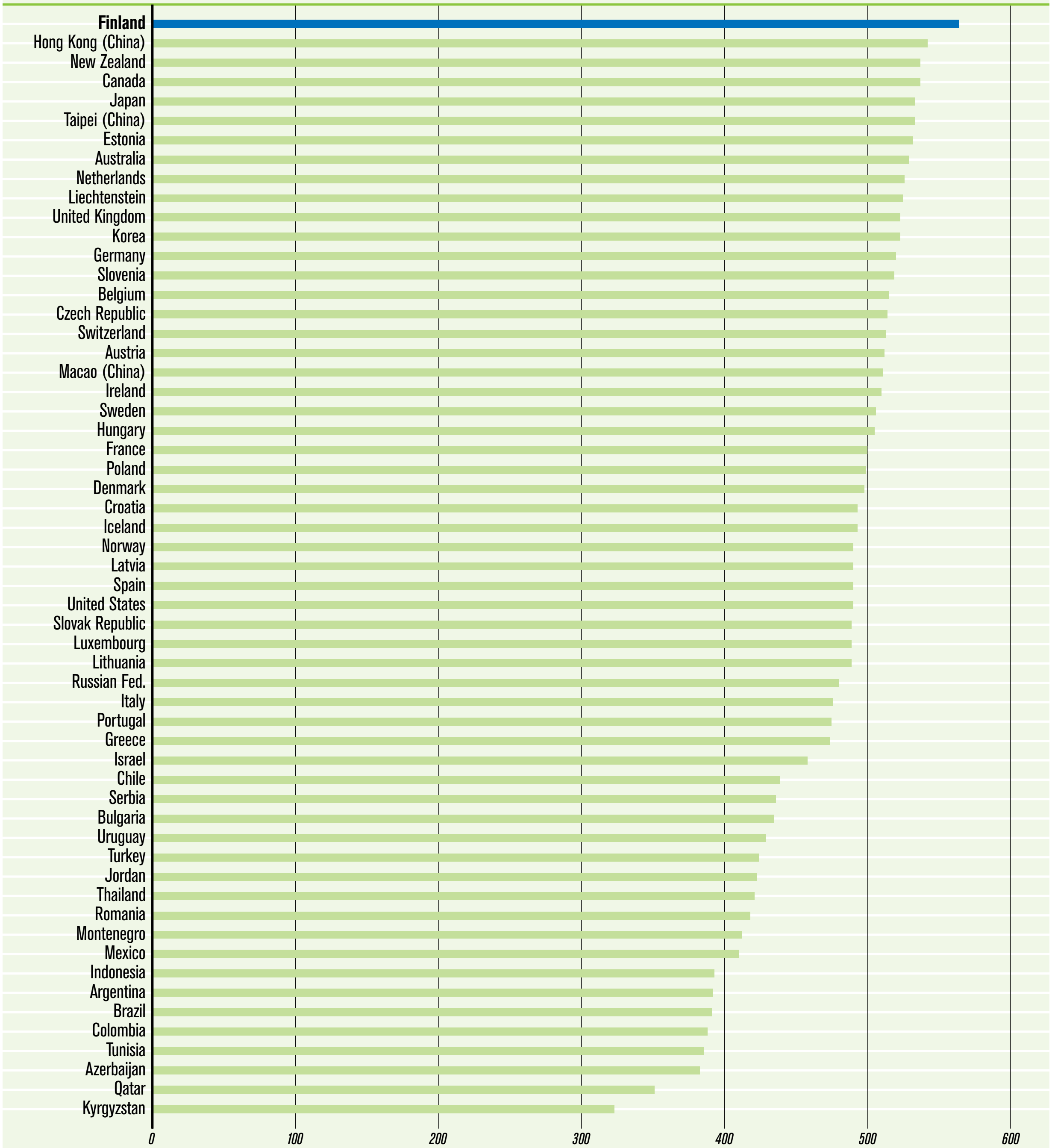
T 1.2 | Trends in PISA achievement from PISA 2000 through 2006 in three proficiency areas

		2000	*2003*	*2006*	*Change*
SCIENCE	Finland	538	548	563	25
	OECD			500	
MATH	Finland	536	544	548	12
	OECD		500	498	
READING	Finland	546	543	547	1
	OECD	500	494	492	

T 1.3 | Five best countries in PISA from PISA 2000 through 2006

2000	*2003*	*2006*
MATH	MATH	MATH
Japan 557	Hong Kong (China) 550	Taipei (China) 549
Korea 547	**Finland** 544	**Finland** 548
New Zealand 537	Korea 542	Hong Kong (China) / Korea 547
Finland 536	Netherlands 538	Netherlands 531
Australia 533	Liechtenstein 536	Switzerland 530
READING	READING	READING
Finland 546	**Finland** 543	Korea 556
Canada 534	Korea 534	**Finland** 547
New Zealand 529	Canada 528	Hong Kong 536
Australia 528	Australia / Liechtenstein 525	Canada 527
Ireland 527	New Zealand 522	New Zealand 521
SCIENCE	SCIENCE	SCIENCE
Korea 552	**Finland** / Japan 548	**Finland** 563
Japan 550	Hong Kong (China) 539	Hong Kong (China) 542
Finland 538	Korea 538	Canada 534
England 532	Australia / Liechtenstein / Macao 525	Taipei (China) 532
Canada 529	Netherlands 524	Estonia / Japan 531

F 1.1 | PISA science means for all PISA countries (2006)



F 1.2 | PISA math means for OECD countries (2003, 2006)

T 1.4 | The proficiency levels (highest cut-off points) in PISA science, PISA mathematics, and PISA reading

	<1	1	2	3	4	5	6
Science	<334	410	484	559	633	710	>710
Math	<358	420	482	545	607	669	>669
Reading	<335	407	480	553	626	>626	

Proficiency levels

In order to assist with the formulation of educational policy implications the outcomes are also described using PISA proficiency levels. These levels consist of either six or seven levels, from below 1 to the highest one, six for science and math, and five for reading. The proficiency levels aim to provide theoretical or criterion referenced models of performance. The proficiency level description claims that the modern knowledge society requires all students to perform at least at Level 2 or above. This claim makes it possible to have a tentative index for the potential for becoming one of the winners in the new knowledge driven society. The cut-off points for proficiency levels are given in Table 1.4.

F 1.3 | PISA reading means for OECD countries (2000, 2003, and 2006)

The distribution of Finnish students in science proficiency levels are given in Figure 1.4. In Finland, 3.9% of students are functioning at the highest proficiency Level 6, New Zealand is even better, and the OECD average is 1.3%. In Finland only 4.1% are below proficiency Level 2, with the OECD average being 19.3%.

In PISA reading, there are five proficiency levels. The Finnish and OECD distributions are presented in Figure 1.5. In proficiency Levels 'below 1' and '1', Finland has 4.8% (OECD about 20%), and in the highest proficiency Level five Finland has 16.7% (OECD 8.6%; Korea 21.7%).

In PISA mathematics there are six proficiency levels. The Finnish and OECD distributions are presented in Figure 1.6. In proficiency Levels 'below 1' and '1', Finland has 5.9% (OECD 21.3%), and in the highest proficiency level Finland has 6.3% (OECD 3.3%; Switzerland 6.8%; Belgium 6.4%).

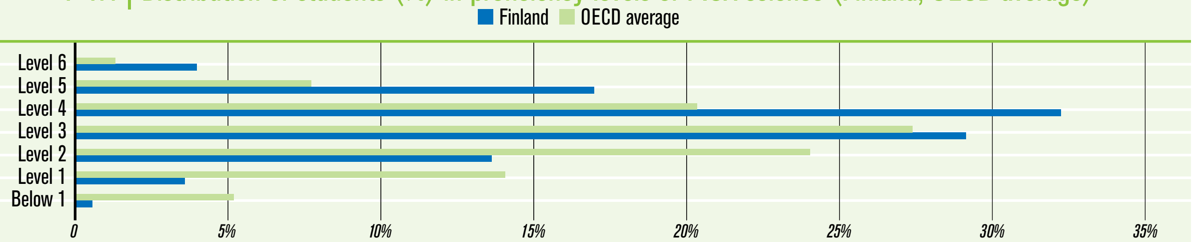
Percentiles

Percentiles are ways to divide a population into ranked subgroups with their respective PISA scale scores. For example, the 25th percentile is the score below which are 25% of the students. In Figure 1.7 the means of Finland and OECD average, for science, are presented for 5th, 10th, 25th, 75th, 90th and 95th percentiles.

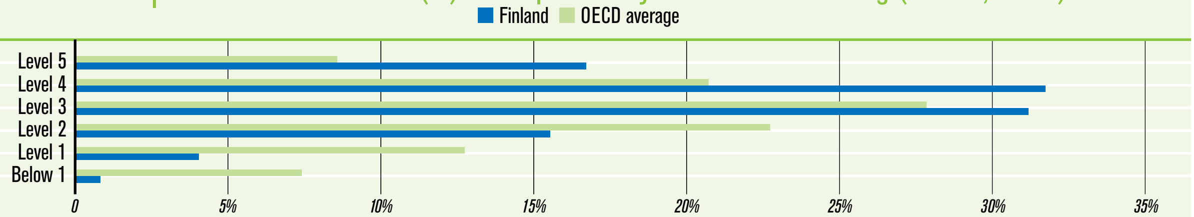
This figure does not express all the details, but shows that Finland is performing well in all percentile groups. In Table 1.5 the distributions of means of the lowest 5th and highest 95th percentile groups of the OECD countries are presented.

The results show that the lowest performing 5% of Finnish students are the best of OECD countries. The results are the same for the highest performing 5% (95th percentile). The PISA science mean for Finland is 700, which is the highest of the highest means.

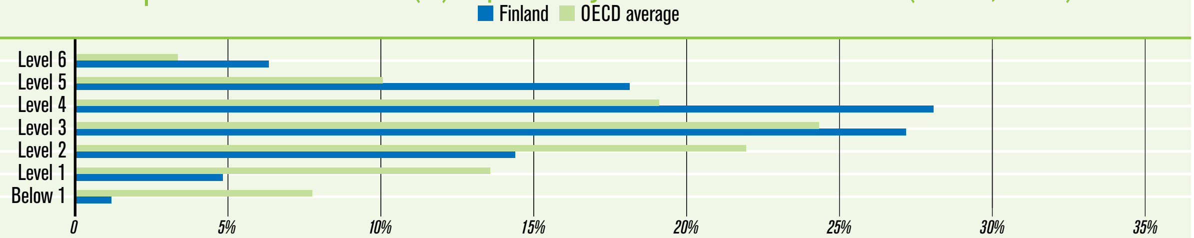
F 1.4 | Distribution of students (%) in proficiency levels of PISA science (Finland, OECD average)



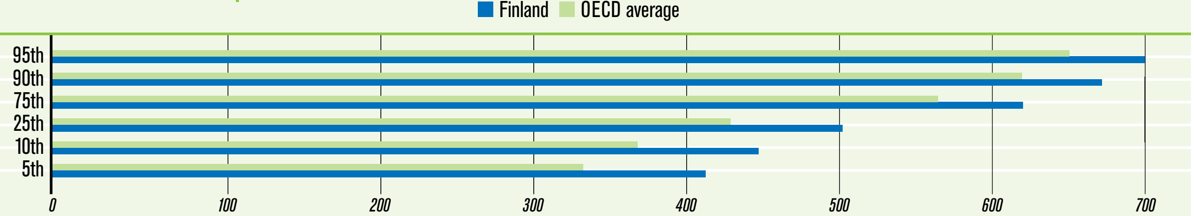
F 1.5 | Distribution of students (%) in the proficiency levels of PISA reading (Finland, OECD)



F 1.6 | Distribution of students (%) in proficiency levels of PISA mathematics (Finland, OECD)



F 1.7 | Means of percentiles for Finland and OECD (average) in PISA science



T 1.5 | The means for the 5th and 95th percentile groups of PISA science, OECD countries in the rank order of mean

	Science 5th		*Science 95th*
Finland	419	**Finland**	700
Canada	372	New Zealand	699
Korea	367	United Kingdom	685
Netherlands	362	Australia	685
Hungary	358	Japan	685
Australia	358	Canada	681
Japan	356	Netherlands	675
Poland	352	Germany	672
Ireland	351	Czech Republic	672
Czech Republic	350	Switzerland	665
New Zealand	347	Austria	663
Sweden	347	Korea	662
Germany	345	United States	662
Austria	341	Ireland	660
Denmark	341	Belgium	660
Switzerland	340	Sweden	654
Spain	338	France	653
United Kingdom	337	Hungary	646
Belgium	336	Denmark	646
Slovak Republic	334	Poland	645
Portugal	329	Iceland	644
Norway	328	Norway	641
Iceland	328	Luxembourg	640
Luxembourg	322	Slovak Republic	638
France	320	Spain	633
United States	318	Italy	630
Italy	318	Greece	619
Greece	317	Portugal	617
Turkey	301	Turkey	575
Mexico	281	Mexico	544

T 1.6 | The means for the 5th and 95th percentile groups of PISA math, OECD countries in the rank order of mean

	Math 5th		*Math 95th*
Finland	411	Korea	694
Korea	392	Switzerland	682
Canada	383	**Finland**	678
Netherlands	382	Belgium	678
Australia	375	Czech Republic	677
Denmark	371	New Zealand	674
Japan	370	Netherlands	672
New Zealand	368	Japan	668
Ireland	366	Canada	664
Switzerland	362	Germany	664
Iceland	357	Australia	663
Sweden	354	Austria	657
Poland	353	Sweden	649
United Kingdom	351	Denmark	649
Hungary	343	Iceland	646
Czech Republic	340	France	646
Germany	339	United Kingdom	643
Norway	339	Hungary	643
Austria	338	Luxembourg	641
Belgium	337	Slovak Republic	640
France	334	Norway	638
Slovak Republic	333	Poland	638
Spain	332	Ireland	634
Luxembourg	332	United States	625
United States	328	Spain	622
Portugal	315	Italy	616
Italy	305	Portugal	612
Greece	304	Greece	607
Turkey	287	Turkey	595
Mexico	268	Mexico	546

T 1.7 | The means for the 5th and 95th percentile groups of PISA reading, OECD countries in the rank order of mean

	Read 5th		*Read 95th*
Finland	410	Korea	688
Korea	399	New Zealand	683
Ireland	358	**Finland**	675
Canada	357	Canada	674
Australia	349	Poland	663
Denmark	339	Ireland	661
New Zealand	339	Sweden	658
Poland	335	Germany	657
Sweden	335	Belgium	657
Netherlands	332	Australia	656
Switzerland	331	Japan	654
Hungary	318	Czech Republic	653
United Kingdom	318	United Kingdom	653
Japan	317	Austria	651
Iceland	314	Netherlands	649
Spain	304	Norway	643
Luxembourg	302	Switzerland	642
Norway	301	France	639
Portugal	299	Iceland	633
Germany	299	Denmark	633
Austria	298	Luxembourg	630
France	298	Slovak Republic	628
Belgium	297	Italy	627
Turkey	291	Hungary	623
Czech Republic	290	Portugal	622
Slovak Republic	281	Greece	613
Italy	276	Spain	594
Greece	272	Turkey	594
Mexico	247	Mexico	559

The conclusion is clear: means for the lowest and highest performing percentiles in PISA science are highest in Finland among the OECD countries, and, according to evidence not presented here, among all participating countries.

The results are almost the same for PISA mathematical literacy and PISA reading literacy. In Table 1.6 the PISA math means for the lowest 5% and highest 5% are presented. In the lowest performing 5% group Finland has the highest mean. In the highest performing 95% group the highest mean is for Taipei (China) and Finland has the 5th position in this rank, or 3rd within OECD.

Table 1.7 presents the same results for PISA reading. In the lowest 5% group Finland has the highest mean. In the best 95% group Korea has the highest mean, whilst Finland has the 3rd highest.

Generally, the conclusion is that in every measured PISA domain Finnish results for the lowest performing 5% are very good and 5%-mean for Finland is highest in all domains. In the best performing 5% Finland is good as well and the mean in science is the highest among PISA countries. Also in reading and math Finland ranks among the best three OECD countries.

Equity

Equity refers to a situation where the learning outcomes are mainly related to the competence and willingness of students to engage with learning. The variation of scores is not due to socio-economic conditions, race or gender, and the educational and social system is not introducing extra differences between children as they enter and go to school. There are three major ways to have a look on equity: how the educational system is able to manage the between student variation, how the variation is distributed within and between schools, and, finally how various contextual and fixed factors influence the outcome, e.g., parents' education, socio-economic status, place of living; gender, race. In this chapter the results of between-student variation and its division into within and between-school components are presented.

F 1.8 | Variation in Student Performance

Between student variation

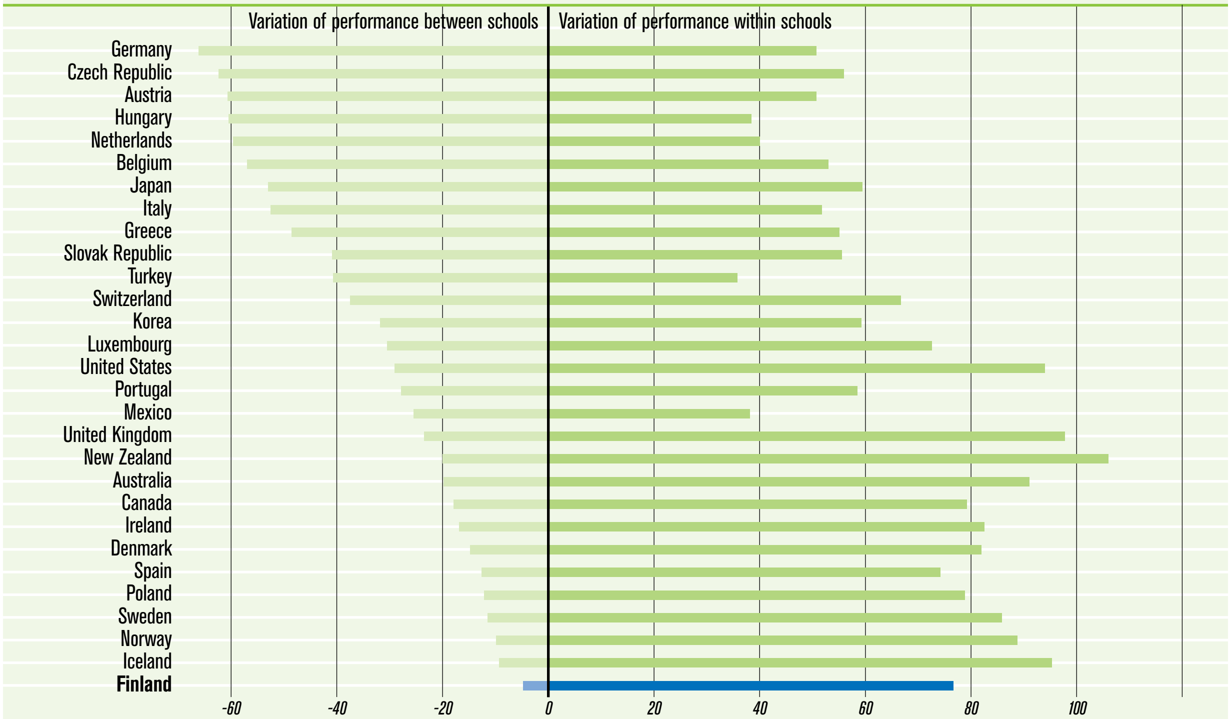
Variation in student science performance is presented in Figure 1.8. In Finland, we have the smallest variation, together with Mexico and Turkey. Thus, Finland has been able to manage very well the variation between pupils, a notorious problem in every educational system.

The student variation can be divided into variation within-schools and between-schools. The results of this decomposing are presented in Figure 1.9. Finland has the smallest between-school variation of all OECD countries. We will return to these issues of variation in a later chapter, as the variation informs about the fairness of the educational system. The parents from different social strata pay for the system, and it should serve all students as well as possible.

The role of socio-economic background is one important index of educational equity balance. The OECD PISA 2006 (OECD 2007a, 2007b) contains several ways to analyse the effects of socio-economic factors. In this connection the results for three aggregate-levels – for students, for students within-schools, and for schools – are presented (Table 1.8). The index is PISA index of economic, social and cultural status of students, ESCS.

There are three different ways to analyse the effects of ESCS: variance explained by the PISA index of economic, social and cultural status of students, variance explained by the PISA index of economic, social and cultural status of students and schools, and variance explained by students' study programmes. The Finnish results when compared to OECD average

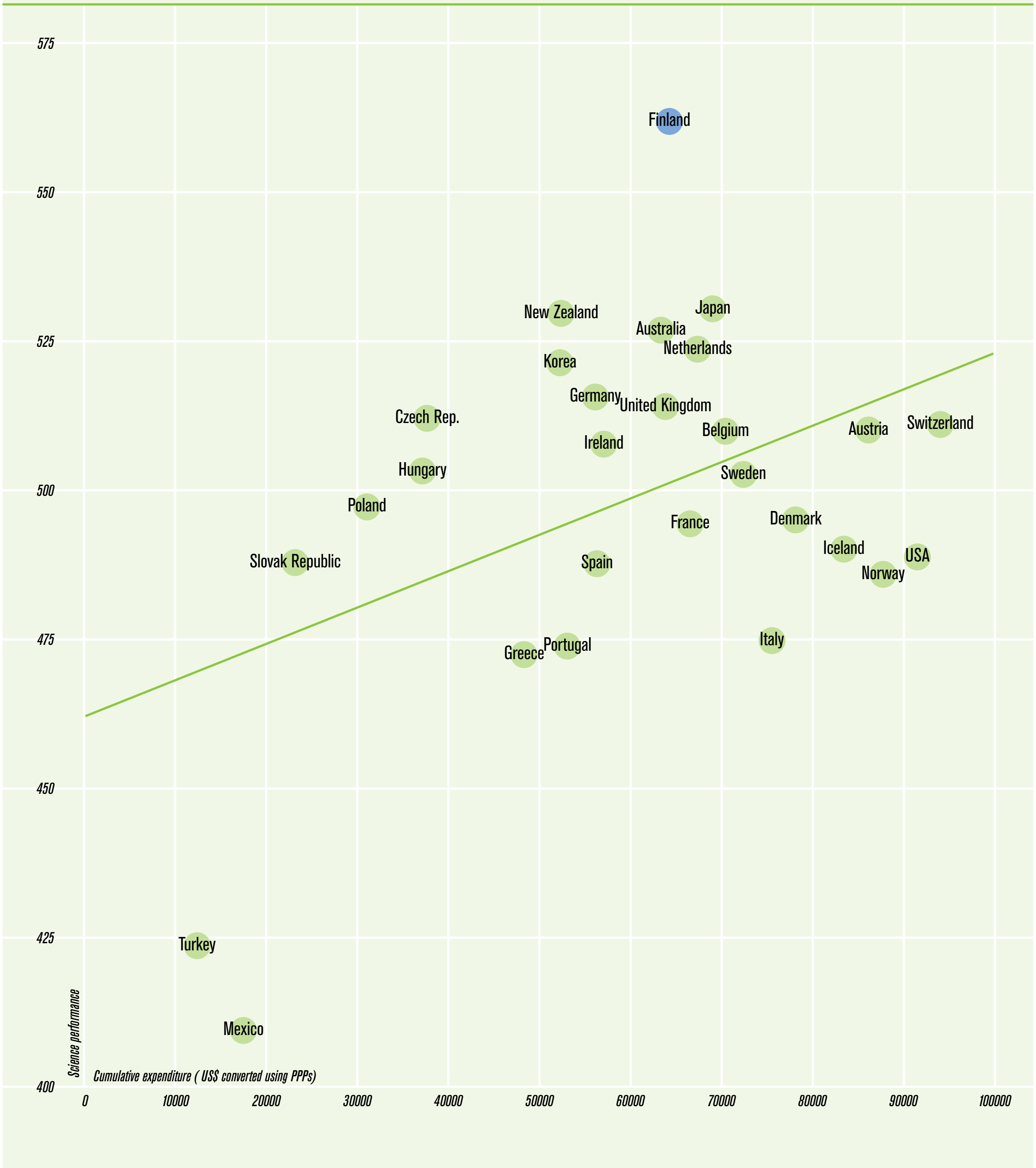
F 1.9 | Student variation divided into between-school and within components



T 1.8 | Variance expressed as a percentage of the average variance in student performance in Finland and OECD average (PISA Table 4.1a)

	Variance explained by the PISA index of economic, social and cultural status of students		Variance explained by the PISA index of economic, social and cultural status of students and schools		Variance explained by students' study programmes	
	Between-school variance explained	Within-school variance explained	Between-school variance explained	Within-school variance explained	Between-school variance explained	Within-school variance explained
Finland	1.2	5.5	1.3	5.5	0.0	0.0
OECD	7.2	3.8	20.5	3.8	17.8	2.8

F 1.10 | Science performance and national expenditure



Sample in Finland

The PISA protocol for sampling is described in details in the technical manual of PISA 2006 and also partly given in the Appendix 3 (PISA 2006 sampling and estimation). The protocol is rigorous and gives a warranty for results. However, in order to orientate to the major results some basics are given here.

In the Tables 1.9 and 1.10, the population of schools and the final sample are given in relation to region and status on the municipality. The table includes information of the proportions of Finnish and Swedish schools, and their location.

In the Table 1.11 the proportions of expected and sampled students are given.

The educational level of a country is an important fact to be remembered when interpreting the good results of PISA of Finland, and also of other countries. The parents' educational levels are given in the Table 1.12 using the international nomenclature for educational levels.

3A is the highest level, referring to higher secondary education. In Finland, about of parents have a completed higher secondary degree, showing the effects of long history of education, and providing a framework for reading the results.

T 1.10 | Total number of schools and number of sampled schools in different regions (school as a unit)

*Region * Status*	*Schools*	*Sampled schools*	*of which Swedish schools*
Metropolitan area Rural	5	2	
Metropolitan area Urban	155	39	1
Southern Finland Rural	75	10	
Southern Finland Urban	159	40	
Eastern Finland Rural	61	9	
Eastern Finland Urban	43	11	
Middle Finland Rural	53	8	1
Middle Finland Urban	53	14	4
Northern Finland Rural	48	5	
Northern Finland Urban	56	13	1
Åland Rural	7	2	2
Åland Urban	2	2	2
Total	717	155	11

T 1.9 | PISA 2006 student sample in Finland (pupil as a unit)

	Rural		*Urban*		
Region	*Female*	*Male*	*Female*	*Male*	*Total*
Metropolitan area	21	19	625	569	1234
Southern FInland	154	148	606	647	1555
Eastern Finland	137	131	173	187	628
Middle Finland	123	121	224	198	666
Northern Finland	78	68	195	187	528
Åland	15	20	34	34	103
Total	528	507	1857	1822	4714
Boys %					50.5
Girls %					49.5

T 1.11 | Percent of eligible students expected in the sample and sampled in different regions, according to status of the municipality

	Rural		*Urban*	
	Expected	*Sampled*	*Expected*	*Sampled*
Metropolitan area	1.3%	0.8%	25.2%	25.3%
Southern FInland	6.5%	6.4%	25.8%	26.6%
Eastern Finland	5.8%	5.7%	7.1%	7.6%
Middle Finland	5.2%	5.2%	9.0%	9.4%
Northern Finland	3.2%	3.1%	8.4%	8.1%
Åland	1.3%	0.7%	1.3%	1.4%
Total	23.2%	21.9%	76.8%	78.4%

T 1.12 | Levels of parents' education in Finnish PISA 2006 sample (%, rounded)

Educational level	*Mother*	*Father*
Completed ISCED 3A	79	72
Completed ISCED 2	9	12
Completed ISCED 1	7	8
Did not complete ISCED 1	1	1
N/A, Missing, Invalid	5	7
Total (%)	100	100

are low, indicating small effects of the status of students and schools. In particular, the study programmes have no effect in Finland, as there is no variation of these during comprehensive school. These results mean that there exists a very good balance of equity of education. In PISA reports there are several other indexes for equity (OECD 2007a, 2007b), but these simply add details, and do not change the outcome.

Toward understanding and explanations

High results – how to explain and understand? In OECD circles, one might say: the more money, the better results. This is the general case, but does not explain Finnish results. That can be seen in Figure 1.10, where the national expenditure is presented in the horizontal axis and PISA performance in the vertical axis: Finland is the exception that does not follow the general pattern. But how to axplain on exception, an odd residual

Given these results, presented only partly in this chapter, the main idea of this book is to offer more detailed descriptions, to proceed towards a better understanding of the Finnish results, and to present the latest set of explanations, from the Finnish perspective in order to form a data informed opinion. Which are the other things that matter?

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Finnish peruskoulu,
the basic education system,
established in 1968 and
started in 1972, aimed for
equity everywhere and for
everybody. Hopes and
doubts were presented.

Can these be
tested with PISA?

2
Reforming Finnish Education 1968–2004

Jarkko Hautamäki and Airi Hautamäki

PISA and the goals of the Finnish comprehensive school

There were great hopes with regards to educational equity in the declarations of the 1960s, when the comprehensive school was to be established in Finland (Aho 1996; Aho, Pitkänen, & Sahlberg 2006; Ahonen 2003; Laukkanen, R. 2008; Lehtisalo & Raivola 2000; Simola 2005). The PISA programme has provided useful data. Accordingly, the PISA programme can be used for testing the model of Finnish education, with the main question asked being: Has educational equity been attained? A model of Finnish education is presented in this chapter to offer historical explanations for the surprisingly high outcomes of Finnish students. The model also guides analyses, which open space for deeper reflections paving the way for national explanations.

History

First and foremost it is important to understand the true meaning of the notion of the Finnish comprehensive school. The original Finnish comprehensive school is called 'peruskoulu', which is made-up of two words: 'Perus' means basic, fundamental, ground, being the start or origin of something, and 'koulu' means in Finnish both the institution and the building. When a child goes to school in Finland, s/he goes to the nearest building, where s/he meets other children from the same living area and is welcomed by the class teacher, who has completed her master's thesis at a university in educational sciences. The teacher has a diploma which is a requirement of all public professions requiring an academic degree.

At the time of testing, the first six years were called in Finnish 'alakoulu' or 'ala-aste', 'underschool', 'lower school', 'lower degree', and often translated as primary school. Teachers are called in Finnish 'luokanopettaja', 'the teacher of one class', which is translated into English as class teacher. Following this most of the pupils move, for the last three years of peruskoulu, to the nearest bigger building, where pupils from several alakoulu are transferred, and which was called 'yläaste' or 'yläkoulu': 'ylä' means 'over', 'upper'¨, and 'koulu' is school and 'aste' is degree. This 'yläkoulu' is often translated as lower secondary school, which does not seem to be a justified translation. This translation, with a UK flavour, creates an association with secondary schools and to parallel schooling systems with early selection and different destinations. This upper part of the comprehensive school is not a relic of a previous parallel system, but a part of basic education for all citizens. One can, of course, still track some old habits and implicit models (Aho 1996) of the segregated school system, but these are met openly and discussed within a framework for school for all. However, the debates include issues of differentiation and selection, tracking and other means of allowing for individual choices and subject selections. These debates are needed in all educational systems which have to cope with the very difficult educational issue of how to handle student variation (Olson 2004). To repeat: the idea of education for all has meant that special attention is given to children from less-educated families. Additionally, major decisions concerning the guiding rules of allocating money and resources have always taken into account that everybody should have the equal right to education. Only then can competence differences be given enough space and understanding in a way, which also takes into account pupils with the most developed competencies. Reijo Laukkanen has given a vivid description of the beginning: "As the government delivered its bill to Parliament in 1967, one of the arguments for the common 9-year education for all was that it was too early to judge individual capacities at the age of 11 or 12. They talked about losing the reserve of human resources that Finland would badly need in order to bring industry up-to-date. At that time, Finland was a poor country. At that time, decision-makers also had to deal with more and more private grammar schools being founded, because the state-run and municipal-run ones could not fulfil all the demand. Parents were voting with their feet. At the same time, there was an increase in ideology, demanding equal education for all children: boys and girls, rich and poor, slow learners and fast learners (Government Proposal 1967)" (Laukkanen 2008, p. 308).

Second, all PISA outcomes, from 2000, 2003 and 2006, are outcomes of generations of students who have experienced only one type of schooling, comprehensive school and with parents most of whom themselves have also been educated in the same school system. These students have been taught by teachers, who have been trained at universities, most of which have personally experienced the early years of the new comprehensive school. Only the oldest teachers still remember the turbulent years (Aho, 1996) of introducing the new form of schooling. Students have experienced teaching, based on principles and guidelines, which were put forward even decades ago. The peruskoulu of today was not created yesterday; it has taken forty years since the birth of the comprehensive school in Finland.

Decades of Finnish Peruskoulu

In Table 2.1 the short development of Finnish basic education starting from the 60s is presented. The table is divided into decades, system level, comprehensive school, and implications. The table is based upon three major sources: Sirkka Ahonen (2003), Aho, Pitkänen & Sahlberg (2006), and Häyrynen & Hautamäki (1978).

Also, there is reference to 1985, when a new framework for national curricula was presented. This framework was still operative for at least the first 6 years of PISA 2006 student cohort, and only partly affected by the newer 1994 or 2002 framework for core curriculum. The implementation of the 1985 framework saw the beginning of decentralisation, after the very firm first years of comprehensive school: "Schools had to follow the very detailed nationally authorised curriculum including 700 pages in very small font meticulously." and "School teaching was inspected by the state's school inspectorates that were founded in all counties. Each school had to be inspected at least once every 5 years. Furthermore, all schools had to submit their very detailed yearly schools' plans for approval by the inspectorate. That was natural and important because state funding was based on the real costs of the schools. Schools books were inspected in advance by the National Board of General Education."(Laukkanen 2008, p. 309).

This decentralisation of Finnish education saw a lot of autonomy in municipalities and schools: "Since 1985-1986 … the ability group system (streaming) at lower secondary education level was abolished and eligibility for further studies became open to everyone (Bill 1983). The legislation changes at the same time provided extra resources for schools at lower secondary level guaranteeing fairly small teaching groups for the whole age group. Schools were given freedom

T 2.1 | Description of decisions creating the Finnish comprehensive education; with educational implications to be tested with PISA 2006 data

System	Comprehensive School, 9 grades, 7-16 yrs*	Implication/hypothesis
60s • Parallel system of state-dominated municipal education is facing systemic problems and crises due to rapid social and economic changes (area differentiation, structure of economy) and is reflected in state/municipal education, low level of basic general education in labour, educational discontinuity, rural/urban differences, gender-issues, home language, education in Swedish changes also • Parents of PISA 2006 students are born • Role of private schools and concerns of education for the gifted/best performers • OECD: human capital as an education issue appears	**60s** • Parliamentary decision taken in 1963 to implement new comprehensive school education for 9 years/ grades: same education for all, but in-house school tracking allowed [primary school/upper school] and then general and vocational continuum to be planned, large support for special needs within schools and guidance is created, club activities, free meals (very old service), 68 Act on Basic Education Reform is voted on in Parliament	**60s** • Implicit or explicit political aims incorporated in the idea of a comprehensive, unified system: - comprehensive, 100% participation - high literacy or general knowledge in subjects - same type of schools everywhere - small effects of social background - rural areas = urban areas - variation between subjects low, but special concerns for the most able
70s • National Board of Education - its inspectorate and provincial inspectorates transfer support to the national and local INSET, planning (1972-85) • Teacher Education starts in universities (1974), first students for master's degree studies are approved 1979 (graduate in early 80s) • OECD: Husen's Social Background and Educational Career; Educability debates based on ideas of scientific-technological revolution	**70s** • 1970 Framework Curriculum for the Comprehensive School 1970 (detailed, same for all schools, textbook approval by NBE: very high curriculum coherence and alignment) • 1972 Implementation of peruskoulu begins in North and East Finland, and eventually reaches the Helsinki area in 1976 • A lot of in-service training for all teachers, includes reluctant and sceptical grammar school teachers	**70s** • The basic assumptions are studied, analysed and debated, but are not radically changed. There are still political claims or doubts concerning the highest quartiles or percentiles (that they would not be as good as in countries with private schools and strong tracking)
80s • 1st PISA2000 cohort is born • New National Framework Curriculum for the Comprehensive School 1985 • 2nd PISA2003 cohort is born First immigrants are arriving in bigger numbers Economic crises starts	**80s** • Advice and blue-prints for local applications are presented, and local differentiation (relative freedom) begins in controlled and inspected ways, but still a high curriculum coherence is maintained • The continued interpretation of basic knowledge and literacy, within state commissions for strengthening the position of reading and literature, humanistic, and sciences; there prevails a position to favour the practicality of school math (PISA Math) than university math, and in science education real-life tasks dominate (PISA Science). These are reflected in INSET and textbooks.	**80s** • No reason to assume that inter-counties and rural/urban differences would have increased since PISA 2000 and PISA 2003 cohorts, and reason to expect Finland to show a high level of potential for life-long learning
90s • PISA2006 pupils are born to parents, who are much better educated than their grand-parents • Decentralisation of education continues • Financing reform supports • New Framework Curriculum for the Comprehensive School 1994 -effects the teaching of PISA subjects (7-9 grades) • New 1999 Law on Education - Education Evaluation Policy, Sample based evaluations, - Unified basic school (grades1-9)	**90s** • PISA2006 pupils are born. • Parents and teachers are better educated than previous generations. • Support and special education provisions are increasing, club and free activities are diminishing. • Special measures are planned for immigrants in the Helsinki area and later in other places *lower or primary (1-6), upper (7-9)	**90s** • PISA2006 pupils are born and take a unified educational career during PISA-15-years • Parents are better educated than their parents • Mainly 1985 and 1994 national core curriculum frameworks effect teaching of PISA subjects (reading, math, science, 7-9 grades)
00s • PISA2000 • PISA2003 • New Framework Curriculum for the Comprehensive School 2004, may have an effect on science education in PISA 06 sample • PISA2006 Data Collection in Finland		**00s** • Education during grades 7-9 is provided, based on mainly previous frameworks and text-books (see science education)

for flexible groupings of pupils and further freedom in terms of how to use resources. …… Ten years later, in 1994, a significant change came about in order to reduce the role of central administration in deciding the contents and aims of teaching (National Board of Education, 1994). The National Board of Education only gave very broad aims and contents for teaching different subjects. The municipalities and, ultimately, the schools set up their own curricula on the basis of the national core curriculum. As part of these plans, local needs could be taken into consideration and special characteristics of schools could be taken into account" (Laukkanen, 2008, p.310).

In constructing Table 2.1 the aim was to state some hypotheses or intended implications of the ideas and decisions when the Finnish comprehensive school was developed. These are expressed in Table 2.2. The table consists of four columns: decades and years for time-lining, a copy of the implications / hypotheses column of Table 1, and the new column for specifying the implications. This column is also presented in Table 2.3 for a second look.

Testable implications of fundamental assumptions

The most important implications are tested using PISA2006 data. It is evident that this way of testing the Finnish model is not a test of whether the Finnish model is the best one. But it is a way to open up the Finnish model for international understanding and discussion, and to make sense of the Finnish outcomes for an international audience. However, it is also politically important for national debates to analyse the PISA outcomes in relation to the origins and later modification of the Finnish comprehensive school.

Clarifying implications

There are two basic types of questions: a) those which can be analysed within Finland-PISA data, and b) those which cannot be interpreted without international comparisons which require using the whole data set. International comparisons are useful for all types of PISA-relevant questions. Particularly, these are necessary for estimating the between-student variation and between-school variation, and for analysing the role of systemic factors, like economy and organisation of schooling. National PISA data can be used for analysing the roles of geography, parents' education and socio-economic status, gender and mother tongue.

All PISA data can be used, not only the scores of literacy scales. This means that sampling and attrition can provide useful information, items with correct/wrong answers and attempted/left unattended questions, and also issues that illuminate the types of items in relation to goals and aims of national education as these are expressed in curricula (Olsen 2005).

The basic idea is to use PISA evidence for testing the national model and some of its fundamental assumptions and expectations concerning the equality of education. Not all the possible assumptions made are tested in this book, and results from analyses are also presented in the other parts of the book than just Chapters 3 and 4.

To conclude, PISA2000 provided the baseline assessment of educational outcomes of a comprehensive school aiming for national equity, which aimed at balancing the effects of the social origins, place of living, and gender of the population (Välijärvi et al. 2003; Lie, Linnakylä, Roe 2003). In Finland, PISA2003 provided even better results, due to several hypothesised factors (Välijärvi et al. 2007; Mejding & Roe 2006). Based on the previous good outcomes, the expectations were high for PISA2006. PISA2006 offered even better results in Finland than expected. Now it is time to proceed from PISA 2003 results to the PISA 2006 data set, to analyse and reflect, what it tells about the current peruskoulu.

T 2.2 | Drawing testable implications for Finnish comprehensive school

Implication/hypothesis	Specification of possible implications and hypotheses
60s • Implicit or explicit political aims incorporated in the idea of a comprehensive, unified system: - comprehensive, 100% participation - high literacy or general knowledge in subjects - same type of schools everywhere - small effects of social background - rural areas = urban areas - variation between subjects low, but special concerns for the most able	**60s** • State/municipal/private education: most of the schools are municipal, and very few are private • All 15-year old children are students, 100% of the relevant age cohort are also PISA eligible Most 15-year olds are in non-special, or no-SEN schools and the number of PISA-excluded pupils is very low as compared to cohorts in other Scandinavian, EU and OECD countries. The results should be very good in relation to other countries • The effect of parents' education and SES should be relatively small or, in extreme cases, zero. Educational continuity: the system is not tracked or divided, thus a low level of between-student variation as compared to Scandinavian, EU- and OECD-countries due to the structure of the system • Rural/urban differences should no longer exist, Geographical areas (counties, administrative areas) should not differ from each other • Gender-differences should have disappeared • The language of use in the home should have no effect, and education in Swedish should produce the same level of results as education in Finnish • Results of private schools should be no different from municipal schools • Education for the gifted/best performers: the relative position of the best 25 / 5 % should be as relatively good as the positions of the mean and low performers • Human capital and education: Finnish education should rank high in the creation of valid human capital as compared to other nations, in terms of PISA Framework
70s • The basic assumptions are studied, analysed and debated, but are not radically changed. There are still political claims or doubts concerning the highest quartiles or percentiles (that they would not be as good as in countries with private schools and strong tracking)	**70s** • Teacher education in universities, teachers with a master's degree make up the majority of qualified teachers in all schools; the number of qualified teachers with 5A/6 education should be very high in PISA06 data • The relative performance of pupils with SEN should be very good as compared to other Scandinavian, EU- and OECD–countries , and the number of PISA eligible SEN students should be high in Finland • High level of basic general education (at least 2nd degree) among parents of PISA2006 pupils
80s • No reason to assume that inter-counties and rural/urban differences would have increased since PISA 2000 and PISA 2003 cohorts, and that Finland would show a high level of potential for life-long learning and interest rates for achieved human capital	**80s** • Immigrants have been arriving in bigger numbers for more than a decade: the outcomes for first and second generation immigrants should be on the same level as the outcomes of natives with the same educational background: the geographical distribution of immigrants is not even, and there might be so small numbers of immigrants that no statistical analysis is possible
90s • PISA2006 pupils are born and undergo a unified educational career during PISA-15-years • Parents are better educated than their parents • Mainly the 1985 and 1994 national core curriculum frameworks effect the teaching of PISA subjects (reading, math, science, 7-9 grades)	**90s** • New Framework Curriculum for the Comprehensive School 1994 effects the teaching of PISA subjects (7-9 grades): • The level of general educational outcomes is high in Finland, and should be even higher than for the PISA00 and PISA03 results due to a higher educational status of parents • PISA Frameworks, 2000, 2003 and especially 2006 are suitable for the general knowledge related aims of Finnish education, and also for the beliefs and personality related aims of education (duty, reliability, good relations between students/teachers/parents). This is reflected in attrition measures of PISA schools and answers (low pupil attrition and low internal attrition)
00s • Education during grades 7-9 is provided, based on mainly previous frameworks and textbooks (see science education)	**00s** • PISA2000 – base level assessment outcomes • PISA2003 – better results, due to higher educational status of parents of PISA03cohort • PISA2006 –Data collection in Finland might show even better results, due to even higher educational status of parents of PISA2006cohort, and due to other possible factors.

T 2.3 | The fundamental assumptions of Finnish comprehensive education to be tested with PISA 2006

State/municipal/private education: most of the schools are municipal, and very few are private

All 15-year-old children are also PISA pupils, 100% of the relevant age cohort are also PISA eligible

Most 15-year-olds are in non-special, or no-SEN schools and the number of PISA-excluded pupils is very low and comparable to other Scandinavian, EU and OECD countries, and the results should be very good in relation to other countries

The role of parents' education and SES should be relatively small or, in extreme models, zero

Educational continuity: the system is not tracked or divided, so a low level of between-student variation as compared to Scandinavian, EU- and OECD-countries due to the structure of the system

Rural/urban differences should not exist any more

Geographical areas (counties, administrative areas) should not differ from each other

Gender-differences should have disappeared

Home language should have no effects and especially education in Swedish should produce the same level of results as education in Finnish

Results of Private Schools should not be different from municipal schools

Education for the gifted/best performers: the relative position of the best 25% / 5 % should be relatively as good as the positions of the average and low performers

Human capital and education: Finnish education should provide a good position in creating valid human capital as compared to other nations and in terms of PISA Framework

Teacher Education in universities, teachers with a master's degree are the majority of qualified teachers in all of schools (the number of qualified teachers should be very high in PISA06 data)

The relative performance of pupils with SEN should be very good as compared to other Scandinavian, EU- and OECD –countries, and the number of PISA eligible SEN students should be high in Finland

High level of basic general education (at least 2nd degree) among parents of PISA2006 pupils

Immigrants have been arriving in bigger numbers for more than a decade: the outcomes for first and second generation immigrants should be on the same level as the outcomes of natives with the same educational background: the geographical distribution of immigrants is not even, and there are counties in Finland with very few immigrants

New Framework Curriculum for the Comprehensive School 1994 effects the teaching of PISA subjects (7-9 grades): the level of general educational outcomes is high in Finland, and should be even higher than for the PISA00 and PISA03 results due to higher educational status of parents

PISA Frameworks, 2000, 2003 and specially 2006 are suitable for the general knowledge related aims of Finnish education, and also for the beliefs and personality related aims of education (duty, trust-worthiness, good relationships between stu-dents/teachers/parents)

This is reflected in attrition measures of PISA schools and answers (low pupil attrition and low internal attrition)

PISA2000 – base level assessment outcomes were provided

PISA2003 – better results, due to higher educational status of parents of PISA03 cohort and other factors, which are difficult to analyse and prove

PISA2006 – Data Collection in Finland –expectations for still better results, due to even higher educational status of parents of PISA2006 cohort, and due to other factors, difficult to estimate

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Level concentrates PISA domains into one indicator; balance shows the relative roles reading and maths.

3
Level and Balance of Achievement

Jarkko Hautamäki, Seppo Laaksonen and Patrik Scheinin

Chapter 3 is devoted to testing the previously presented hypotheses concerning the Finnish comprehensive school. For that purpose, two variables have been constructed to capture PISA outcomes for a general analysis, level and balance. The idea stems from a journal article by Hunt & Wittmann (2008). They refer to Wittmann's (2004) use of componential analysis of the plausible values for math and reading to define two orthogonal scales. The first component, named level, could be thought to present a general PISA competence, condensing the measured two domains, PISA reading and PISA mathematics. PISA science was not included. The second component was a bipolar factor that indicated a person's relative strengths on the mathematical and reading scales: "[t]his factor determines the shape of a profile" (Wittmann, 2004, p. 6). The name of this index was tilt, from tilting or tilted, like the tilting PISA tower. We use the notion balance, i.e., a profile of the use of competencies. The Hunt and Wittman article has been a part of recent discussion concerning relation between learned competencies and intelligence (Adey & al., 2007, Baumert & al., 2007, Rindermann, 2007).

The level and balance estimations can be calculated using only Finnish, only OECD or all PISA data. The distinction between these ways of calculating is that the means will be different. In Finnish data the means for level and balance are set to zero with a standard deviation of 1. In the whole of OECD/PISA data the Finnish means are of course higher, but these two other ways allow for comparisons. All three ways have been used. This chapter uses mainly the Finnish data. When the other ways of calculating are applied, it is carefully reported.

Finnish data

We have used principal component analysis to condense 15 PISA plausible values, 5 for math, 5 for reading and 5 for science into one variable. This is named level, following Hunt & Wittmann (2008). The second factor is named balance, i.e., a profile of competencies. High values of level indicate a high PISA competence in Finland. Positive values of balance indicate a performance where PISA reading is relatively strong in relation to math, mainly, and to science scores, to some extent, and negative values indicate a performance where PISA math is relatively strong in relation to reading. Balance is accordingly an index for competence profile.

The descriptives of level and balance in Finland are given in Table 3.1. Standard deviation and variance are by definition 1, and mean is zero. This is the result of using only the Finish PISA file for estimating level and balance. The value of the Finnish level using the OECD countries data is +0.66, and +0.83 when all participating countries are used. The second Finnish value is highest among all OECD countries and the

T 3.1 | Descriptives of LEVEL and BALANCE (PISA2006 Finland)

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Level	4714	6.94	-3.90	3.03	.0000	1.00000	1.000
Balance	4714	6.56	-3.10	3.46	.0000	1.00000	1.000
Valid N (listwise)	4714						

T 3.2 | Loadings of 5 plausible values of Math, 5 plausible values of Read and 5 plausible values of Science on level and balance using Finnish PISA2006 data

	Component. level	Component. balance
PV1MATH	.89	-.27
PV2MATH	.89	-.26
PV3MATH	.89	-.27
PV4MATH	.89	-.26
PV5MATH	.89	-.26
PV1READ	.87	.36
PV2READ	.87	.37
PV3READ	.87	.35
PV4READ	.87	.37
PV5READ	.87	.37
PV1SCIE	.93	-.09
PV2SCIE	.93	-.08
PV3SCIE	.93	-.09
PV4SCIE	.92	-.09
PV5SCIE	.93	-.08

third Finnish value is highest among all the participating countries.

The loadings of the 15 plausible values on these two components are given in Table 3.2. It is easy to see that level captures well all the three domains, and there are not significant differences in the loadings. Balance is a bipolar profile variable, where PISA reading estimates are loading with moderate positive values [+0.37], and PISA math estimates with moderate negative values [-0.27]. Science indicators are loading with low but negative values [-0.1]. The loadings are virtually the same when the principal component analysis is done with the whole PISA data. The 1st factor (sum of squared loadings is 12.04) explains 80% of the variance and the 2nd factor (sum of squared loadings is 1.05) explains 7% of the variance, together 87% of the variance. This is more than enough for further analyses. The balance or profile indicator is a relatively weak component, but it is important for testing the national profiles, i.e., how well Finland and other PISA countries have succeeded in balancing reading and mathematics teaching.

OECD countries

We have also made a componential analysis of OECD countries' data. The results for level are given in Table 3.3 with standard errors and 95% confidence limits. Here Finland has the highest level value of 30 OECD countries, which we included in these analyses. Taking into account confidence intervals, it can be seen that Finland is indeed the best OECD country, and statistically better than the second best OECD country, Korea. US figures are included, as the lacking reading scores have been estimated.

The results for balance in OECD countries are presented in Table 3.4. The negative end of the bipolar balance factor is occupied by –PISA math prevails in this profile – Czech Republic, Japan, Switzerland, Slovakia and the Netherlands. Their profiles are mathematics dominated. The positive end of balance is occupied by Poland, Korea, Ireland and Turkey. In these countries the scores of reading is dominant in relation to PISA math scores. The profile is reading dominated. This means that if one compares the reading scores to math scores the reading scores are higher. Accordingly, the negative balance values means that in comparison the math scores are higher that reading scores.

Here, balance value for Finland is close to zero (+0.1). Given the proposed interpretation of balance, this implies a very well balanced use of reading and math competencies in solving the PISA type of tasks in science, math and reading. This balanced general knowledge has been and still is a central aim of Finnish education.

In comparison with Hunt and Wittmann's (2008) results for PISA 2003, with 34 countries taking part, Finland had for level 0 .64 (now 0.66) and for BALANCE +0.09 (now +0.01). These are very similar results.

The country scores for level and balance for Finland, and for OECD countries, were calculated from individual scores. For individual scores, the correlation of level and balance is by definition zero. But on the country aggregate level, this is not the case, correlations could be different from zero. Hunt and Wittmann calculate for PISA2003 a correlation -0.5 between PISA level and balance on the country level, but here we have a correlation -0.16 on the country level. The negative correlation means that there is a tendency for high level countries to have a negative balance score, reflecting the stronger use of a math kind of thinking in solving PISA items.

The plan for this chapter is to test level and balance differences in policy relevant topics, in testing the

T 3.3 | Estimates of PISA level for OECD countries (N=30)

OECD country	*Mean*	*se*	*low95*	*high95*
Mexico	-0.93	0.03	-0.99	-0.86
Turkey	-0.68	0.06	-0.79	-0.57
Greece	-0.32	0.04	-0.40	-0.23
Italy	-0.27	0.02	-0.32	-0.22
Portugal	-0.24	0.05	-0.34	-0.15
Spain	-0.18	0.02	-0.22	-0.14
United States	-0.14	0.05	-0.23	-0.04
Slovakia	-0.11	0.04	-0.20	-0.03
Luxembourg	-0.08	0.12	-0.31	0.14
Norway	-0.07	0.03	-0.13	-0.01
Hungary	0.00	0.04	-0.08	0.07
France	0.00	0.04	-0.07	0.07
Iceland	0.01	0.03	-0.06	0.07
Poland	0.08	0.03	0.02	0.13
Denmark	0.09	0.03	0.04	0.14
UK	0.10	0.04	0.02	0.17
Czech	0.10	0.04	0.01	0.19
Austria	0.10	0.06	-0.02	0.22
Sweden	0.12	0.03	0.07	0.17
Germany	0.13	0.06	0.02	0.24
Ireland	0.17	0.03	0.11	0.23
Belgium	0.19	0.04	0.12	0.27
Switzerland	0.23	0.04	0.15	0.31
Japan	0.27	0.05	0.17	0.38
Australi	0.30	0.03	0.24	0.35
Netherlands	0.31	0.04	0.23	0.39
New Zealand	0.34	0.04	0.27	0.42
Canada	0.40	0.02	0.36	0.44
Korea	0.53	0.03	0.46	0.60
Finland	0.66	0.02	0.61	0.70

T 3.4 | Estimates of PISA BALANCE for OECD countries (N=30)

OECD	*Mean*	*se*	*low95*	*high95*
CzechRep	-0.41	0.05	-0.50	-0.31
Japan	-0.40	0.04	-0.47	-0.33
Switzerland	-0.38	0.03	-0.43	-0.32
SlovakRep	-0.34	0.05	-0.43	-0.26
Netherland	-0.31	0.04	-0.39	-0.24
Spain	-0.27	0.03	-0.32	-0.22
Iceland	-0.21	0.04	-0.28	-0.14
Belgium	-0.20	0.03	-0.27	-0.14
Austria	-0.19	0.05	-0.30	-0.09
Denmark	-0.15	0.03	-0.21	-0.09
Germany	-0.10	0.04	-0.18	-0.02
Hungary	-0.09	0.04	-0.17	-0.01
Luxembourg	-0.05	0.05	-0.15	0.05
Australia	-0.05	0.02	-0.09	0.00
France	-0.02	0.04	-0.09	0.06
Finland	0.01	0.03	-0.04	0.07
United Kingdom	0.03	0.03	-0.02	0.09
Norway	0.04	0.03	-0.02	0.11
NewZealand	0.06	0.04	-0.01	0.14
Canada	0.08	0.02	0.04	0.13
Greece	0.09	0.04	0.01	0.17
United States	0.15	0.02	0.11	0.18
Italy	0.21	0.04	0.13	0.29
Sweden	0.22	0.04	0.14	0.30
Portugal	0.22	0.03	0.16	0.29
Mexico	0.24	0.03	0.17	0.30
Poland	0.35	0.03	0.29	0.42
Korea	0.40	0.04	0.32	0.48
Ireland	0.40	0.04	0.32	0.48
Turkey	0.60	0.05	0.51	0.70

effects of educational context factors. Mainly the Finnish level and balance estimations are used. At the end we compare immigrants to natives using the OECD estimates for level and balance.

Regional differences in Finland

Finland is divided into six administrative regions. There are no differences between regions in level but a small difference in balance (Figures 3.1. and 3.2). The level conclusion has been tested using plausible values in replicates analyses for math, science and reading.

In balance, the profile of region 6 is math-balanced, all the others are close to zero.

In conclusion, in Finland there are no significant regional differences. This is very true for all Finnish speaking regions. Only in region 6, the Swedish speaking region, are there some differences: in PISA reading, the mean for region 6 is lower than in other regions, and in balance there is a math favour.

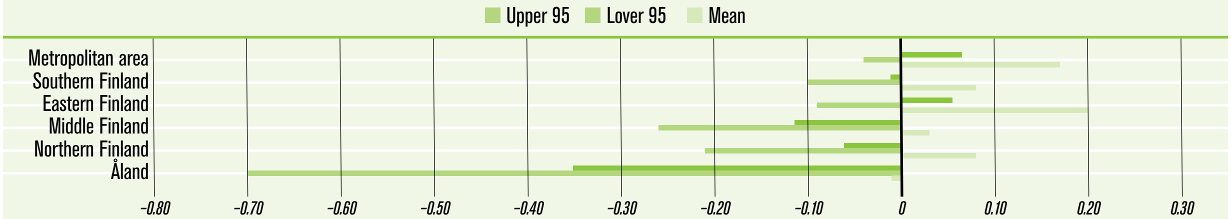
Urban/rural factors in Finland

In the original blue-print for Finnish comprehensive school there was a goal to diminish differences between towns and villages, to make the urban/rural difference non-significant. The name for this distinction in PISA data is status. For level, urban areas have higher means than rural areas (Table 3.5, Wald F=5.4, p=.021, R2 =.003). Status explains, however, less than 1% of the variance. For balance, status is a significant factor (Table 3.5, Wald F=7.97, p=.005, R2=.007), but status explains a very small part of variance (less than 1%).

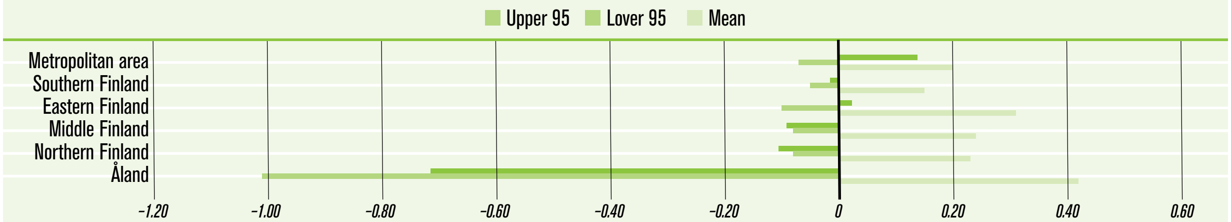
Status has been relatively well taken into account in Finnish educational policy, but there are, however, small differences between urban and rural status.

In conclusion, status has a role in relation to level of PISA competencies: urban status means a higher mean of level. The difference is not important due to a small percentage of explained variance. Status has a role in relation to balance of reading/math use: urban

F 3.1 | Level of competence in Finnish administrative regions (means with 95 confidence intervals; Finnish data)



F 3.2 | Balance of competence (profile dominance) in Finnish administrative regions (means with 95 confidence intervals; Finnish data)



status means slightly more PISA reading dominated learning activity and rural status implies a slight PISA math dominance. This difference may not be important due to the small percentage of explained variance. However, the role of reading, or non-reading in rural areas might have didactic implications of some importance. Level of performance can be increased by simply teaching better, but the dominant way of using competencies cannot be directly taught, nor should it be (nobody knows the best method to attain peak performance later in life).

T 3.5 | Level and balance in urban/rural types of living areas

Factor	*R/u*	*Mean*	*Se*	*Lower95*	*Upper95*
Level	rural	-.11	.05	-.21	-.01
	urban	.03	.03	-.03	.09
Balance	rural	-.15	.06	-.26	-.03
	urban	.05	.04	-.02	.12

T 3.6 | Level and balance Read/Math for females and males in Finland

Factor	Gender	Mean	Se	Lower95	Upper95
Level	Female	.09	.03	.03	.15
	Male	-.10	.03	-.16	-.03
Balance	Female	.62	.03	.57	.68
	Male	-.62	.03	-.69	-.55

Gender differences in Finland

For level, gender is a significant factor (Table 3.6; Wald F= 33.4, p<.001, R2=.009), and the mean for girls is higher than the mean for boys. Gender explains about 1% of the variance of level.

For balance, gender is a very significant factor (Table 3.6; Wald F= 281.2, p<.001, R2=.39). The values of the means are very different: value for girls is high positive and for boys equally high negative. Girls are very reading dominated, whereas boys are not, they are (PISA) math dominated. Gender explains almost 40% of variance of balance scores. This is the biggest single difference in PISA results, and it is also universal: there seems to be no countries in the whole OECD-world where the females would not be reading-dominated and males math-dominated. This outcome is independent of the level.

In conclusion, gender has a significant role in relation to level of PISA competencies: females have a higher mean of level than males. However, this difference is not very significant, or seems to diminish in importance, when discussed simultaneously with the very strong factor of balance. Gender has a very strong effect in balance: females are very reading dominated, and males are math dominated. Gender explains almost 40% of variances.

This observation is the strongest in PISA analyses in Finland. Gender differences in balance are universal in the whole PISA study. All countries have a balance profile that shows a gender difference, where the mean for females are positive and for males negative.

Family background

The role of the parents' education is central to the blue-print of Finnish comprehensive school. There are two basic positions: orthodox and pragmatic. The orthodox position argues that parents should not have any effect on educational achievements, and that only the competencies of students should make a difference; only then can educational equity be said to exist. The pragmatic position accepts the idea that the education level of parents has an effect on the education of their children. A well educated parent would perform his/her parental obligations better than a less educated parent. They would have a better command of language, better command of math and science, and better salaries, which would provide more overall benefit for their children on a daily basis.

In this section we use classified levels for parents' education (3rd degree education as separate from other levels of education, the ISCED codes 5A or 6).

Both father and mother have their individual effects. For example, a father could have a different effect on his son than on his daughter, and likewise a mother's effect on her children could also be gender differentiated. There is evidence of these kinds of complex effects in Finnish studies on learning-to-learn (Hautamäki et al, 2000). Here we are content with testing simple effects of father and mother in PISA students, whilst disregarding the gender of students.

For level, both father (Wald F=101.1, p<.001, R2=.032) and mother (Wald F= 82.2, p>.001, R2=.029) have effects, which are statistically significant, but in both cases educational background explains about 3% of variance (Table 3.7). With regards to balance, neither a father's nor a mother's education has statistically significant effects.

In sum, the educational background of both fathers and mothers has a significant effect on their children's PISA competencies and PISA level: if a mother or father has a university degree the level of their children as students is higher. The explained variances are for both parents about 3%. For balance, no effects of educational background were found. It seems that the general effects are acceptable for the pragmatic school, and both schools can accept that there are no effects on balance. According to the orthodox interpretation, effects on level should also not exist.

Swedish-speaking students

There are 6.4% students, who are studying at schools, which use Swedish as their teaching language. The mean level of Swedish speaking students in Level is lower than the mean for Finnish speaking students (Table 2.8) (Wald F= 19.9, p<.001, R2=.005), However, of course there are both Finnish and Swedish speaking students in all levels of level (Figure 3.3). There is no difference on balance. We will return to Finnish/Swedish issue in the end of this chapter, in relation to analysing the role of languages of schooling and home.

Students with immigrant background

There are 1.5% immigrants in Finland's PISA2006 population (Table 3.9).

Immigrant status is a significant factor (Wald F =28.7, p<.001, Rsq=.018). The mean of natives is higher than the mean of immigrants. Immigrant status explains about 2% of the variance of level. There is no difference between first- and second-generation immigrants (Table 3.10).

For balance or profile, immigrant status is a significant factor (Wald F =9.22, p<.001, Rsq=.004). The mean of natives is zero (almost by definition) and the value of the mean of immigrants is positive, referring to the PISA reading dominance. Immigrant status explains about 0.4% of the variance of balance.

With regards to immigrants we also need international reference to show the level and balance of immigrants in Finland as compared to the level and balance of immigrants in OECD and EU countries.

In conclusion, immigrant status has a role in relation to the level of PISA competencies: natives have a higher mean of level of PISA competencies. The explained variance is small. Immigrant status has a role in relation to the balance of reading/math use, so that

T 3.7 | Effects on Level and balance of father's and mother's university education

Factor	*Parents' educ 5A or 6*		*Mean*	*Se*	*Lower95*	*Upper95*
Level	Father	Yes	.32	.04	.24	.40
		No	-.06	.02	-.11	.01
	Mother	Yes	.27	.04	.19	.34
		No	-.08	.03	-.13	-.03
Balance	Father	Yes	.01	.05	-.08	.10
		No	-.01	.05	-.08	.05
	Mother	Yes	.01	.04	-.08	.09
		No	.00	.04	-.07	.08

T 3.8 | Effects on Level of students' language (Finnish or Swedish)

			95% Confidence Interval	
Testlang	Mean	Std. Error	Lower	Upper
Finnish	.01	.03	-.04	.06
Swedish	-.32	.07	-.46	-.18

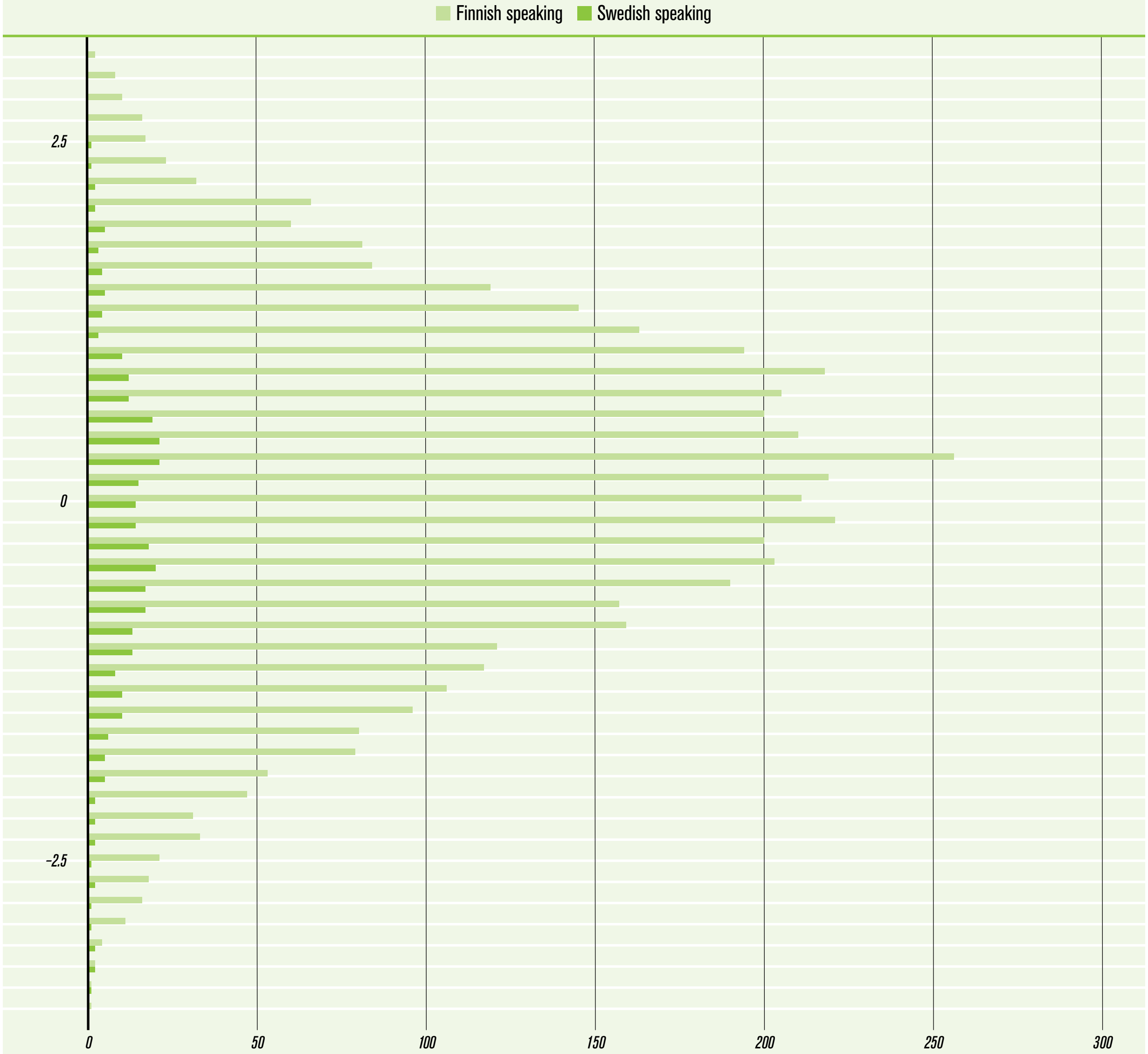
T 3.9 | Immigrants in Finnish PISA 2006 data

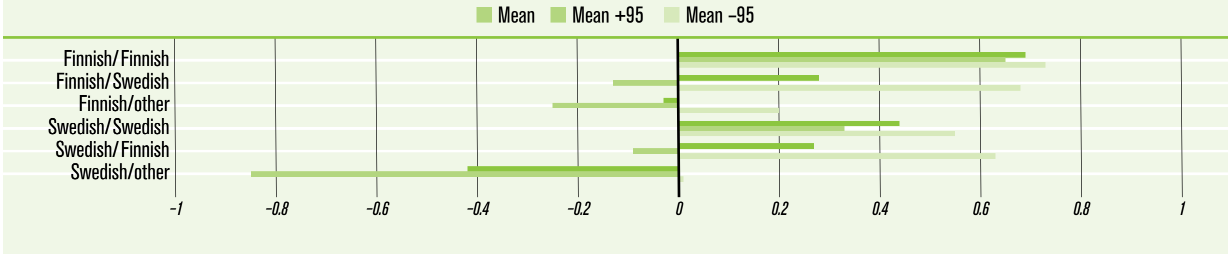
Immigration status	*Weighted Count*	*Weighted Percent*
Native	59909	98.5%
Second-Generation	130	.2%
First-Generation	809	1.3%
Population Size	60850	100.0%

T 3.10 | Effects on Level of students' immigrant status

			95% Confidence Interval	
Immigration status	*Mean*	*Std. Error*	*Lower*	*Upper*
Native	.02	.03	-.03	.07
Second-Generation	-1.04	.36	-1.76	-.33
First-Generation	-1.05	.17	-1.38	-.71

F 3.3 | Population pyramid on level by Finnish and Swedish speaking students





F 3.4 | Means of level (with 95% CI, Finnish norms) for different test-/home-language combinations in Finland

students with an immigrant origin are more reading than math dominated.

Generally, the Finnish PISA 2006 results show in almost every relevant aspect reasonably small or very small differences. The major gender difference in the balance/profile factor might benefit from further research.

We will now turn our attention to language differences both in relation to Finnish and Swedish, and also in relation to other languages.

Role of language in PISA assessment

In Finland there are two official languages: Finnish and Swedish. Most students come from Finnish speaking schools and also speak Finnish at home. However, in Finnish schools it is possible to have students, which are studying in Swedish, but at home use Swedish or Finnish or both Swedish and Finnish. In Finnish PISA studies we have booklets in both these languages. This fact can be used as a starting point for analysing the role of language(s) in PISA outcomes.

In these analyses we have used level estimations for 30 OECD countries. We use mainly data aggregated on the country level, but have tested major results using student data. The standard errors have been estimated taking into account sampling.

Finnish/Swedish

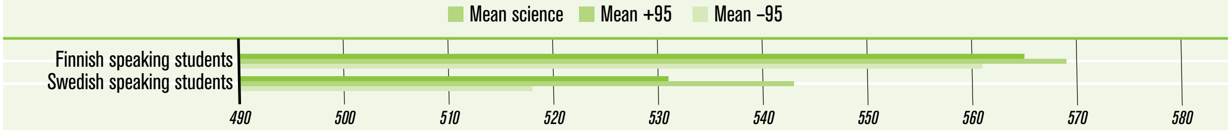
First, the effects of being schooled in Finland in Finnish or in Swedish and using at home either one of the official languages or some other language are tested. Together we have six combinations: being tested in Finnish, using Finnish at home, Swedish or some other language (few missing values for home language variable were also included in this group), being tested in Swedish, using Swedish at home, and Finnish or some other language. The results are given in Figure 3.4.

The difference between the major comparison “Finnish/Finnish” and “Swedish/ Swedish” is significant, but educationally not alarming. Of the other differences only those within the Swedish group, between the other home languages and national languages are significant, in relation to both Swedish and Finnish. Also the differences between the groups Fi1 (Finnish/Finnish) and Fi3 (Finnish/other) are significant. The confidence limits are large in these small subgroups. However, the trend is visible: it is better to study in a school which uses the same language as used at home. But, in Finland, it does not make a big difference if the languages are national languages.

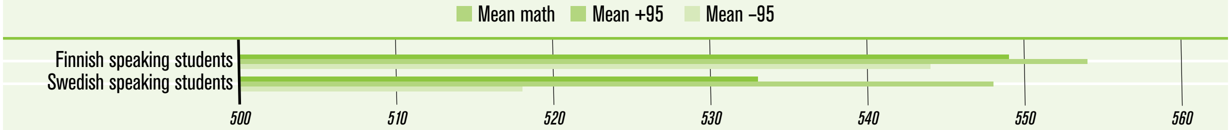
More details

Next, we will specify the Finnish – Swedish differences using PISA plausible values for science, math and

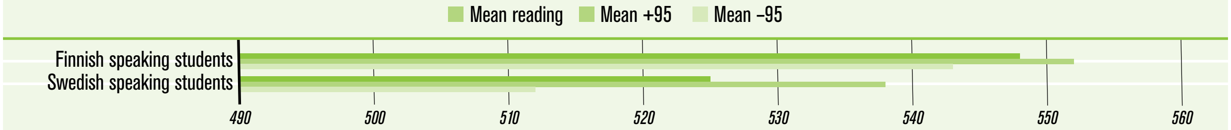
F 3.5 | PISA science mean scores (95% CI) for Finnish and Swedish Speaking Students in Finland



F 3.6 | PISA math mean scores (95% CI) for Finnish and Swedish Speaking Students in Finland



F 3.7 | PISA reading mean scores (95% CI) for Finnish and Swedish Speaking Students in Finland



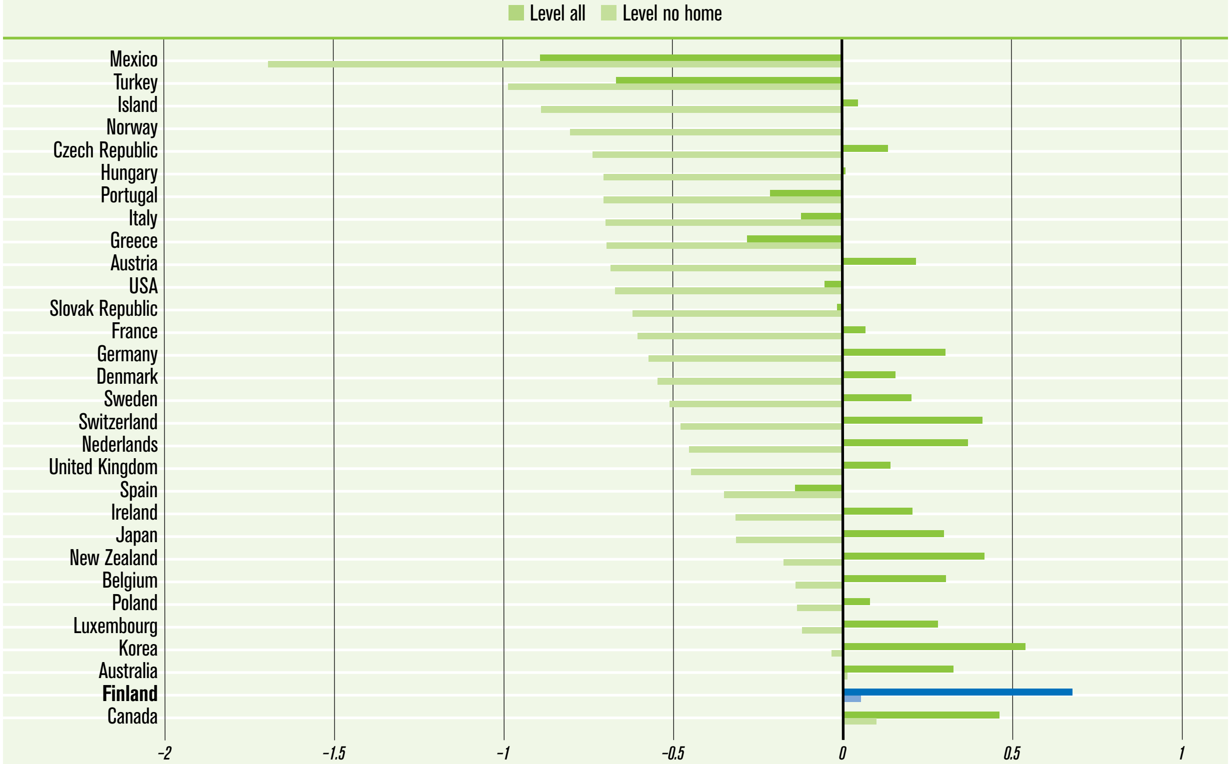
reading (using the replicates module in SPSS which gives correct standard errors, checking also with MLwiN). The results for PISA science are given in Figure 3.5. This difference is significant. Results in PISA math are given in Figure 3.6. This difference is not significant. Results in PISA reading are given in Figure 3.7. This difference is significant.

The major differences are in PISA science and PISA reading, but not in PISA mathematics.

Generally

The generalisation concerning the language issue is hardly revolutionary, but all the same it is still important. We can try to generalise the results further using the variables of level, and test-language and home-language. The original PISA data includes three distinctions: 1) the home language is also the language of testing (and schooling), 2) the home language is not the testing language, but is an official national language, 3) the home language is not the testing language and is not among the official languages. Here we have combined three categories into a dummy variable: the test-language is the same as the language at home (value 1 for both Finnish and Swedish) or the home language is different from the test language (0, for Finnish speaking in Swedish speaking schools, Swedish speaking in Finnish speaking schools, and students in Finnish or Swedish speaking schools, who

F 3.8 | Average for level by country for all (level all) and for those with another language (level no home) (OECD countries, N=30)



use some a third language at home). Missing values are also coded into 0 (very few cases).

We have calculated for 30 OECD countries the values of level (with standard errors) for those, who have been tested in their home language and for those, who have another home-language, and for all. In Figure 3.8. there are two lines: a line for values of level for the all students[home-language-is-same or different-as-testing-language] group and a line for those students who speak a different language at home [home-language-is-not-same-as-testing-language] (Figure 3.8).

The average difference is .61 units of level, which equates to a vast difference. Level/OECD is calculated with a mean of zero and 1 for SD. Accordingly, the relative lack of shown PISA competence is around -.60 in effect sizes for those, who answer PISA items using a language, which is different from their home language. This, of course, means different social implications in respective countries, but these are beyond the scope of this book. However, it might be interesting to use the material for further, independent research (Table 3.13).

In Finland, the difference between being Finnish speaking and tested in Finnish and being Swedish speaking and tested in Swedish is statistically significant. This goes against the assumptions of the Finnish comprehensive school that there exists full equivalence

T 3.12 | OECD countries, level values for home (testing and home language same), for no-home (testing language is different from home language), level for all students and difference between level-home and level-no-home

CNT	*level home*	*level no home*	*level all*	*Diff*
MEX	-0.89	-1.69	-0.93	0.80
TUR	-0.67	-0.99	-0.68	0.32
ISL	0.05	-0.89	0.01	0.93
NOR	0.00	-0.80	-0.07	0.81
CZE	0.13	-0.74	0.10	0.87
HUN	0.01	-0.70	0.00	0.71
PRT	-0.21	-0.70	-0.24	0.49
ITA	-0.12	-0.70	-0.27	0.58
GRC	-0.28	-0.69	-0.32	0.41
AUT	0.22	-0.68	0.10	0.90
USA	-0.05	-0.67	-0.13	0.62
SVK	-0.02	-0.62	-0.11	0.60
FRA	0.07	-0.60	0.00	0.67
DEU	0.30	-0.57	0.13	0.87
DNK	0.16	-0.54	0.09	0.70
SWE	0.20	-0.51	0.12	0.71
CHE	0.41	-0.48	0.23	0.89
NLD	0.37	-0.45	0.31	0.82
GBR	0.14	-0.45	0.10	0.59
ESP	-0.14	-0.35	-0.18	0.21
IRL	0.21	-0.32	0.17	0.52
JPN	0.30	-0.31	0.27	0.61
NZL	0.42	-0.17	0.34	0.59
BEL	0.30	-0.14	0.19	0.44
POL	0.08	-0.13	0.08	0.21
LUX	0.28	-0.12	-0.08	0.40
KOR	0.54	-0.03	0.53	0.57
AUS	0.33	0.01	0.30	0.31
FIN	0.68	0.05	0.66	0.62
CAN	0.46	0.10	0.40	0.36

of the two official languages. But, this turned out not to be the case. However, the difference is small, and corresponds with earlier studies.

Furthermore, the levels of those students studying in school using a language other than the home-language (different Finnish/Swedish combinations) are very comparable, showing a reasonable outcome in relation to educational policy in a country with two official languages, and taking into account mixed marriages. But, in Finland, the difference (.62) between home-language tested students and no-home-language tested students is statistically and educationally significant.

The value of the Finnish difference is an average OECD difference. It is also relevant that the level estimations for non-home group in all OECD countries are mainly negative; only three countries – Australia, Finland and Canada – have means over zero. The OECD mean for level is zero. This means that only in those three countries, where people with a different home language from the official school language, have outcomes that are OECD average. All this shows that the issue of home/schooling language is universal.

There are countries where the difference is smaller than in most other countries: Australia, Canada, Poland, Spain and Turkey. There are policy differences in these countries, but one could conclude that Australia and Canada would be good general examples for further exploration to learn how they have been able to cope with the issue of different languages at school and at home.

On a general level, this section has shown that it is relevant to pay attention to the testing language, and, by induction, to other relevant educability issues. Schooling is a demanding experience where all the resources, provided by the cultural support of families and other forms of congregations, are both used and needed. However, there is surprising outcome that shows the whole educational and social milieu has a peculiar effect of raising the level of those using other languages, but at the same time keeping the gap at a

T 3.13 | Compared factors with the results in level and balance/profile and an interpretation

Factor	*Level*	*Balance*	*Interpretation*
Regional differences	no difference	small difference in region 6<0	regional balance has been achieved
Urban/rural difference	Urban mean > rural mean	Urban > 0, Rural < 0	there are differences, which have to be attended to
Parents' education	Higher means for students with better educated parents	No difference	Debates and further analyses are still needed, the effects are relatively small
Finnish/Swedish	Finnish means > Swedish means	No difference	Need to be further analysed, even if the results were same in PISA 2000 and PISA 2003
Immigrants	Native's mean > Immigrants' mean	Native = 0, Immigrants > 0	Need to be analysed
Gender	Girls > Boys	Boys' mean < 0, girls mean > 0	Level difference is found, relatively modest; a important balance/profile difference is universal

fairly constant size. This provides a path to take, but it is a long one: the better we educate the original or dominant groups, the better it is also for those, who arrive later and want to stay, to work, and to educate themselves and their children. There seems to be no shortcut to good results in education.

Conclusions

The major summary is given in Table 3.13. The tested educational relevant issues and results are repeated, and some conclusions are given.

On the whole, these comparisons have been taken as relevant examples for the understanding of the Finnish educational policy of peruskoulu, comprehensive general education for all citizens. We have shown that these issues have been and still are fundamental in Finnish education. PISA, after the full cycle of three studies (PISA 2000, PISA 2003 and PISA 2006), has made it possible for Finns to have a look at their education system, and the opportunity for other countries to better understand the Finnish system, in order to enhance the comparability of different educational systems.

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Parents want to and should trust the high standards of schooling across the country.

However, without a true prospect for good outcomes this trust cannot exist.

4
PISA as a Tool for Comparing Educational Systems

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Schooling can be conceptualised, but not totally covered, as a socially organised set of practices to deal with the variation between students. Organising this is the major challenge of education systems. The education system is a balanced compromise between the psychological interpretation of the variation and the socio-economic resources available for buildings, teachers and relevant materials. The interpretations are a part of the political system of the country, but also a part of the real existing differences, or variation between students. The ways to deal with the variation are classes within schools, which are located around the regional units. The age cohorts move in this system in a unified or tracked manner with or without grade repetition, and with other arrangements.

Part of the variation, also at the age of 15, reflects the genetic or other non-malleable factors, while another part reflects developmentally relevant transactions of a student within families, neighbourhoods, and schools. Also the cohorts can have different characteristics, means and deviations, which show an even, or increasing or decreasing trajectory. At the time when PISA assessment is implemented, outcomes of students' complex histories as learners become visible. However, part of the measured variance can be decomposed using as a means the fact that students study in their respective schools. Analysing students' variation and its different components, between-school and within-school variations, offers a possibility to study some of the systemic differences in Finland and in other participating countries.

The major claim in this chapter is that if the between-school variation is small, assuming a high average level, parents can rely and trust on high and consistent performance standards across schools in the entire education system, and may, as OECD expresses it, therefore be less concerned about choice between schools in order to attain high performance for their children (OECD 2007, p. 175). For Finland, it is a high priority of the comprehensive school to be as equal as possible, in every school and for all students. However, without a solid prospect for at least good outcomes this thrust of parents in regard to their own children cannot exist. So between-school variation is to be interpreted with the proficiency levels and competence achieved.

T 4.1 | Variance estimates for between-school, between-students within-school, total variance and the explained variance by school-differences (all participating countries)

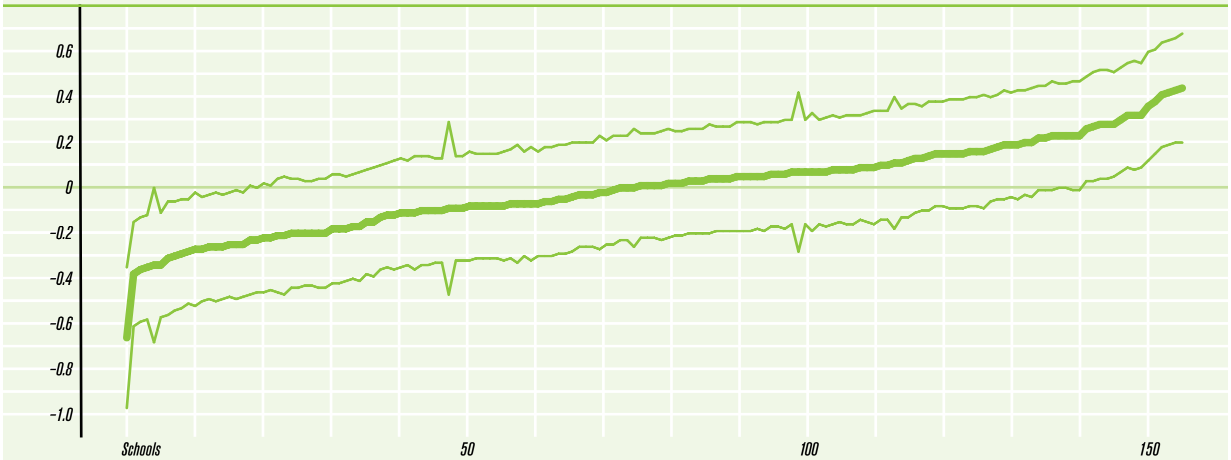
Country	*SchoolV*	*PupilV*	*TotalV*	*explained*
Azerbaijan	0.13	0.1	0.23	0.57
Argentina	0.509	0.371	0.88	0.58
Australia	0.206	0.636	0.842	0.24
Austria	0.556	0.366	0.922	0.60
Belgium	0.576	0.407	0.983	0.59
Brazil	0.413	0.274	0.687	0.60
Bulgaria	0.603	0.397	1	0.60
Canada	0.191	0.585	0.776	0.25
Chile	0.484	0.316	0.8	0.61
Chinese Taipei	0.405	0.315	0.72	0.56
Colombia	0.264	0.344	0.608	0.43
Croatia	0.299	0.338	0.637	0.47
Czech Republic	0.666	0.382	1.048	0.64
Denmark	0.116	0.565	0.681	0.17
Estonia	0.155	0.43	0.585	0.26
Finland	0.044	0.515	0.559	0.08
France	0.543	0.311	0.854	0.64
Germany	0.691	0.324	1.015	0.68
Greece	0.428	0.379	0.807	0.53
Hong Kong-China	0.297	0.37	0.667	0.45
Hungary	0.59	0.238	0.828	0.71
Iceland	0.077	0.683	0.76	0.10
Indonesia	0.217	0.154	0.371	0.58
Ireland	0.142	0.551	0.693	0.20
Israel	0.451	0.649	1.1	0.41
Italy	0.532	0.342	0.874	0.61
Japan	0.485	0.355	0.84	0.58
Jordan	0.178	0.429	0.607	0.29
Korea	0.308	0.402	0.71	0.43
Kyrgyzstan	0.304	0.3	0.604	0.50
Latvia	0.147	0.451	0.598	0.25
Liechtenstein	0.312	0.313	0.625	0.50
Lithuania	0.249	0.486	0.735	0.34
Luxembourg	0.272	0.53	0.802	0.34
Macao-China	0.167	0.385	0.552	0.30
Montenegro	0.2	0.39	0.59	0.34
Mexico	0.255	0.254	0.509	0.50
Netherlands	0.518	0.236	0.754	0.69
New Zealand	0.157	0.755	0.912	0.17
Norway	0.085	0.712	0.797	0.11
Poland	0.205	0.595	0.8	0.26
Portugal	0.277	0.595	0.872	0.32
Qatar	0.503	0.318	0.821	0.61
Romania	0.368	0.23	0.598	0.62
Russian Federation	0.221	0.427	0.648	0.34
Serbia	0.35	0.35	0.7	0.5
Slovak Republic	0.426	0.392	0.818	0.52
Slovenia	0.56	0.216	0.776	0.72
Spain	0.12	0.501	0.621	0.19
Sweden	0.107	0.657	0.764	0.14
Switzerland	0.298	0.492	0.79	0.38
Thailand	0.294	0.294	0.588	0.50
Tunisia	0.36	0.257	0.617	0.58
Turkey	0.402	0.243	0.645	0.62
United Kingdom	0.252	0.595	0.847	0.30
Uruguay	0.414	0.391	0.805	0.51
USA	0.23	0.61	0.84	

Variance estimates

Using school and student level data, the estimates for between-student and within-school variances have been calculated. The dependent variable has been the level, calculated, as previously described, as the first principal component of the 15 plausible estimates, five for each of PISA reading, PISA math and PISA science for all participating countries (USA estimated by imputing the lacking reading scores) (Table 4.1).

For Finland, Table 4.1 gives 0.04 for between-school variation and .52 for within-school variation, meaning that about 8% of the total variance is explained by differences between schools. This is also the lowest between-school variation among the par-

F 4.1 | School residuals of the PISA level score with 95 % confidence intervals in rank order in Finland



ticipating countries. The school residuals with 95% confidence intervals are plotted (using MLwiN) in rank order (Figure 4.1). The between school standard deviation for level scores is about 0.23 level-points. This means that about 95% of estimated school means are between 0.20 and 1.02, both well above the OECD average of zero. There are 17 schools below and 15 schools above the Finnish reference line of 0.66 (OECD mean), implying that about a fifth of the schools (32 schools, 21%), perform either better or worse than average schools in Finland.

Due to the importance of this result for Finnish comprehensive school ideology, further details are given in the next section.

T 4.2 | Two-level variance component model for the science, mathematics and reading literacy, baseline models (MLwiN) (Finland)

Fixed effect	*Science*	*Math*	*Reading*
Intercept	563.0	548.5	546.3
s.e.	2.04	2.07	2.33
Random effect	*Science*	*Math*	*Reading*
Between school	432.7	479	660.6
Within school	6331.3	5366.6	5253.6
ICC	0.064	.082	.112
Nschools	155	155	155
Nstudents	4714	4714	4714

School differences in PISA Science, PISA Math and PISA Reading

School differences are analysed more thoroughly using calculated mean scores for the three domains. One estimate for each domain has been calculated as a mean of five plausible values. The mean science, the mean math and the mean reading scores are used as dependent variables in MLwiN model with two levels (Level 1 students, Level 2 schools). The baseline models are presented in Table 4.2.

The ICC is the intra-class correlation which, multiplied by 100, gives in percentages the between-school variation, i.e., how much of the total variance can be attributed to differences between schools. The between-school variation is 6.4% in PISA science, 8.2% in PISA math and 11.2% in PISA reading.

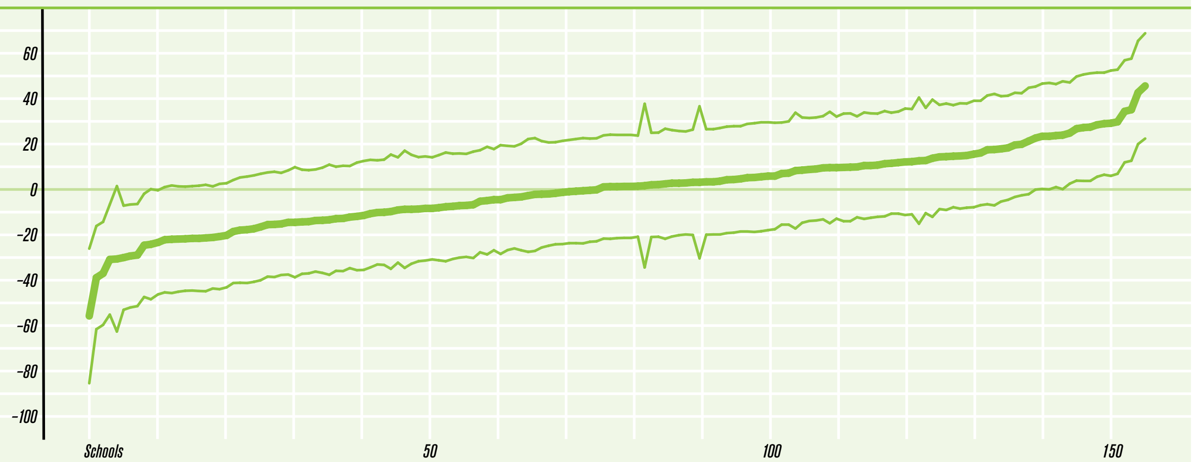
The school residuals for PISA science are presented in rank order in Figure 4.2. The between-school standard deviation for science scores is about 21 points. About 95% of estimated school means are between 512 and 592, both well above the OECD average of 500 points. This excellent result, however, means that there were also 13 schools above and 9 below the reference value of 563. These 22 schools represent 14% of Finnish schools in the PISA sample.

The school residuals for PISA math are presented in rank order in Figure 4.3. The between-school standard deviation for mathematics scores is about 22 points. About 95% of estimated school means are between 505 and 605, both well above the OECD average of 500 points. Again, this excellent result means that there were also 16 schools above and 15 below the reference value of 548. These 31 schools represent 20% of Finnish schools in the PISA sample.

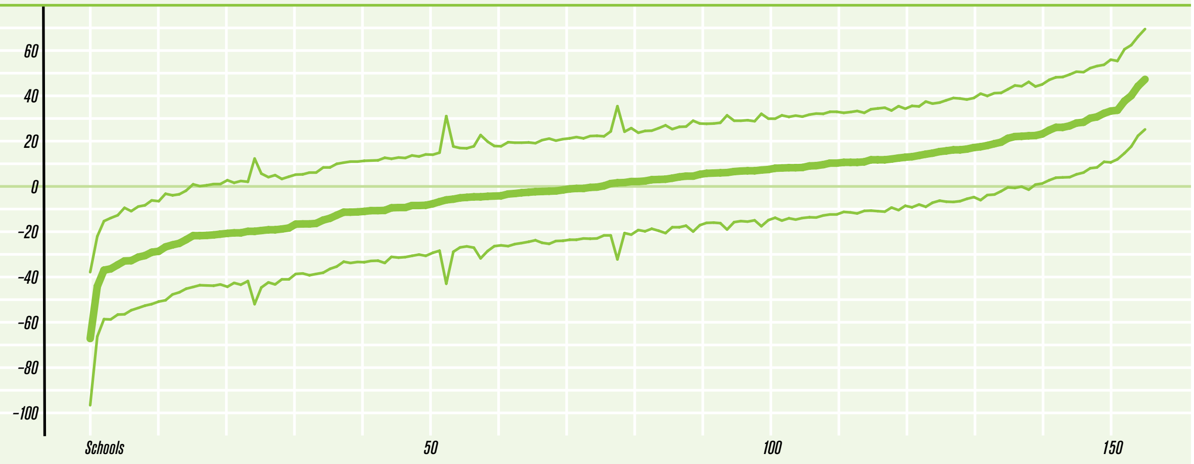
The school residuals for PISA reading are presented in rank order in Figure 4.4. The between-school standard deviation for reading scores is about 26 points. About 95% of estimated school means are between 494 and 598. However, this means that now the lower estimate for the school means is below the OECD average of 500 points. Again, being such a good result means that there were 23 schools above and 25 below the reference value of 546. These 48 schools represent 31% Finnish schools in the PISA sample.

The PISA 2000 reading results have been analysed by Antero Malin (2005). He reported an ICC of 5.6%, using comparable methods. The intercept in 2000 was 545.0 (s.e. 2.09), and in 2006 it was 546.3 (2.33), with an increase mainly in the size of the standard error. However, there are major changes in variances. In 2000 the between-school variances were 435 and in 2006 they were 661. The within-school variances in 2000 were 7307 and in 2006 they were 5253. In 2000 there were 12 schools above and 12 schools below the Finnish average, altogether 16% of the Finnish schools. The present 2006 estimation is that there are 31% of the schools. The first interpretation is that the total variation has decreased, but the between school differences in reading have increased in Finland since 2000.

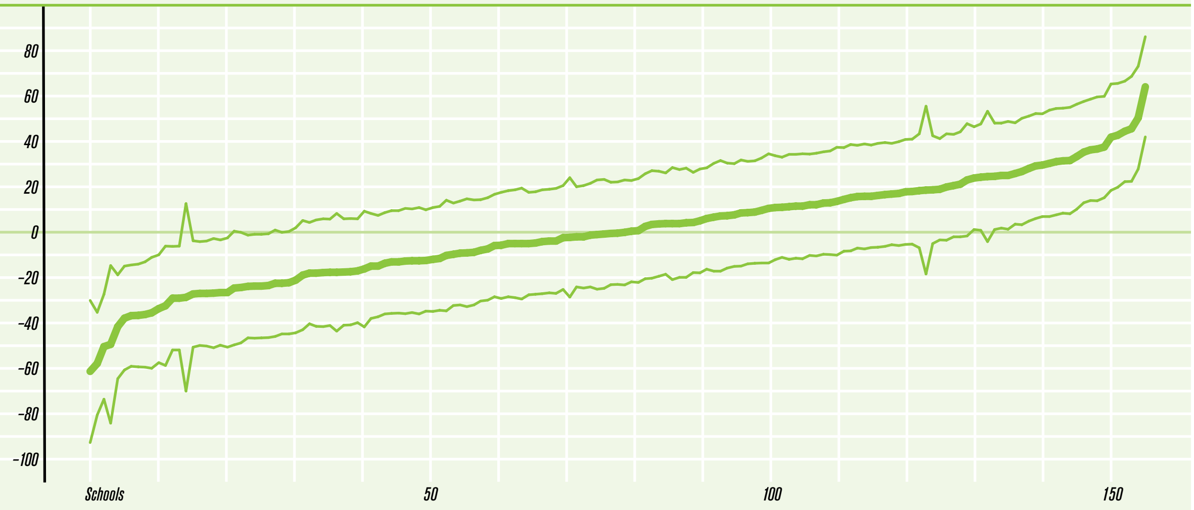
F 4.2 | School residuals of the PISA mean science score with 95 % confidence intervals in rank order in Finland



F 4.3 | School residuals of the PISA mean mathematics score with 95 % confidence intervals in rank order in Finland



F 4.4 | School residuals of the PISA mean reading score with 95 % confidence intervals in rank order in Finland



Describing educational systems

The between-school and within-school variations, together with the level are used to describe education in participating countries. This allows for a comparison so as to understand which education systems seem to be able to provide students with a high educational competence, and which are the best ways for achieving high performance. Also of importance is to locate Finland among the participating countries.

In Figure 4.5, the scatter is presented for level and within-school variance estimates for 55 PISA countries. The highest values for level are in Finland, Hong Kong (China), Korea and Chinese Taipei, and the lowest values are in Qatar and Kyrgyzstan. The largest within-school variations are in New Zealand, Norway and Iceland, and the lowest values are in Azerbaijan and in Indonesia.

In Figure 4.6, the scatter is given for the level and the between-school variance for 55 PISA countries. Finland, in the upper left corner, shows both a high level and a low between-school variation. Countries in the same corner include New Zealand, Estonia, Ireland, Canada, Australia, the other Scandinavian countries, Macao-China, Poland, and Spain. In the upper right corner are countries with a high level and a high between-school variation: Czech Republic, Germany, Belgium, Austria, Japan, Netherlands, Hungary, and France. In the middle upper area there are countries with a high level and average between-school variation: included are Hong Kong (China), Korea and Chinese Taipei.

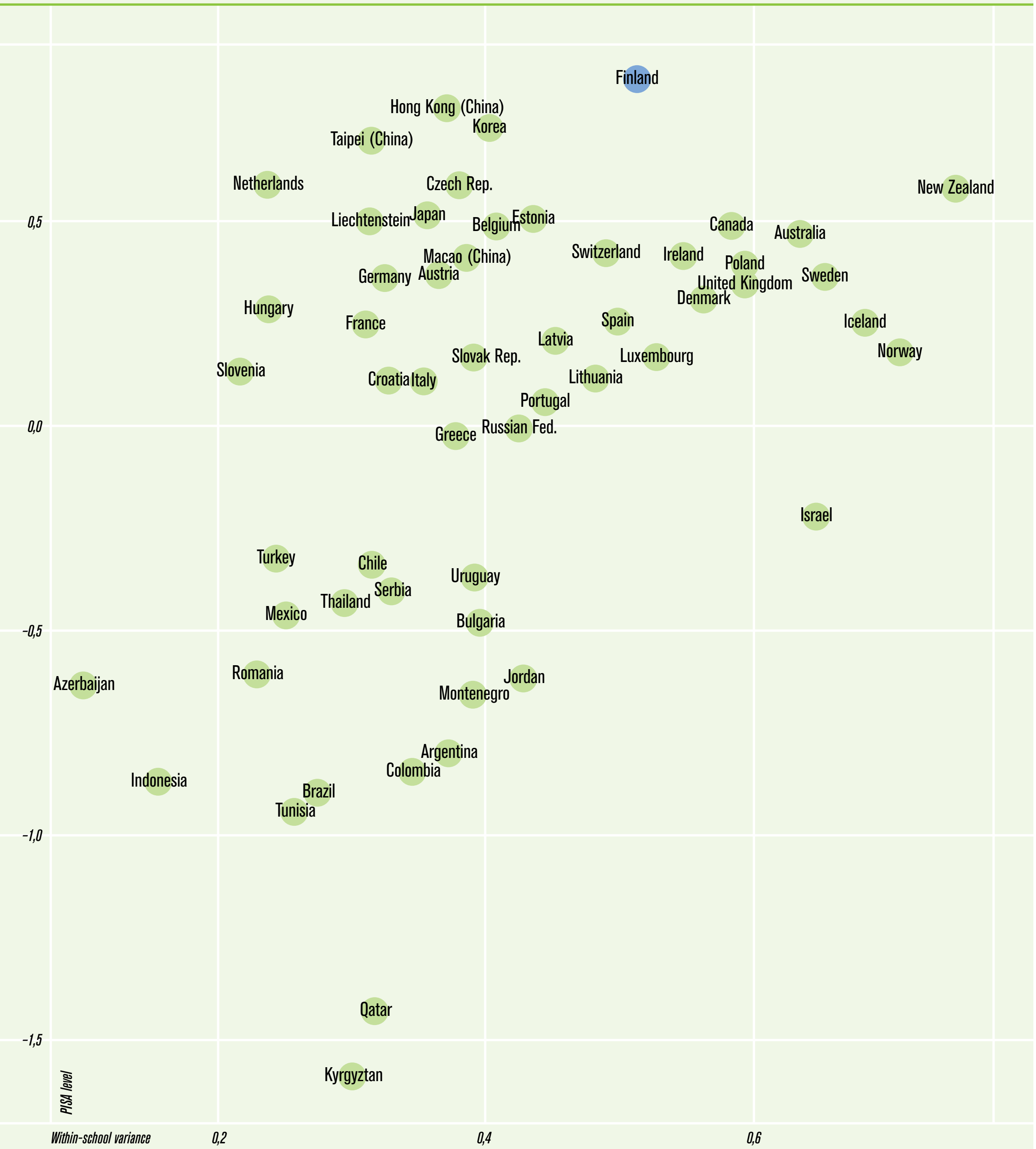
In Figure 4.7 we present all three variables together. The X-axis represents the within-school variance, and the Y-axis the between-school variance. The countries are furthermore classified according to the value of level, in three classes. The bigger the circle, the better is the level. Some of the countries with a high level are marked with red filled circles, in order to assist readers to orientate the complex information. The filled circles are some of the countries where the average level is more than half of SD above the OECD average. This difference is statistically significant and also meaningful. There are three types of countries: a) there are untracked comprehensive systems still at the age of 15 in Finland and New Zealand, b) the schools of the Far East, in Hong Kong, Korea and Chinese Taipei, where the tracked systems started at the age of 14, and c) schools of Czech Republic and the Netherlands, where the tracked system starts at the age of 11-12.

Types of educational systems

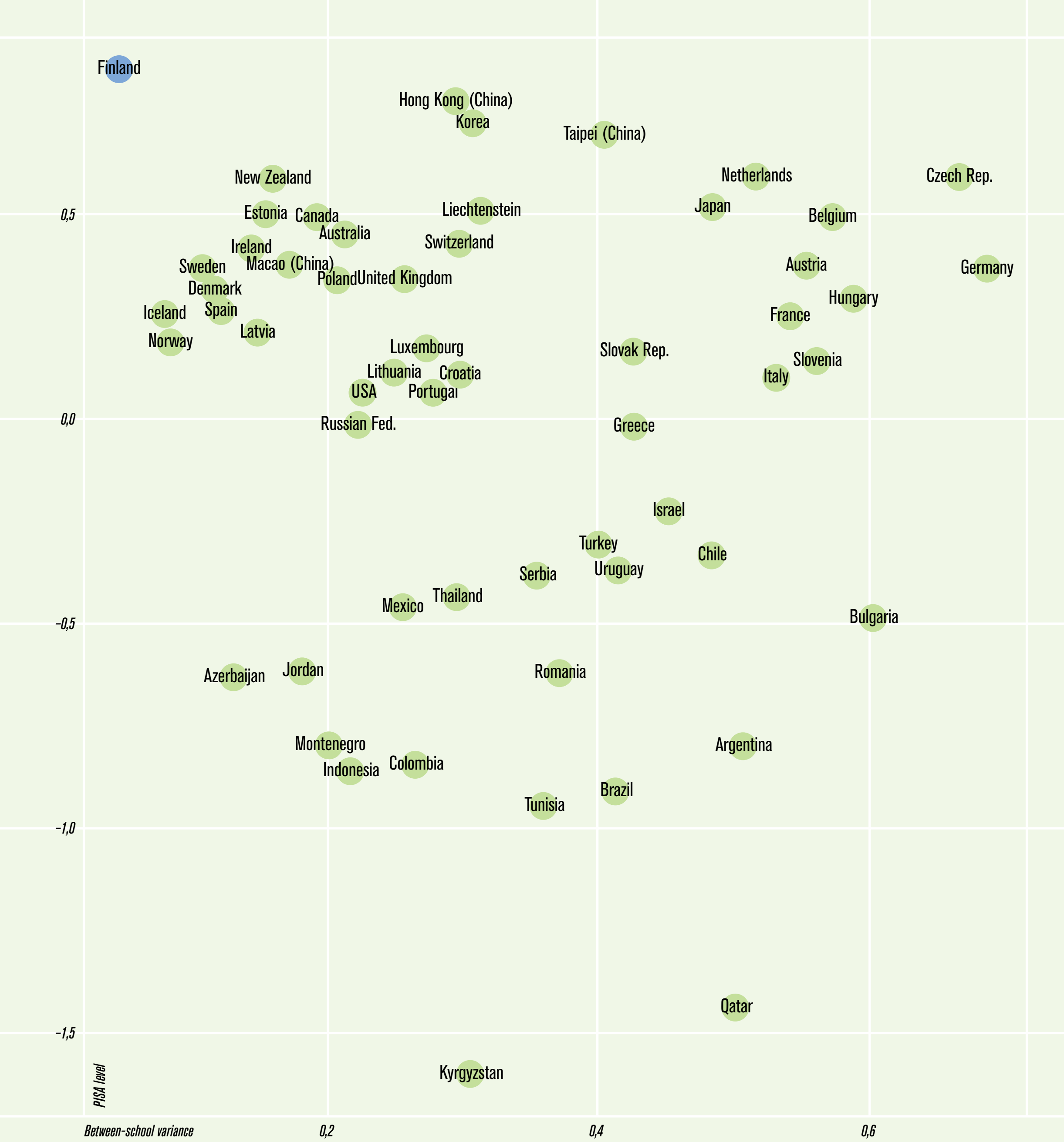
In order to generalise about the results, the countries have been cross-classified using the within-school variation and the between-school variation. Both variables have been classified into three classes: low, average and high. Following this the 55 countries (US excluded) have been classified into a 3x3 cross-tabulation (Table 4.3).

The first observation is that the top 15 countries in PISA science are spread across all three groups of between-school variation: 6 in the low, 5 in the average and 4 in the high between-school variation. The generalisation is that low between-school variation is not the only way to achieving high competence in the PISA assessment. However, another observation refers to a more effective factor. Most of the top countries have an average within-school variation. Finland belongs to a group with an average within-school variation and a low between-school variation. This typology should be read with a comparison to Figures 4.6 and 4.7. The most important interpretation is that the educational system seems to work best, when the total variation is somehow controlled or in the average range.

F 4.5 | Scatter of level and within-school variance, by countries (N=55)

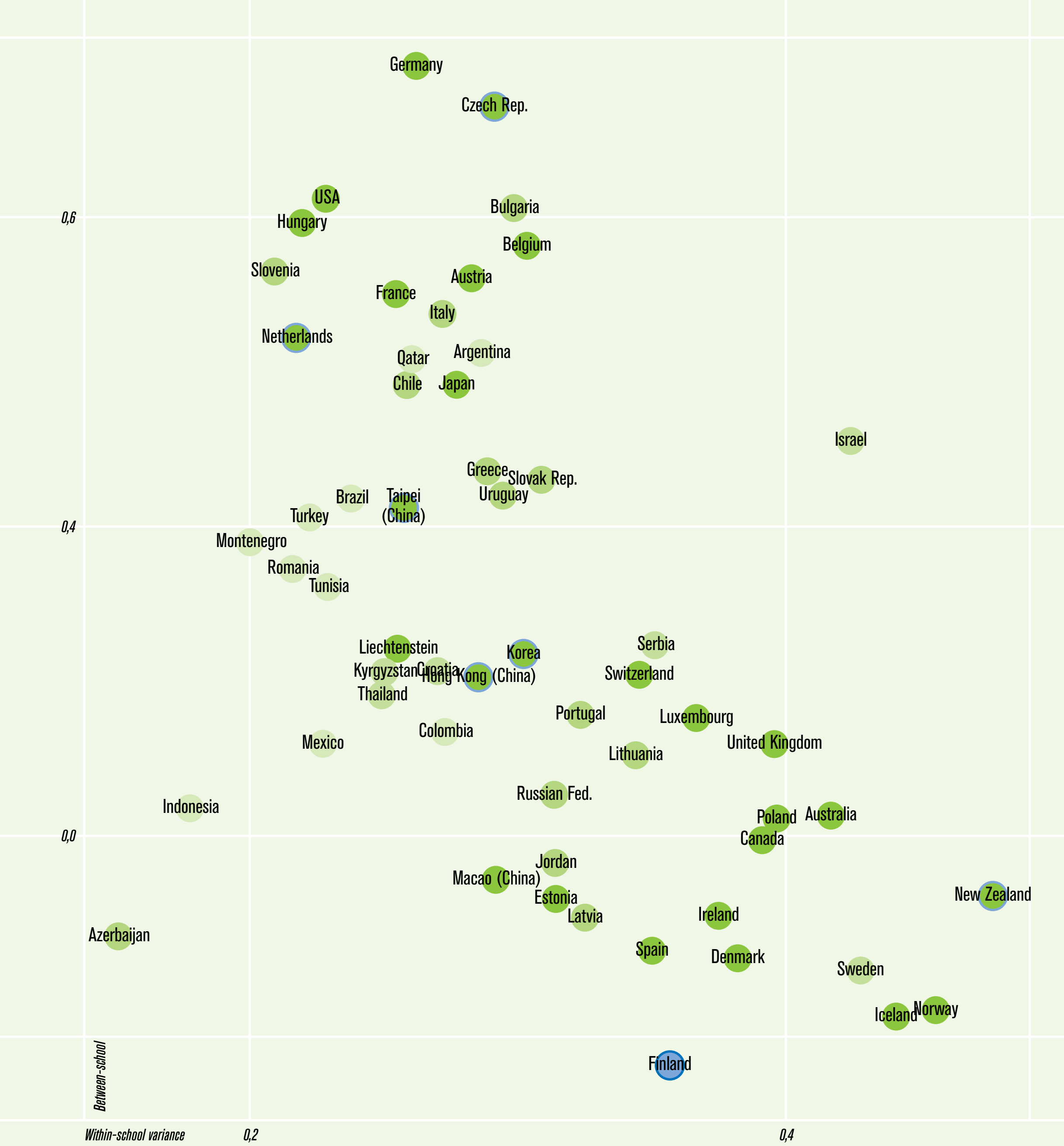


F 4.6 | Scatter of level and between-school variation, by countries (N=55)



F 4.7 | Between-school and within-school variance, by countries (seven well-doing countries marked)

PISA general level −1,602 −0,383 0,837



T 4.3 | Typology of Educational Systems

	School Variation Low	*School Variation Middle*	*School Variation High*
Student Variation High	Australia		
	Canada		
	Iceland		
	New Zealand		
	Norway		
	Poland		
	Sweden		
	United Kingdom		
	USA		
Student Variation Middle	Denmark	Chinese Taipei	Austria
	Estonia	Croatia	Belgium
	Finland	Hong Kong-China	Czech Republic
	Ireland	Japan	France
	Latvia	Korea	Germany
	Lithuania	Liechtenstein	Hungary
	Luxembourg	Argentina	Italy
	Macao-China	Bulgaria	Netherlands
	Portugal	Chile	Slovenia
	Russian Federation	Greece	
	Spain	Israel	
	Switzerland	Slovak Republic	
		Uruguay	
Student Variation Low		Azerbaijan	
		Brazil	
		Colombia	
		Indonesia	
		Jordan	
		Kyrgyzstan	
		Montenegro	
		Mexico	
		Qatar	
		Romania	
		Serbia	
		Thailand	
		Tunisia	
		Turkey	

Discussion

There are some reservations, especially with concerns to Finland. The first one is the fact that in Finland the educational system is divided into vocational and general track only after the 9th grade, when the students are already 15 or older. One reason for the timing of the division is that children start going to school in Finland when they are 7 years old. In several other countries, with basically the same kind of comprehensive system, the division takes place one or even two years earlier. This division in relation to both between-school and within-school variation seems to boost the differences. Also in Finland, the between-school variation is substantially higher after the division, at the age of 17 plus (Hautamäki & a. 2002). The conclusion is that for a general interpretation of the education system's competence to meet the variation one would need several cross-sectional samples at different ages, and also longitudinal studies.

The second point is that, especially in Finland, the class-composition during the upper part of the comprehensive school absorbs a lot of the total variation. This source of the variation cannot be analysed using PISA design, because the studied 30/35 students are selected randomly from their schools. This is an important omission, as in Finland there are large between-class variation components (Hautamäki et al. 2005), which partly made the low between-school variance understandable.

The third point is that more detailed modelling should be done separately in science, mathematics and reading. The analyses of these three domains constitute chapters 5, 6 and 7.

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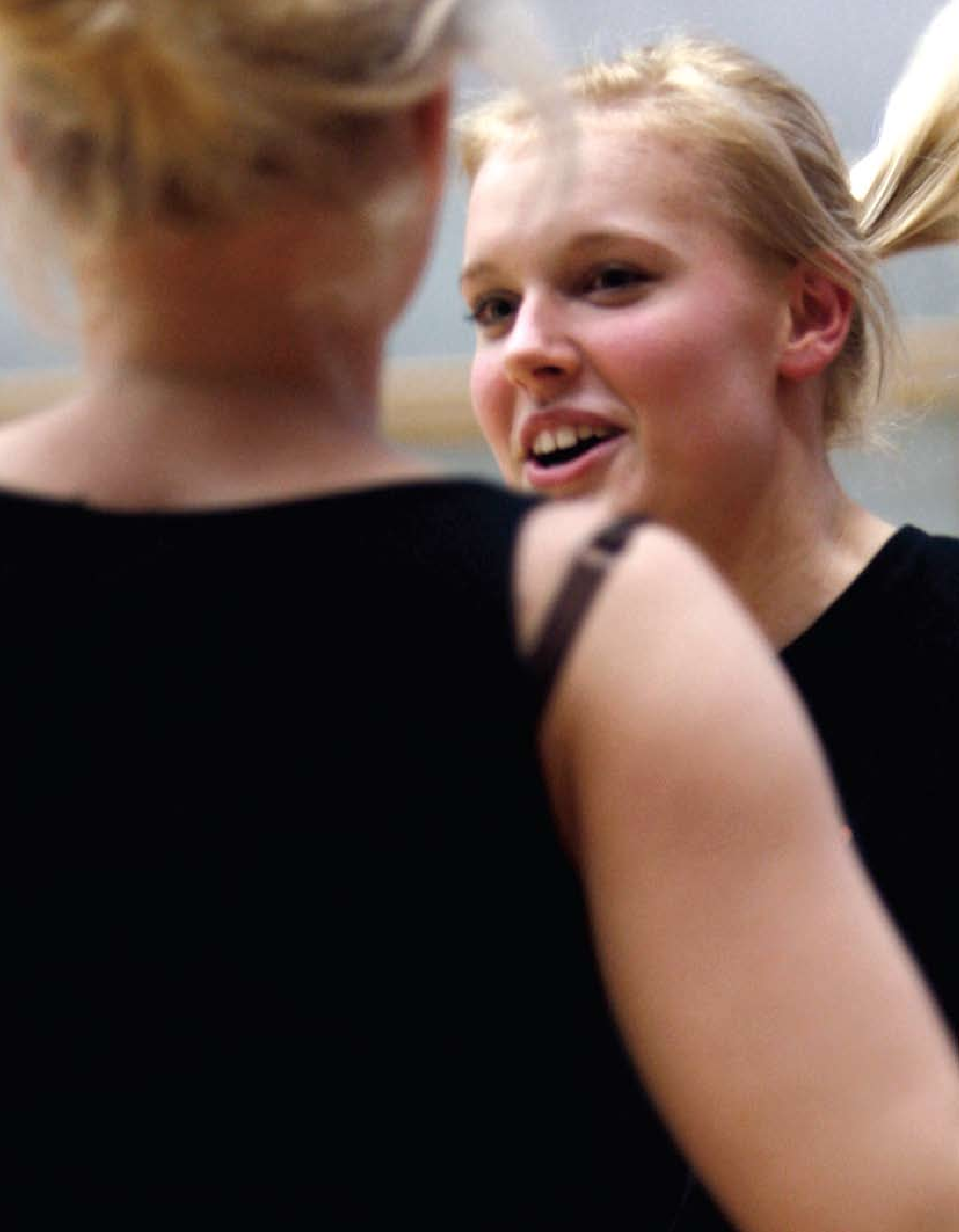


Finnish students think that science is valuable to society and that it usually improves the economy and people's living conditions.

However, the students think that science is not relevant to them personally.

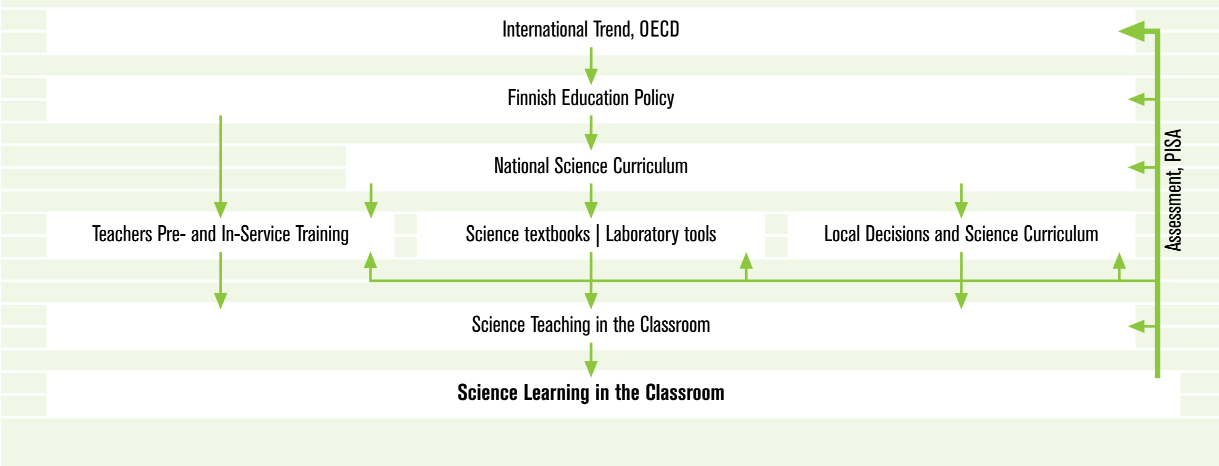
5
Scientific Literacy Assessment

Jari Lavonen

The purpose of this chapter is to analyse cognitive and affective PISA 2006 Scientific Literacy Assessment data (OECD 2007a, 2007b). This includes data concerning approaches to science learning, learning environment, and the organisation of schooling, acquired with the School Questionnaire (OECD 2005a) and the Student Questionnaire (OECH 2005 b). In addition to the PISA data, the Finnish education policy regarding science education will be analysed. This policy is implemented through the national and local level science curriculum, learning materials and teacher education. Figure 1 presents the framework for the analysis. It is assumed that local, nationwide and PISA assessments give feedback to each component of the framework (cf. Halinen, 2008).

The main focus of PISA 2006 was scientific literacy. The PISA 2006 assessment data (described in OECD 2007a, 2007b) and data acquired with the School Questionnaire (OECD 2005a) and the Student Questionnaire (OECH 2005b) is available on the

F 5.1 | The Finnish education policy and implementation of it through national and local level science curriculum, teacher education and science classroom practice.



PISA 2006 web page (http://pisa2006.acer.edu.au/downloads.php#questionnaires).

The PISA 2006 Technical Report (OECD 2005c) describes the complex PISA 2006 methodology including information on the test and random sample design, methodologies used to analyse the data, quality control mechanisms and other technical features of the project. More detailed information about the data and how it can be analysed is given in the PISA 2006 Data Analysis Manual. All basic PISA 2006 assessment results have been published in two books (OECD 2007a, 2007b).

In addition to PISA 2006 data, we review the national education policy documents and other documents, like national curriculum, which are important to science education at the comprehensive school level in Finland.

5|1 PISA 2006 scientific literacy assessment

The Program for International Student Assessment (PISA) assesses how far students near the end of compulsory education have acquired some of the knowledge and skills, scientific literacy, that are essential for their full participation in society. Scientific literacy is defined as the ability to use scientific knowledge and processes to understand the natural world and to participate in decisions that affect it (OECD, 2006, 2007a, p. 16).

Scientific literacy is assessed in PISA in relation to:

- Scientific knowledge or concepts constitute the links that aid understanding of related phenomena. The concepts used in the tasks are familiar ones relating to physics, chemistry, biological sciences, and earth and space sciences but they are applied to the content of the items and not just recalled.
- Scientific processes are centred on the ability to acquire, interpret and act upon evidence. Three such processes present in PISA relate to: i) describing, explaining and predicting scientific phenomena, ii) understanding scientific investigation, and iii) interpreting scientific evidence and conclusions.
- Situations or contexts concern the application of scientific knowledge and the use of scientific processes. The framework identifies three main areas: science in life and health, science in Earth and environment, and science in technology.

Students performance in PISA Science -items

PISA 2006 science framework (OECD, 2006) emphasises competencies, contents, life situations, contexts and item difficulty as a framework for science test and item design. The main science competencies are defined in terms of an individual's scientific knowledge and use of that knowledge to identify scientific issues; explain scientific phenomena and; draw evidence-based conclusions. The four content areas of scientific knowledge are physical systems, living systems, earth and space systems, and technology systems. These four content areas represent important knowledge that is required by adults for understanding the natural world and for making decisions. Two categories of knowledge about science are: scientific enquiry, and scientific explanations. Scientific enquiry centres on enquiry as the central process of science and the various components of that process. Scientific explanations are the results of scientific enquiry.

The PISA programme assesses students' orientation for future life. Therefore, the PISA 2006 science questions were framed within a wide variety of life situations involving science and technology, namely: health, natural resources, environmental quality, hazards and frontiers of science and technology. These situations were related in item design to three major contexts: personal (self, family and peer groups), social (community) and global (life across the world). Consequently, the contexts used for questions were chosen in the light of relevance to students' interests and lives, representing science-related situations that adults encounter. Almost daily, adults hear about and face decisions concerning health, use of resources, environmental quality, hazard mitigation, and advances in science and technology. The science contexts also align with various issues policy makers confront.

Items are classified also by item difficulty, with the six point relative difficulty scale. Questions at Levels 1 or 2 could be typically solved by students who have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations or some interpretations of the results of scientific inquiry or technological problem solving. These kinds of students are at proficiency Level 1 or 2.

Questions at Levels 3 or 4 could be solved by students who are at the proficiency Level 3 or 4 and can in addition to previous skills work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions and they can communicate decisions using scientific knowledge and evidence. At Level 3 the models or inquiry strategies students are using are simpler than at Level 4 and the students can develop short statements using facts and make decisions based on scientific knowledge.

Questions at Levels 5 or 6 could be solved by students who can, in addition to previous skills, consistently identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations (proficiency Level 5 or 6 students). The students can link different information sources and explanations and use evidence from those sources to justify decisions. They demonstrate advanced scientific thinking and reasoning, and willingness to use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, social or global situations. At Level 5, the students can use well-developed inquiry abilities, link knowledge appropriately and bring critical insights to situations, and can construct explanations based on evidence and arguments based on their critical analysis. However, the reasoning at Level 5 is not as advanced as at Level 6.

Some examples of PISA items and Finnish students' performance on them are given in Figures 5.2 – 5.5 and Tables 5.1 – 5.6. The classification of an item, presented at the end of each item, is based on the multidimensional PISA science items classification system. Finally, scoring criteria is presented. The percentages of correct answers on average in Finland and in OECD countries are presented after each item in table form.

First question concidering acid rain is presented in Figure F 5.2. In the scoring, full 'Credits' were given to any mention regarding car exhausts, factory emissions, burning fossil fuels such as oil and coal, gases from volcanoes or other similar things. Examples of correct answers: "Burning coal and gas", "Oxides in the air come from pollution from factories and industries.", "Volcanoes.", "Fumes from power plants", "They come from the burning of materials that contain sulphur and nitrogen". Partial credits were given to the responses that included an incorrect as well as a correct source of the pollution, for example: "Fossil fuel and nuclear power plants." [Nuclear power plants are not a source of acid rain.]", "The oxides come from the ozone, atmosphere and meteors coming toward Earth." Also responses that referred to "pollution" when describing the burning, but did not give a source of pollution that is a significant cause of acid rain, like: "Pollution.", "The environment in general, the atmosphere we live in – e.g. pollution." (OECD, 2007a).

Acid rain - Question 2 (S485Q02) is an example of a question in the middle of the difficulty scale. The question requires students to explain the origin of sulphur and nitrogen oxides in the air. Correct responses

F 5.2 | Example task | Acid rain

ACID RAIN

Below is a photo of statues called Caryatids that were built on the Acropolis in Athens more than 2500 years ago. The statues are made of a type of rock called marble. Marble is composed of calcium carbonate.
In 1980, the original statues were transferred inside the museum of the Acropolis and were replaced by replicas. The original statues were being eaten away by acid rain.

Question 2: ACID RAIN *S485Q02 – 0 1 9*

Normal rain is slightly acidic because it has absorbed some carbon dioxide from the air. Acid rain is more acidic than normal rain because it has absorbed gases like sulfur oxides and nitrogen oxides as well.

Where do these sulfur oxides and nitrogen oxides in the air come from?

....

Question type: Open-constructed response | Competency: Explaining phenomena scientifically
Knowledge category: “Physical systems” (knowledge of science)
Application area: “Hazards” | Setting: Social | Difficulty level (1… 6): 3

T 5.1 | Finnish students' performance in the item "Acid rain - Question 2" of the PISA 2006 Scientific Literacy Assessment.

	Missing Data	Incorrect	Partially Correct	Totally Correct
Finland	1.1	21.4	12.4	65.1
OECD Average	2.4	31.3	20.2	46.3

require students to demonstrate an understanding of the chemicals as originating as car exhaust, factory emission, and burning fossil fuels. Students have to know that sulphur and nitrogen oxides are products of the oxidation of most fossil fuels or arise from volcanic activity. Students gaining credit display a capacity to recall relevant facts and thus explain that the source of the gases contributing to acid rain was atmospheric pollutants. The awareness that oxidation results in the production of these gases places the question in the "Physical systems" content area. Since acid rain is a relatively localised hazard, its setting is social. Attributing the gases to unspecified pollution is also an acceptable response. Analysis of student responses shows little difference in the ability levels of students giving this response compared to those giving the more detailed response. For partial credit and a response considered to be at difficulty Level 3, they have simply to state it is a comparison, although if a student states that the acid (vinegar) is necessary for the reaction the response will be considered difficulty Level 6. Both responses are linked to the competency identifying scientific issues (OECD, 2007a).

Second question on acid rain is presented on Figure 5.3. Full credits in scoring of this question were given to the choice of alternative A: Less than 2.0 grams. This question is an example of a Level 2 difficulty item measuring competency of "using scientific evidence". The question asks students to use information provided to draw a conclusion about the effects of vinegar on marble (a simple model for the influence of acid rain). Several pieces of information are available from which a student can draw a conclusion. In addition to the descriptive evidence provided, the student must also draw on knowledge that a chemical reaction is the source of the bubbles of gas and that the reaction happens between the chemicals in the marble chip. Consequently, the marble chip will lose mass. Since an awareness of a chemical process is a prerequisite for drawing the correct conclusion this question belongs in the "Physical systems" content area. The application is dealing with the hazard of acid rain, but the experiment relates to the individual and thus the setting is personal. A student able to correctly respond to this difficulty Level 2 question can recognise relevant and obvious cues that outline the logical path to a simple conclusion (OECD, 2007a).

In the acid rain theme, there was a third question, formulated as an open-constructed response, and coded to be top of the difficulty scale (6): "Students who did this experiment also placed marble chips in pure (distilled) water overnight. Explain why the students included this step in their experiment?" This question guides students to identify scientific issues and measures students' knowledge about science. Full credits were given to students who showed in their response that the acid (vinegar) was necessary for the reaction, for example by stating: "To make sure that rainwater must be acidic like acid rain to cause this reaction." or "To see whether there are other reasons for the holes in the marble chips." The percentage of correct answers in Finland was 59.7% and on average in OECD countries 35.6 %. Students who gained full credit for answering this question correctly understand that it is necessary to show that the reaction will not occur in water. Vinegar is a necessary reactant. Placing marble chips in distilled water demonstrates an understanding of a control in scientific experiments. The question requires students to exhibit knowledge about the structure of an experiment and therefore it belongs in the "Scientific enquiry" category. A student obtaining full credits for this question is able to both understand the experimental modelling used and to articulate the method used to control a major variable. A student who received only partial credits was only able

F 5.3 | Example task | Acid rain

Question 3: ACID RAIN S485Q03

A marble chip has a mass of 2.0 grams before being immersed in vinegar overnight. The chip is removed and dried the next day. What will the mass of the dried marble chip be?

A Less than 2.0 grams
B Exactly 2.0 grams
C Between 2.0 and 2.4 grams
D More than 2.4 grams

Question type: Multiple choice | Competency: Using scientific evidence
Knowledge category: "Physical systems" (knowledge of science)
Application area: "Hazards" | Setting: Personal | Difficulty level (1… 6): 2

to recognise the comparison being made, but without appreciating the purpose of the comparison (OECD, 2007a).

Question concidering sunscreen are presented in figures 5.4 and 5.5. Full credits in scoring of the question 2 (F 5.4) were given to the choice of alternative D: Mineral oil and zinc oxide are both reference substances. This question is an example of a difficulty Level 4 item measuring competency of "identifying scientific issues". The question requires the student to understand the nature of a scientific enquiry in general and to recognise how the effectiveness of the sunscreens is being measured by reference to two substances at the extremes of the measured effect in particular. The application is about protection from UV radiation and the setting has a personal focus. In addition to being able to recognise the change and measured variables from a description of the experiment, a student gaining full credit can identify the method being used to quantify the measured variable. (OECD, 2007a)

Full credits in scoring of the question 5 (F 5.5) were given to those who chose alternative A and gave the explanation that the ZnO spot has stayed dark grey (because it blocks sunlight) and the M spot has gone white (because mineral oil absorbs very little sunlight). [It was not necessary to include the further explanations that are shown in parentheses]. This question is an example of a difficulty level 4 item measuring competency of "using scientific evidence". Full credits were given for example to the responses: "A. ZnO has blocked the sunlight as it should and M has let it through.", "I chose A because the mineral oil needs to be the lightest shade while the zinc oxide is the darkest." Partial credits were given, for example, to responses which gave a correct explanation for either the ZnO spot or the M spot, but not both. Consequently, the question requires a student to demonstrate an understanding of

T 5.2 | Finnish students' performance in the item "Acid rain - Question 3" of the PISA 2006 Scientific Literacy Assessment

	Missing	*A*	*B*	*C*	*D*
Finland	1.7 %	77.8 %	7.4 %	11.1 %	1.9 %
OECD Average	2.9 %	65.7 %	12.1 %	16.2 %	3.2 %

F 5.4 | Example task | Sunscreen

SUNSCREENS

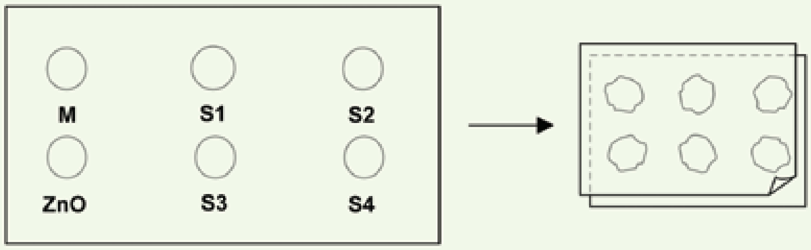
Mimi and Dean wondered which sunscreen product provides the best protection for their skin. Sunscreen products have a *Sun Protection Factor (SPF)* that shows how well each product absorbs the ultraviolet radiation component of sunlight. A high SPF sunscreen protects skin for longer than a low SPF sunscreen.

Mimi thought of a way to compare some different sunscreen products. She and Dean collected the following:

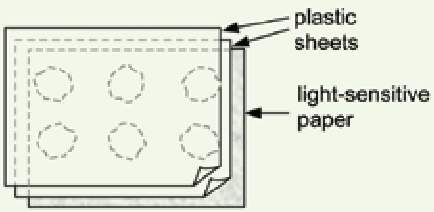
- two sheets of clear plastic that do not absorb sunlight;
- one sheet of light-sensitive paper;
- mineral oil (M) and a cream containing zinc oxide (ZnO); and
- four different sunscreens that they called S1, S2, S3, and S4.

Mimi and Dean included mineral oil because it lets most of the sunlight through, and zinc oxide because it almost completely blocks sunlight.

Dean placed a drop of each substance inside a circle marked on one sheet of plastic, then put the second plastic sheet over the top. He placed a large book on top of both sheets and pressed down.



Mimi then put the plastic sheets on top of the sheet of light-sensitive paper. Light-sensitive paper changes from dark grey to white (or very light grey), depending on how long it is exposed to sunlight. Finally, Dean placed the sheets in a sunny place.



F 5.4 continue , F 5.5 | Example task | Sunscreen

Question 2: SUNSCREENS

S447Q02

Which one of these statements is a scientific description of the role of the mineral oil and the zinc oxide in comparing the effectiveness of the sunscreens?

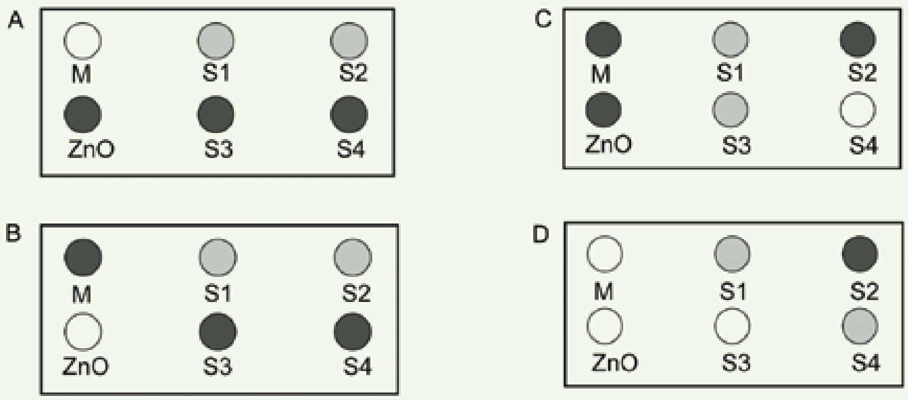
A Mineral oil and zinc oxide are both factors being tested.
B Mineral oil is a factor being tested and zinc oxide is a reference substance.
C Mineral oil is a reference substance and zinc oxide is a factor being tested.
D Mineral oil and zinc oxide are both reference substances.

Question type: Multiple choice | Competency: Identifying scientific issues
Knowledge category: "Scientific enquiry" (knowledge about science)
Application area: "Health" | Setting: Personal | Difficulty level (1. 6): 4

Question 5: SUNSCREENS

S447Q05 – 0 1 2 9

The light-sensitive paper is a dark grey and fades to a lighter grey when it is exposed to some sunlight, and to white when exposed to a lot of sunlight.
Which one of these diagrams shows a pattern that might occur? Explain why you chose it.



Answer: ....

Explanation: ....

Question type: Open-constructed response | Competency: Using scientific evidence
Knowledge category: "Scientific explanations" (knowledge about science)
Application area: "Health" | Setting: Personal | Difficulty level (1. 6): 4

T 5.3 | Finnish students' performance in the item "Sunscreen – Question 2" of the PISA 2006 Scientific Literacy Assessment

	Missing	A	B	C	D
Finland	0.4 %	10.7 %	10.9 %	9.3 %	68.7 %
OECD Average	1.6 %	22.5 %	15.7 %	17.7 %	42.5 %

T 5.4 | Finnish students' performance in the item "Sunscreen – Question 5" of the PISA 2006 Scientific Literacy Assessment

	Missing Data	Incorrect	Partially Correct	Totally Correct
Finland	0.8 %	50.6 %	4.8 %	43.8 %
OECD Average	2.6 %	62.2 %	4.8 %	30.4 %

T 5.5 | Finnish students' performance in the item "Mary Montagu – Question 2" of the PISA 2006 Scientific Literacy Assessment

	Missing	A	B	C	D
Finland	0.2 %	1.3 %	91.3 %	4.1 %	3.0 %
OECD Average	0.8 %	4.9 %	78.1 %	6.9 %	9.3 %

the diagrams shown and then to make a correct selection. Answering correctly requires matching the shades of grey shown in the diagram with the evidence provided in the stimuli of the question and the unit. The student must bring together three pieces of evidence in order to form a conclusion: (1) that mineral oil lets most of the sunlight through while ZnO blocks most of the sunlight; (2) that the light-sensitive paper lightens on exposure to sunlight; and (3) that only one of the diagrams meets both of the criteria. By requiring a conclusion to be drawn that is logically consistent with the available evidence, this question is placed in the category of "Scientific explanations". The application is about protection from UV radiation and the setting is personal. The student must bring together several pieces of evidence and effectively explain its logical consistency by generating a correct conclusion. (OECD, 2007a)

Question concidering the history of vacination is presented in figure 5.6. Full credits in scoring were given to those who chose alternative B: Diseases that are caused by viruses, like polio. This question is an example of a difficulty Level 2 item measuring competency of "explaining phenomena scientifically". To gain credit the student had to recall a specific piece of knowledge that vaccination helps prevent diseases, the cause for which is external to normal body components. This fact is then applied in the selection of the correct explanation and the rejection of other explanations. The term "virus" appears in the stimulus text and provides a hint for students. This lowered the difficulty of the question. Recalling an appropriate, tangible scientific fact and its application in a relatively simple context locates the question at a low level (2) of difficulty. (OECD, 2007a)

Finnish students performance

PISA science scores and standard deviations of the participating countries in PISA science scale are presented in Figure 5.7. OECD mean is 500 and standard deviation 100, as is always the case in PISA assessment.

PISA student scores are classified into six proficiency levels. The distribution of student performance across the proficiency levels in Finland is different to any other countries (Figure 5.8). In Finland the percentage of students at Level 1 (or lower) was 4.1% while it was 19.3% on average in OECD countries. At Levels 5 and 6 the percentage of Finnish students was 20.9% while it was 9% on average in OECD countries.

F 5.6 | Example task | Mary Montagy

MARY MONTAGU

Read the following newspaper article and answer the questions that follow.

THE HISTORY OF VACCINATION

Mary Montagu was a beautiful woman. She survived an attack of smallpox in 1715 but she was left covered with scars. While living in Turkey in 1717, she observed a method called inoculation that was commonly used there. This treatment involved scratching a weak type of smallpox virus into the skin of healthy young people who then became sick, but in most cases only with a mild form of the disease.

Mary Montagu was so convinced of the safety of these inoculations that she allowed her son and daughter to be inoculated.

In 1796, Edward Jenner used inoculations of a related disease, cowpox, to produce antibodies against smallpox. Compared with the inoculation of smallpox, this treatment had less side effects and the treated person could not infect others. The treatment became known as vaccination.

Question 2: MARY MONTAGU *S477Q02*

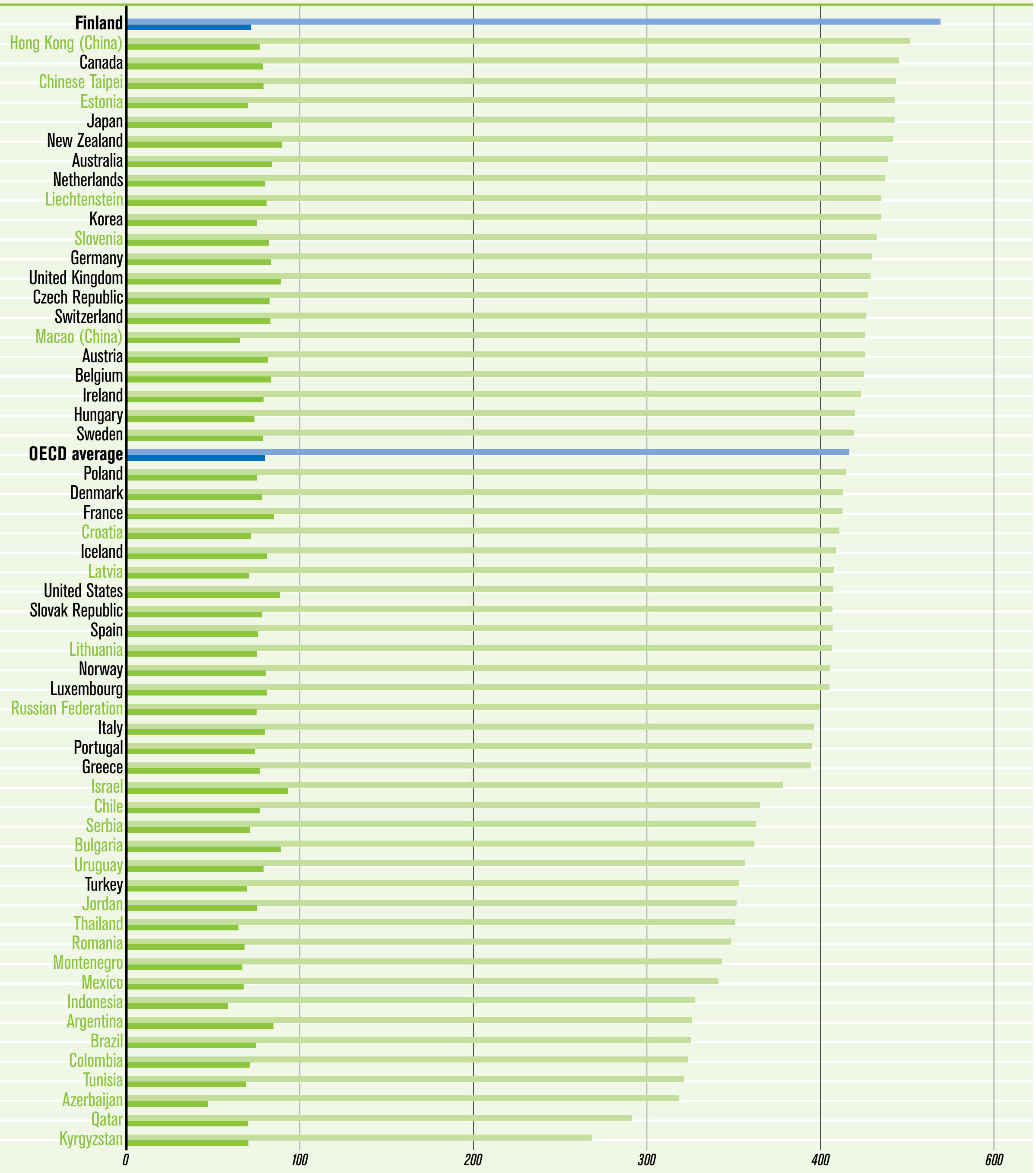
What kinds of diseases can people be vaccinated against?

A Inherited diseases like haemophilia.
B Diseases that are caused by viruses, like polio.
C Diseases from the malfunctioning of the body, like diabetes.
D Any sort of disease that has no cure.

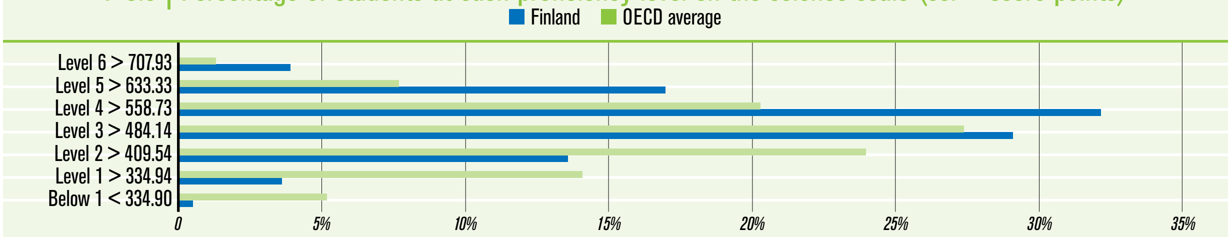
Question type: Multiple choice | Competency: Explaining phenomena scientifically
Knowledge category: “Living systems” (knowledge of science)
Application area: “Health” | Setting: Social | Difficulty level (1 ... 6): 2

F 5.7 | PISA science scores and standard deviations of the participating countries on the PISA science scale

Mean ■ Standard Deviation | Names of the OECD countries are in black and Partner countries in green



F 5.8 | Percentage of students at each proficiency level on the science scale (sc. = score points)



For making comparisons with the PISA scale, it is useful to remember that a difference of 74.7 score points represents one proficiency level on the PISA science scale. This means that there is a large difference, in student performance, between levels on the PISA scale. For example, Level 3 requires students to select facts and knowledge to explain phenomena and apply simple models or inquiry strategies, whereas at Level 2 they are only required to engage in direct reasoning and make literal interpretations. Another benchmark is that the difference in performance on the science scale between the countries with the highest and lowest mean performance is 241 score points, and the performance gap between the countries with the fifth highest and the fifth lowest mean performance is 143 score points.

Finland had the lowest standard deviation (SD = 81.4 score points) between students in well performing OECD countries. The second lowest deviation was in Poland (89.7). The highest standard deviation between students was found in the United Kingdom (124.4), United States (124.7) and New Zealand (125.2).

Figure 5.9 illustrates the variation of the PISA 2006 Scientific Literacy scores, which is divided to variation of performance within schools and between schools in some participating countries. The data is arranged according to performance between schools. Variation between schools is lowest in Finland and highest in Germany.

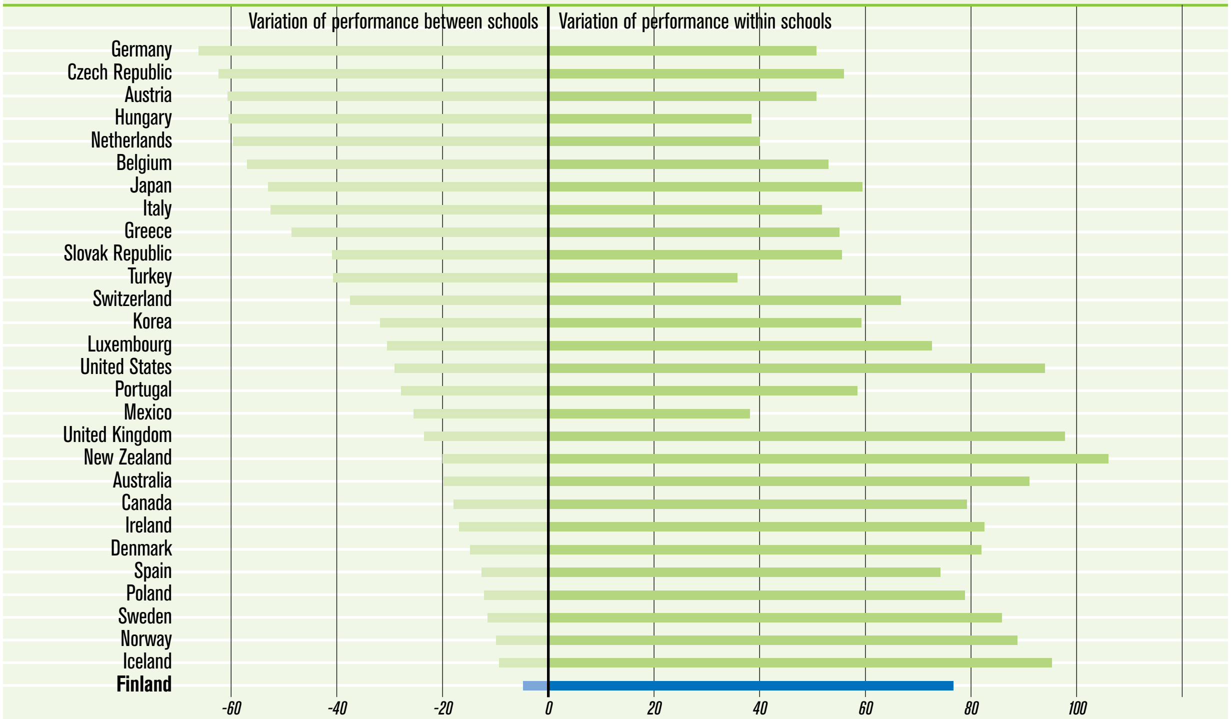
In Figure 5.10 students' PISA scores in different competence categories, and in some knowledge areas and knowledge about science in selected countries are presented on the PISA scale.

Figure 5.10 demonstrates that Finnish students get higher scores in all competence levels and knowledge areas. It is especially important to observe that the difference in all areas between Finnish students and students in other Scandinavian countries is equal to one proficiency level (74.7 scores points).

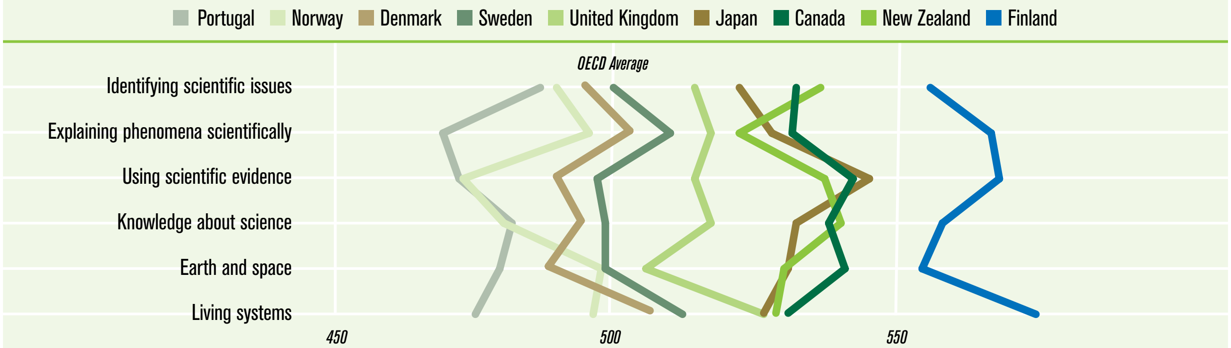
One important point of view to PISA science results is the achievement of high and low performing students in different countries. These students can be compared by comparing country percentile scores to the OECD average percentile scores on PISA 2006 science scale. According to Figure 5.11, Finnish students' performance profile is different to any other country profile, except to students' performance profile in Estonia. The high scores of the "low achievers" had an important role in placing Finland at the top of the PISA 2006 science scale.

The Finnish students clearly outperformed their peers in other Scandinavian countries throughout the percentile scale, although they all have similar societies. The figure also illustrates that the Estonian and Korean profile is very similar to the Finnish profile. This kind of profile can also be found, for example, in China, Hungary, Latvia, Macao, Poland and Portugal. It is also interesting to note that the United Kingdom, New Zealand and Australia have similar profiles: the low achieving students' relative position is lower than the position of higher performers, in relation to respective OECD value (in these three countries). This kind of profile is also typical of France, Germany and the United States.

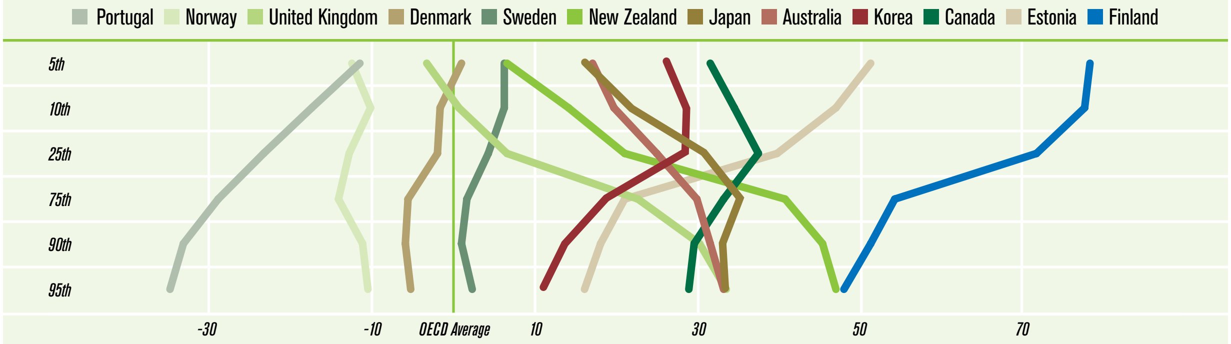
F 5.9 | Variation of the PISA 2006 Scientific Literacy scores



F 5.10 | Students' PISA scores in some countries in different competence categories, knowledge areas and knowledge about science in selected countries



F 5.11 | Difference between country percentile scores and OECD average percentile scores on PISA 2006 science



It seems that Finland, Estonia and Korea are more capable than other countries in taking care of the lower achieving and mid-range students.

The Science score was 562 for males and 565 for females in Finland. Although girls performed a little better, the difference was not statistically significant. However, when the male and female students' performance in different competencies are compared more significant differences can be found. In Finland, as well as in most other countries, females are stronger in identifying scientific issues competence, while males are stronger at explaining phenomena scientifically competence. In the third competency category using scientific evidence, the gender differences were smaller. In the scientific content areas in general, Finnish female students outperform there males counterparts, as is the case in most countries. The female students' mean score on the items measuring knowledge about science scale was 566 (OECD average 497) with the male students' being 550 (OECD average 488). Equally, the female students' mean score in the items measuring student performance on the Living systems scale was 579 (487) and male 569 (493). In contrast, the male students' mean score in items measuring student performance on the Earth and space systems scale was 562 (OECD average 500) and female students' was 547 (OECD average 486) and on the Physical systems scale 576 (500) and 544 (478) respectively. All these male/female differences were statistically significant.

Both students' and schools' socio-economic, social and cultural status have a positive effect on PISA 2006 Scientific Literacy score, but in Finland the effects are smaller than in OECD countries in general.

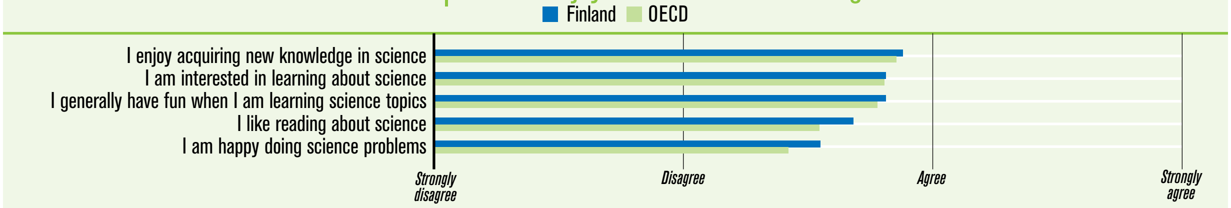
Finnish students' interest in science

In PISA, attitudes are seen as a key component of an individual's science competency and include an individual's values, motivational orientations and sense of self-efficacy. Therefore, PISA 2006 gathered data on students' attitudes and engagement with science in four areas:

- support for scientific enquiry,
- self-belief as science learners,
- interest in science and
- responsibility towards resources and environments.

These areas provide a summary of students' general appreciation of science, personal beliefs as science learners, specific scientific attitudes and values, and responsibility towards selected science-related issues that have national and international ramifications.

F 5.12 | Student enjoyment of science learning



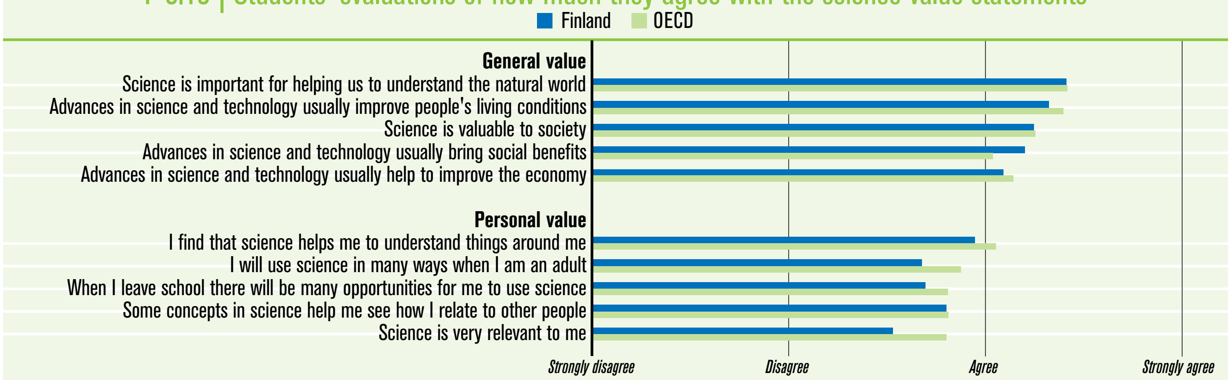
Students' interest towards science and technology and interest in careers in those fields have been extensively researched since the 1960s. It is known that science and technology in general is quite interesting for students and they understand that science is important for industry, economic life and for the whole of society, but most students, especially girls, do not find school science and technology or careers and occupations in those fields interesting (Jones, Howe & Rua, 2000; Osborne, Simon & Collins, 2003; EU, 2004, 2005; Schreiner & Sjøberg, 2005).

The social position of scientists and engineers has weakened in developed countries and their lifestyle appears unattractive to students: working hard and alone in a laboratory. Science and technology occupations are perceived as being of too low a status in relation to the workload. Consequently, a lack of interest in science and technology occupations has more to do with the perceived values and images of science and technology and careers in those fields than with a lack of interest in general to science and technology. Scientists and engineers are no longer seen as being such major symbols of social and economical progress in developed countries as they were before or as they nowadays are in undeveloped countries. Furthermore, several students had stereotypical views of science and technology occupations, like 'I want to work with people and scientists don't do that', 'I think engineering is a man's job', 'I want to be a nurse and so don't need science'. However, discovering new things and an ability to do something useful were recognised as being important reasons for studying science and choosing an occupation in science. Consequently, it seems that students are unaware of the range of career opportunities opened up by studying science and technology, neither are they familiar with the characteristics of science and technology careers (OECD Global Science Forum, 2005).

Motivation research (Deci & Ryan, 2004) suggests that student attitude towards, interest in or motivation to science learning is a prerequisite for science learning. Therefore, PISA 2006 assessed motivational issues of science learning. In Figure 5.12 students' enjoyment for science learning is presented. In Finland male students' mean was on average 0.12 higher than female students' mean (significant difference) (OECD, 2006a).

Data, dealing with the enjoyment of learning, is an indication of self-determined behaviour or intrinsic motivation (Deci & Ryan, 2004). In the PISA 2006 questionnaire there were also questions dealing with extrinsic motivation. This kind of instrumental motivation has been found to be an important predictor for course selection, career choice and performance (Eccles, 1994; Eccles and Wigfield, 1995; Wigfield, Eccles & Rodrgues, 1998). In general, 63% of Finnish students perceived science to be useful to them (67% on average across OECD countries) and helpful for their career prospects and future work (in Finland 51% and 53%; in OECD countries 61% and 63% on average). Although, a slightly smaller proportion felt that what they learned in science would actually help them get a

F 5.13 | Students' evaluations of how much they agree with the science value statements

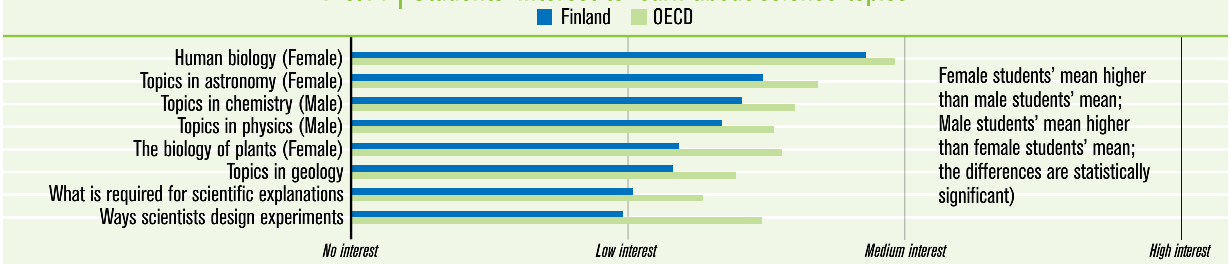


job or be useful for further studies (48% and 43% in Finland and 56% for both in OECD on average). In addition, the students were asked also a series of questions about their motivational orientation to continue their scientific studies or to work in a science-related field. In Finland 26% (OECD 37%) would like to work in a career involving science, 23% (31%) would like to continue to study science after secondary school, 21% (27%) would like to work on science projects as adults and only 12% (21%) would like to spend their whole life doing advanced science.

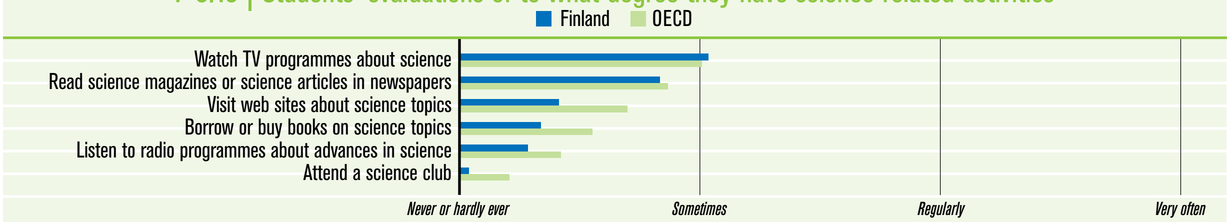
The majority of students in Finland and in OECD countries reported that they, in general, valued science or their attitude was positive to science (Figure 5.13). However, students, especially in Finland, think that science is not so relevant for them, in general or in the future (Personal value). On average, across OECD countries, students almost universally reported believing that science was important for understanding the natural world and that advances in science and technology usually improve people's living conditions, and stated a belief that science was valuable to society. Students also agree that advances in science and technology usually brought social benefits or improved the economy. This suggests that a significant proportion of students distinguish between science value in general and personal value of science. In Finland there were no statistically significant gender differences in the items measuring personal value of science. Male students evaluated more positively the general value items.

Interest in a subject can influence the intensity and continuity of student engagement in learning situations. In turn, strong engagement with a subject deepens students' understanding of that subject. In order to measure students' general interest in science subjects PISA 2006 asked students a set of questions on the following: their level of interest in different subjects [human biology, astronomy, chemistry, physics, the biology of plants and geology]; their general interest in the ways in which scientists design experiments; and their understanding of what is required for scientific explanations (Figure 5.14). While the majority of students in OECD countries reported an interest in human biology, students reported less interest in astronomy, chemistry, physics, the biology of plants and geology. The ways in which scientists design experiments and what is required for scientific explanations were also less interesting. In all areas Finnish students demonstrate much lower interest than on average when compared to OECD countries. In particular, Finnish students had on average low interest in the science process.

F 5.14 | Students' interest to learn about science topics



F 5.15 | Students' evaluations of to what degree they have science related activities

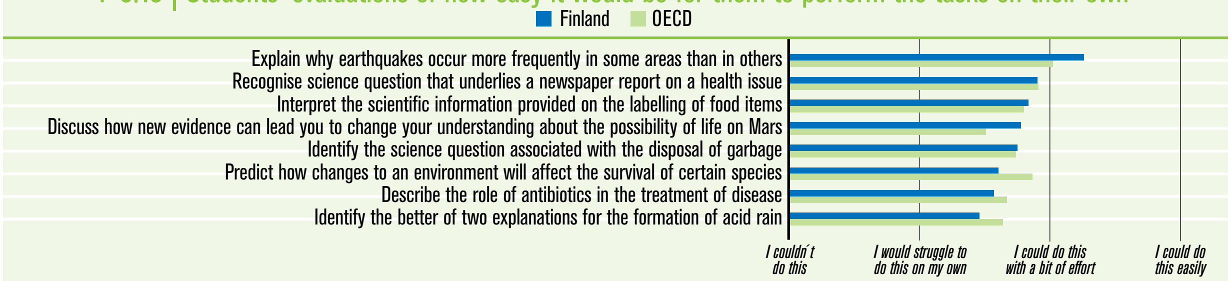


In Finland, male students' mean was 0.5 higher than female students' mean for the item measuring interest in physics and 0.4 higher for the item measuring interest in chemistry. In contrast, female students' mean was 0.5 higher than male students' mean for the item measuring interest in human biology; 0.3 higher for the item measuring interest in plant biology and 0.15 higher for the item measuring interest in Astronomy. The standard deviation varies from 0.8 to 1.0 for both genders. All these differences were statistically significant. In the other three items the difference between means was less than 0.1.

Students' interest in science was measured also by clarifying their science-related activities in their free time. Across OECD countries, and especially in Finland, only a minority of students reported that they engaged regularly in science-related activities (Figure 5.15). On average, students were more likely to report that they regularly watch television programmes on science or read science magazines or articles in newspapers on science than visit websites on science, borrow books on science and listen to radio programmes on science. The vast majority of students reported that they did not regularly attend a science club. It therefore seems that print and television media have the most influence over students in communicating information about science beyond the classroom.

Successful learners are confident of their abilities and believe that investment in learning can make a difference and help them to overcome difficulties – that is, they have a strong sense of their own efficacy. Self-efficacy goes beyond how good students think they are in subjects such as science (Bandura, 1994). To assess self-efficacy in PISA 2006, students were asked to rate the ease with which they believe they could perform eight listed scientific tasks. For each of the eight scientific tasks, the averages are presented in Figure 16. Generally, there were no gender differ-

F 5.16 | Students' evaluations of how easy it would be for them to perform the tasks on their own



ences in the responses of male and female students in Finland. However, male students were more optimistic for explaining why earthquakes occur more frequently in some areas than in others.

In addition to students' self-efficacy also their academic self-concept was measured. It is an important outcome of education and a trait that correlates strongly with student success. Belief in one's own abilities is highly relevant to successful learning (Marsh, 1986). It can also affect other factors such as well-being and personality development, factors that are especially important for students from less advantaged backgrounds. In contrast to self-efficacy in science, where students are asked about their level of confidence in tackling specific scientific tasks, self-concept measures the general level of belief that students have in their academic abilities. On average, 69% of Finnish students (in OECD 69%) reported that they could usually give good answers in science tests. In Finland 52% (in OECD 59%) of the students evaluated that they understand the concepts very well when they are taught science, 61% (56%) thought that they learn quickly, and 61% (55) can easily understand new ideas in school science. Totally 50% (47%) thought that school science topics are easy for them, and 53% (47%) thought that learning of those topics will be easy for them.

In Finland, male students evaluated more positively their own abilities than female students. Although the differences in all items were statistically significant, the real difference was rather small. The male students' mean varied between 2.7 - 2.8 and the female students' mean between 2.5 - 2.8 on the scale (1 = strongly disagree, 4 = strongly agree). Male students were more optimistic than female for explaining why earthquakes occur more frequently in some areas than in others and identified the better of two explanations for formation of acid rain: the difference between means was 0.2. On average the difference between means was 0.1.

In summary, it can be said that in general Finnish students appreciate science. They, especially, think that science is valuable to society and that it usually improves the economy and people's living conditions. Moreover, they think that science helps people to understand the natural world. On the other hand, however, the students also think that science is not relevant to them personally. In addition, most of the students do not see science relevant or useful for further studies and only a minority of them saw themselves doing science in the future. The students reported confidence as science learners, but this varies according to the task. Most of the students participating in PISA 2006 reported that they are interested in learning science and enjoy science learning in general. However, on average, they had low interest in specific topics like biology of plants, physics and chemistry.

5|2 Finnish education policy

A short description of national education policy and its implementation in Finland is outlined from the point of view of comprehensive school science education. Education policy is controlled by the Finnish Ministry of Education (ME). The Finnish National Board of Education (FNBE) takes care of the implementation of this policy. It is responsible for development of education, preparation of the National Core Curriculum for Basic Education (FNBE, 2004), and the organisation of national evaluations based on samples (Figure 5.1).

Education policy is intended to improve and enhance the quality of education, schools and instruction in single subjects, and to make subjects more attractive and teaching more effective. For improving science education, a number of countries have initiated or are initiating action plans and other types of remedies to make science education more effective and attractive, for example, Main à la pâte in France, the Technical-scientific basic year in Sweden, Radboud in the Netherlands and Sinus in Germany. These initiatives can be divided into two types: the "action plans" that include a large spectrum of actions and the "best practices" that are more specific actions focused on specific objectives and targets. Also, in Finland in 1996 the government set as a target in its LUMA programme to raise the level of mathematical and scientific knowledge to the international level (LUMA Programme, 2004). The implementation of the LUMA programme was diverse and it consisted of several sub-projects. One large sub-project was named "the LUMA project" and it was launched by the National Board of Education with the aim to develop the teaching and learning of mathematics and the natural sciences. Approaches included in this project were the financing of school laboratory equipment, developing pedagogical study materials for teachers, and organising long-term in-service training programs for teachers (Lavonen, Meisalo & Juuti, 2004).

Basic national goals

According to Finnish educational policy documents the most important feature of the policy is commitment to a vision of a knowledge-based-society. This vision can already be found in national documents published in the 70s, where idea of common comprehensive school (Committee report, 1970) and university level teacher education (KATU-project, 1978) were presented. A central aspect of the vision has been a broad conception of knowledge. In the Finnish school curriculum, equal value has been given to all subjects. There is a dynamic balance between humanities and science subjects. This balanced thinking is met also in Finnish science centres: a balance of exhibitions in humanities and sciences is emphasised.

Another long-term objective of Finnish education policy has been to raise the general standard of education and to promote educational equality. Basic decisions in this direction were made during the 1970s along with other Nordic countries, when it was decided to change to a comprehensive obligatory school system (Committee report, 1970). According to this policy all students should go to common comprehensive schools and learn together as long as possible. In practice, comprehensive school education is provided free of charge, including schoolbooks, meals, transport and health care. According to School Questionnaire data 97.1% of the Finnish schools participating in the PISA 2006 were public schools (OECD 82.7%). More than 97.5 % of the schools reported that more than 99% of the school funding came from the government. Although, the policymakers' vision is that Finnish students complete the same nine year comprehensive school some minor grouping of students are made at the local level based on students' abilities. According to PISA 2006 School Questionnaire data, 64.3% of the schools participating in the PISA 2006 in Finland reported that students were not grouped by ability into different classes in any subject, and 31.5% were grouped by ability into different classes in some subjects, like in mathematics or foreign languages (In OECD corresponding percentages were 33.3% and 48.2%). Only 5.9% of the participating schools reported that more than 1 % of the students repeat a grade. One reason for this low repeat rate is that special teachers support those with learning difficulties or special educational needs.

Devolution of decision power

Although, there is a national office, Finnish National Board of Education (FNBE), for the implementation of education policy, local authorities have strong autonomy, a lot of freedom, power and responsibility. For example, the participating schools reported that in 65.3% of the schools a principal teacher together with regional or local education authorities (68.1%) formulate the school budget (OECD 53.2% and 35.1% respectively).

In the 1985 national curriculum it was proposed that schools should develop their own local curriculum (FNBE 1985). This movement was strengthened in the1994 curriculum, The Framework Curriculum Guidelines (FNBE, 1994). Therefore, one essential general education policy principle in Finland is the devolution of decision making and responsibility at the local level. The local education providers, municipalities, are responsible for planning local curriculum and organising general assessment and using this data for evaluating how well the goals have been achieved. The role of a principal or a head teacher is important in school development and evaluation and, moreover, in implementation of educational policy at the local level. The participating schools reported that a principal teacher and teachers were responsible for disciplinary policy (96.0%) and for assessment policy (97.0%) (OECD 80.5% and 76.9% respectively).

The schools and teachers are free to choose learning materials and are also responsible for their decisions as national level inspection of learning materials was terminated at the beginning of the1990s. The participating schools reported that a principal teacher and teachers were responsible for selecting the textbooks (100%) and for determining the course content (70.1%) and courses offered (90.1) (OECD 83.5%, 65.9% and 69.9% respectively). Moreover, there have been no national or local school inspectors since the late 1980s. Teachers are valued as experts in curriculum development, teaching and in assessment at all levels (FNBE, 2004). The School Questionnaire data also describes well the positive climate of schools: In Finland student achievement data are used in evaluation of teachers' performance only in 13.7% of the schools (OECD 48.3%).

The culture of trust means that education authorities and national level education policymakers believe that teachers, together with principals, headmasters and parents, know how to provide the best possible education for children and youth at a certain level. Also, the parents trust teachers. According to School Questionnaire data only 1.4% of the schools reported that there is constant pressure from many parents, who expect the school to help the students more, so as to achieve very high academic standards (In OECD the corresponding percentage was 26.1%).

5|3 Science curriculum in the national core curriculum

Guidelines for science education are presented in the national curriculum. The curriculum in Finland has been renewed, during the existence of the comprehensive school system, in 1970, 1985, 1994 and 2004. When the PISA 2006 Scientific Literacy Assessment was done, most students in the lower secondary school were studying according to the National Core Curriculum for Basic Education 2004 (FNBE, 2004). There are special reasons for this claim. In general, new regulations would not start being effective so quickly. In this case the claim can be made as the most frequently used textbooks (e.g., Aspholm, Hirvonen, Hongisto, Lavonen, Penttilä, Saari & Viiri, 2001) were renewed in 2001 in anticipation of the 2004 curriculum and had been used since autumn 2002. Moreover, preliminary versions of the 2004 curriculum were distributed and already in use in 2002. However, the students participating in PISA 2006 assessment had been studying science at primary level according to the1994 curriculum.

When the National Core Curriculum for Basic Education (FNBE, 2004) is compared to the Framework Curriculum Guidelines (FNBE, 1994) three differences can be found. Firstly, one lesson hour (per three year) was increased at grades 7 – 9 in physics and chemistry. Secondly, Environmental and natural studies at grades 5 – 6 was split into two: Biology and geography and Physics and chemistry. Thirdly, health education as an intercurricular subject was introduced for grades 1 -6 and as a school subject for grades 7 – 9.

The latest national curriculum, National Core Curriculum for Basic Education 2004 (FNBE, 2004), is a core curriculum according to which education providers, typically municipalities, prepare the local curriculum. Decisions over the local curriculum should be made regarding the educational and teaching tasks of comprehensive school. Moreover, the objectives and contents specified in the core curriculum, as well as other factors bearing on provision of the education should be taken into consideration.

General aims in the core curriculum

In the general part of the National Core Curriculum for Basic Education (FNBE, 2004) structure, the underlying values and mission of basic education are described. In addition, the core curriculum contains views and recommendations on learning, learning environments, operational cultures and teaching methods. The National Core Curriculum for Basic Education emphasises sosio-constructivist and situational views of learning: The properties of good learning are described as follows:

"…. In addition to new knowledge and skills, both learning and work habits are to be learned that will serve as tools of lifelong learning. … Learning re-

F 5.17 | Allocation of science subjects to grades (lesson hours/week/year) in comprehensive school

Grade	1	2	3	4	5	6	7	8	9
Students age	7	8	9	10	11	12	13	14	15
Level (unofficial)	Primary school						Lower secondary school		
Science subjects	Integrated environmental and natural studies is a subject group comprising biology, geography, physics, chemistry, and health education. 2.25 lesson hours/week/year				Integrated Biology and geography 1.5 hours Physics and chemistry 1 hour		Separate: Biology 1.2 hours Geography 1.2 hours Physics 1.2 hours Chemistry 1.2 hours Health education 1 hour		

sults from the pupils' active and purposeful activity, in which they process and interpret the material to be learned on the basis of their existing structure of knowledge. Although the general principles of learning are the same for everyone, learning depends on the learner's previously constructed knowledge, motivation, and learning and work habits. … In all its forms, learning is an active and goal-oriented process that includes independent or collective problem-solving. Learning is situational, so special attention must be given to the diversity of the learning environment. In learning, new possibilities open up for understanding culture and the meanings that culture contains, and for participating in social activity.

In the National Core Curriculum for Basic Education (FNBE, 2004), general goals and subject specific goals, basic concepts in each subject (syllabus), integration and cross-curricular themes, and final-assessment criteria (standards) are described. The goals described in the National Core Curriculum for Basic Education are, from the point of view of legislation, standards, (compared to law) and the municipalities and the teachers have to follow these guidelines.

Science in the core curriculum

Internationally, like in the UK, USA and partly in Sweden, it is common that science is taught at grades 7 to 9 as an integrated subject by science teachers who are specialised in all science subjects or in some cases only in one subject. In Finland, science is divided into the separate subjects of physics, chemistry and biology and, recently, health education. This is a novel and not very common solution. In Finland geography is included as a science subject. Allocation of science-related subjects to grades in the Finnish curriculum is illustrated in Figure 5.17.

In the National Core Curriculum for Basic Education (FNBE, 2004), the nature of the teaching/learning process in science is emphasised:

"The starting points for physics and chemistry instruction are the students' prior knowledge, skills, and experiences, and their observations and investigations of objects, substances, and phenomena in the nature. From these, the instruction progresses towards the laws and fundamental principles of physics and chemistry. The purpose of the experimental orientation is to help the students both (i) to perceive the nature of science and (ii) to learn new scientific concepts, principles, and models; (iii) to develop skills in experimental work and (iv) cooperation; and (v) to stimulate the students to study physics and chemistry (interest)." (FNBE, 2004).

Experimental orientation means here the physical (hands-on) and mental activity (mind-on) of the student emphasising empirical meanings of the concepts (see, for example, Lavonen et al., 2004). Of course, the role of a teacher is important in this process.

Science goals in the national core curriculum for basic education and PISA competencies

In the National Core Curriculum for Basic Education goals and contents are not allocated to a certain grade but between grades, for example, for grades 7-9 (FNBE, 2004). In Finnish curriculum thinking, goals for science education are most important part in the framework curriculum. They are compared to legislation and teachers should follow the goals while they are planning science lessons, teaching and evaluating. The list of contents, the syllabus, and descriptions of good performance are described in the framework curriculum for helping teachers in their work.

The goals for science education are classified for the purpose of this chapter into the categories typically found in science education literature (e.g. Hodson 1996, Millar, Le Maréchal & Tiberghien, 1999, p. 42–47). Concepts related to the PISA 2006 framework (OECD, 2006) are presented with bold typeface and discussed after the presentation of goals.

Classification of goals in the finnish national core curriculum for basic education for physics, chemistry and biology education are:

Examples of goals for learning science subject matter:
- At grades 5 – 6 progress is made towards the basic concepts and principles of physics and chemistry.
- The tasks of chemistry instruction in the seventh through ninth grades is to guide the pupil in **applying that knowledge** in different life situations.
- At grades 7 – 9 the pupils will learn in physics to use appropriate concepts, quantities, and units in describing physical phenomena and technological questions.

Examples of goals for learning scientific methods:
The pupils will learn in physics and chemistry at grades 5 – 6
- scientific skills, such as the **formulation of questions** and … ,
- to make **observations** and measurements,
- to **look for information** on the subject of study,
- to make, compare, and classify **observations**, measurements, and **conclusions**;
- to **present and test a hypothesis**,
- to process, present and **interpret** results,
- to **formulate simple models**, to use them in **explaining** phenomena,
- to **make generalisations**,
- to **make conclusions** about their **observations** and measurements and **recognise** the causal relationships associated with the properties of natural phenomena and objects,
- to carry out simple scientific experiments clarifying the properties of phenomena.

The pupils will learn in biology at grades 5 – 6
- to **observe** and investigate nature outdoors,
- **identification** of the main flora and fauna in nearby areas.

The core task of physics instruction at grades 7 – 9 is to strengthen pupils' skills in the experimental acquisition of information. In addition to the goals already presented above for grades 5 - 6, the pupils will learn in physics at grades 7 – 9
- to present and **interpret results**,
- to plan and carry out a scientific investigation in which variables affecting natural phenomena are held constant and varied and correlations among the variables are found out,
- to evaluate the reliability of the research process and results,
- to **use various graphs and algebraic models in explaining** natural phenomena, making predictions, and solving problems.

The instruction in chemistry at grades 7 - 9 relies on an experimental approach in which the starting point is the observation and investigation of substances and phenomena associated with the living environment. The pupil progresses from that point to the **interpretation**, **explanation**, and **description** of phenomena, and to **modelling both the structure of matter and chemical reactions** with the symbolic language of chemistry. In addition to the goals already presented above for grades 5 - 6, the pupils will learn in chemistry at grades 7 – 9

- to **acquire knowledge** in different life situations,
- to **interpret** and present the results,
- to use research methods typical from the standpoint of **acquiring scientific knowledge**,
- to carry out scientific investigation,
- to evaluate the reliability of the research process and results.

Biology instruction at grades 7–9 must be inquiry-based learning and it is to develop pupils' thinking in the natural sciences. The objective of the instruction is to give pupils the ability to observe and investigate nature. In addition to the goals already presented above for grades 5–6, the pupils will learn in biology at grades 7–9

- to know the principles of growing and cultivating plants,
- to **identify** the main species of plants, fungi, and animals in the pupils' home region,
- to **recognise** environmental changes in the pupils' home region.

Examples of goals for learning the nature of science:

- At grades 7 – 9 the core task of physics instruction in the seventh through ninth grades is to broaden the pupils' conception of the nature of physics. The instruction guides the pupil in thinking in a manner characteristic of science, in acquiring and using knowledge, and in evaluating the reliability and importance of knowledge in different life situations. The purpose of the experimental orientation is to help the pupils to perceive the nature of science.

Examples of goals for stimulating the pupils' interest to study science subjects:

- At grades 5 – 6 the instruction must stimulate the pupils to study science.
- At grades 7 – 9 the purpose of the experimental orientation is to stimulate the pupils to study physics and chemistry.

Examples of goals for stimulating the pupils to become familiar with society and decision making:

- At grades 5 – 6 the instruction must stimulate the pupils to take care of their environment and act responsibly in it.
- At grades 7 – 9 the instruction in physics helps pupils' understand the importance of physics and technology in everyday life, the living environment, and society. It also **provides capabilities for making everyday choices**, especially in matters related to environmental protection and the use of energy resources.

Examples of goals for cooperative skills development:

- At grades 7 – 9 the purpose of the experimental orientation is to help pupils to learn cooperation skills. The pupils will learn in physics to work and investigate natural phenomena safely, together with others.

According to PISA 2006 framework (OECD, 2006), the PISA assessment emphasises science competencies, defined in terms of an individual's scientific knowledge and use of that knowledge to identify scientific issues, explain scientific phenomena and, draw evidence-based conclusions. In addition, the framework emphasises understanding of the characteristic features of science as a form of human knowledge and enquiry and the awareness of how science and technology shape our material, intellectual and cultural environments. These competencies are tested in PISA by a large number of complex open-ended tasks. In the previous list of examples of goals for physics, chemistry and biology education, concepts related to the PISA 2006 framework are highlighted with bold typeface. As can be seen, there are many goals highlighted regarding learning of scientific methods. However, using the PISA wording "identify scientific issues" in the examples of goals, the following expressions are used: to recognise, to observe, to formulate a question, acquiring of knowledge, and looking for information. Further, instead of using "explain scientific phenomena" the following expressions are used: to interpret, to apply that knowledge, to test a hypothesis, and to use various graphs and algebraic models in explaining. Finally, instead of using "draw evidence-based conclusions" the following expressions are used: to make conclusions, to formulate simple models, to make generalisations and to provide capabilities for making everyday choices.

The students participating in the PISA 2006 Scientific Literacy Assessment had been generally studying at primary level according to the1994 curriculum, The Framework Curriculum Guidelines (FNBE, 1994). According to these guidelines science should be taught as a part of the environmental and natural studies. This subject formed an entity which contains elements of biology, geography, environmental studies and civics. The specific content areas of Environmental and Natural Studies were: matter and energy, organism and their environments, the globe and its areas, and man and the environment. The National Core Curriculum for Basic Education (FNBE, 2004) describes the science goals in more detail. In addition, physics and chemistry have been strengthened at primary level.

Science contents in the national core curriculum for basic education and PISA Competencies

Another important area in the National Core Curriculum for Basic Education (FNBE, 2004) from the point of view of PISA Scientific Literacy Assessment are content areas presented in the curriculum. In PISA 2006 (OECD, 2006), scientific literacy encompasses both knowledge of science (knowledge of the different scientific disciplines and the natural world) and knowledge about science as a form of human enquiry. The former includes understanding fundamental scientific concepts and theories, the latter includes understanding the nature of science. An example of a goal for learning the nature of science is already presented in previous examples from the National Core Curriculum for Basic Education (FNBE, 2004).

For more detailed analysis we present in this chapter a comparison of the PISA 2006 Framework and the National Core Curriculum for Basic Education (FNBE, 2004). In the PISA 2006 there were four content areas: Physical systems, Living systems, Earth and space systems, and Technology systems. These areas represent important knowledge that is required by adults for understanding the natural world and for making sense of experiences in the personal, social and global contexts. Examples of physics, chemistry and biology contents presented in the content areas for the knowledge of the science domain in PISA 2006 are:

Examples of contents of physical systems:
- producing heat, light (grades 5 – 6);
- motion and equilibrium phenomena due to forces (grades 5 – 6);
- natural structures and proportions (grades 7 – 9);
- motion and forces, models of uniform and uniformly accelerating motion (grades 7 – 9);
- various basic phenomena of vibrations and wave motion; production, detection; observation, reflection, and refraction of wave motion (grades 7 – 9);
- interpretation of chemical reaction equations and the balancing of simple reaction equations (grades 7 – 9);
- composition of air; the atmosphere (grades 7 – 9);
- properties of water and its importance as a solvent; investigation of natural waters; water purification (grades 7 – 9).

Examples of contents of living systems:
- structure and main vital functions of the human body; reproduction; physical; psychological and social changes accompanying puberty (grades 5 – 6);
- structure and activity of the cell (grades 7 – 9);

- ecologically sustainable development and the substance and objectives of environmental protection (grades 7 – 9);
- the ecosystem and its structure and operation; distinctive features of forest and aquatic ecosystems; independent research on one ecosystem (grades 7 – 9);
- biological and cultural evolution of the human being; distinctive features of the human species (grades 7 – 9).

Examples of contents of earth and space systems:
- motion of the earth and moon, structure of the solar system (grades 5 – 6);
- structures of the Earth's systems (lithosphere, atmosphere, hydrosphere) (grades 7 – 9);
- interactions and the corresponding forces; motion and equilibrium phenomena that arise from those interactions; occurrence of those phenomena in nature (grades 7 – 9);
- the Earth's gravity (grades 7 – 9);
- interactions that keep structural components together; binding and release of energy in processes occurring between components (grades 7 – 9).

Examples of contents of technology systems:
- various ways of producing electricity and heat; energy resources (grades 5 – 6);
- electromagnetic induction and its use in energy transmission; use of electricity at home (grades 7 – 9); origin, utilisation, and recycling of products and materials belonging to the living environment; safe usage of those products and materials (grades 7 – 9);
- washing and cosmetic materials; textiles (grades 7 – 9).

Although, science education in Finland is divided into biology, chemistry and physics, the 2004 framework curriculum (FNBE, 2004) strongly advocates also connections between sciences and links to society, professional and daily life.

Science goals and contents in Finland and PISA assessment

As a summary, goals for science education and contents described in the National Core Curriculum for Basic Education 2004 (FNBE, 2004) are very compatible with the competencies described in the PISA 2006 framework (OECD, 2006). The Finnish science curriculum emphasises, in particular, activities where the students can identify, recognise or observe scientific issues within their inquiry activities or other activities where they use written sources of information, explain or interpret data or scientific phenomena, and draw conclusions based on the evidence or formulate simple models or generalisations. The curriculum guides teachers to organise activities where the students make observations or collect data and present the data as a graph and then give a scientific explanation.

The contents of biology, chemistry and physics, described in the National Core Curriculum for Basic Education 2004 (FHBE, 2004) belongs especially to the physical systems, living systems and technology systems of the PISA 2006 content areas. In particular, the structure and properties of matter, chemical reactions, waves, electricity, motion and forces, energy and its transformation, basics of astronomy and issues concerning how physics and chemistry knowledge is applied in technology and health care, in solving environmental issues and in everyday life, all mentioned in the PISA 2006 content area list concerning knowledge about the science domain, are all core content of Finnish school physics and chemistry. The following topics are core content of school biology: cells, the human being, animals and plants around us, population, ecosystem and sustainability. In addition, there are a number of content areas which are included in PISA which are classified as being part of geography in Finland: energy resources and energy, raw materials and trade, flow, structures of the Earth's systems (lithosphere, atmosphere, hydrosphere), changes in the Earth's systems, and the Earth in space.

As already mentioned in the list of goals for science education, "the core task of physics instruction in the seventh through ninth grades is to broaden the pupils' conception of the nature of physics". Moreover, in the National Core Curriculum for Basic Education 2004 there are several sentences which give guidelines of how to increase students' knowledge about science. The PISA framework identifies two categories of knowledge about science: "Scientific enquiry" and "Scientific explanations". In the list of Finnish goals, there are several examples of goals for both categories. In particular, the asking of scientific questions, models and modelling, taking measurements, observations and investigations belongs to the first category; whereas, presentation of types of scientific explanations (hypothesis, scientific law, model, and theory), formation of knowledge and outcomes of research (new knowledge, new methods, new technologies, new investigations), belong to the second category.

5|4 Physics, chemistry and biology teachers in Finland

The Finnish comprehensive school system is very demanding on teachers, as versatile professional skills are needed in heterogeneous classes – all students are learning in a common comprehensive school. Therefore, over 30 years ago it was decided that class teachers (at grades 1 – 6 in primary school) and subject teachers, at lower and upper secondary school (grades 7 – 12) should be educated at universities.

Class teachers are teaching almost all subjects in primary school at grades 1-6, including mathematics and science. Subject teachers are teaching in lower and upper secondary school typically two subjects. The teaching profession in Finland has always enjoyed great public respect and appreciation (Simola, 2005). Parents trust teachers as professionals who know what is best for their children. Teachers therefore have considerable classroom independence in selecting the most appropriate pedagogical methods. The teacher profession, especially at primary level, is also very popular and teacher-education departments can select from among the nation's best students and highest scorers on university entrance examinations (Simola, 2005; Jakku-Sihvonen & Niemi, 2006).

All class and subject teachers are educated in master's level programmes requiring 300 credit points (cp.), which are offered by eight universities in Finland (KATU-project, 1978). Master's level programmes are justified by the central role teachers play in preparing each new generation. The local education provider (local authority or municipalities) and FNBE are responsible for teachers' in-service training (Kansanen, Tirri Meri, Krokfors, Husu & Jyrhämä, 2000).

Physics, chemistry and biology teacher education is organised in co-operation with the Faculty of Science and the Faculty of Education (Kaivola, Kärpijoki & Saarikko, 2004). Studies are divided into two parts: the subject is studied at the department of the particular subject (e.g. physics) and the pedagogical studies at the department of teacher education. In the subject teacher education programme students take a major and a minor in the subjects they intend to teach in school. A typical combination of major and minor subjects could be, for example, mathematics – physics, mathematics – chemistry, physics – chemistry, biology – geography and chemistry – biology. There are minor variations between universities.

During the subject studies the students participate in university level undergraduate courses at the subject department. These courses help students to develop a deep understanding of factual knowledge and concepts as a part of a conceptual framework, and help to organise knowledge in ways that facilitate retrieval and application. This kind of knowledge can be used, for example, in recognising features and meaningful patterns of information acquired from nature through observations or experiments, or from other sources of information such as textbooks and, moreover, in recognising and solving problems in the subject area (Bransford, Brown & Cocking 2000, 31; Lavonen, Krzywacki-Vainio, Aksela, Krokfors, Oikkonen & Saarikko, 2007).

The advanced study courses at the physics and chemistry departments have been designed based on the research of the teaching and learning of science. Moreover, the requirements of teachers' professional qualifications have been taken into account. The courses have undergone continuous development through the invention of new methods and subject matter for pre- and in-service physics teachers, with special aims related to PCK. They introduce the students, for example, to the central notions of science, its epistemology and methodology and the interaction between science and technology, conceptual and process structures of the main areas of school physics and chemistry, methods for planning and carrying out experiments and demonstrations in the physics and chemistry classroom, the history and philosophy of science and its relations to society and technology (Lavonen, Jauhiainen, Koponen & Kurki-Suonio, 2004).

During the pedagogical studies, the students' subject knowledge, knowledge about teaching and learning, mathematics and science education and school practises are integrated into students' own personal pedagogical theory. According to the curriculum the students should, for example be aware of the different dimensions of the teaching profession (social, philosophical, psychological, sociological, and historical basis of education), be able to reflect broadly on their own personal pedagogical "theory" or assumptions on their own work, and have the potential for lifelong professional development (Lavonen & al., 2007).

The subject teacher students write a master's thesis (40 cp.) on the subject. They can choose for their master's thesis either a pedagogical orientation or a subject orientation and prepare the thesis under the guidance of a professor or in a research group. Research studies are an opportunity to undertake a real project, in which students have to formulate a problem, seek information and data independently, then elaborate on it with the latest research and make a synthesis as a written thesis. They learn to study actively and to internalise the attitude that teachers may act like researchers in their work.

According to PISA 2006 School Questionnaire data, 97.2% of the schools reported that there was no serious lack of physics, chemistry or biology teachers (OECD 81.9%). On average 10% of the full-time teachers in the participating schools did not have an appropriate qualification in Finland. Consequently, in most of the schools there were highly educated and qualified teachers with a deep subject matter and pedagogical knowledge. Due to there being no inspectors, national evaluation of learning materials or national assessment, they are very responsible for pupils' learning.

5|5 Science textbooks in Finland

Official national science curriculum documents in Finland emphasise socio-constructivist and situational views of science learning. However, these views, described in national level documents, are not met in practice if the science textbooks, laboratory books and workbooks are not supporting teachers in their teaching profession. It has been argued, based on empirical studies, that most science teachers design their lessons based on a textbook, and use it or a workbook for most of the classroom time. Therefore, the textbooks and workbooks provide the major instructional format for lessons (Hamm, 1991).

In Finland science homework is given after each science subject lesson. This homework is based on the questions at the end of each textbook chapter. Based on the PISA student questionnaire data, 65.6% of Finnish students estimate that they perform science homework less than 2 hours per week and 12.1% more than 2 hours a week (in OECD 50.1% and 22.3% respectively).

When the PISA 2006 Scientific Literacy Assessment was organised, there were two physics, two chemistry and three biology textbook series in lower secondary school and three textbook series in primary school based on the national science curriculum. Most of them included laboratory books, workbooks or student activity cards and teachers' guidebooks.

In Finland private publishing companies play a key role in designing and preparing textbooks and laboratory books. The companies interview school teachers and conduct surveys. They then collect together groups of textbook authors, consisting of school and university teachers. These groups prepare manuscripts in collaboration with editors from the publishing companies. The manuscripts are then field-tested. Consequently, the whole process of writing a textbook or a laboratory manual is iterative and typically takes several years. The authors do not receive a salary, but they do receive a royalty.

When writing a textbook authors take into consideration several issues. Meaningful learning engages students in tackling the topic to be learnt in such a way that they create meaningful and understandable knowledge structures (Bransford, Brown & Cocking, 2000). There are different kinds of pre-tests and graphical network presentations or advanced organisers as texts and figures. In the textbooks, physics and chemistry concepts are used in real life situations: in technological, human orientated or environmental contexts.

Finally, one important property of a textbook and a laboratory book is usability. This criterion has been approached for example in the framework of usability research made by psychologists and engineers (e.g. Nielsen, 1993). A textbook should be error free and it should be pleasant to use (Lavonen & Meisalo, 2002).

In the following, some examples from physics textbooks (Aspholm, Hirvonen, Hongisto, Lavonen, Penttilä, Saari & Viiri, 2001) and workbooks are presented.

F 5.18 | A typical textbook page

A page consists of a motivation picture and its caption, text, photographs of an experiment and models explaining the phenomena.
A) Introduction to the theme of the chapter | B) A demonstration about magnetic interaction between a wire and a magnet
C) Emphasis of important natural law | D) A model for observed phenomena

F 5.19 | A textbook page

A page helps students to combine their earlier knowledge with the new topics to be learnt.
The concepts are met in real life situations. The contexts have been selected to increase interest.
A) Role of science-based technology: How electricity is produced in a water power station
B) Living systems and energy: How kinetic energy is transferred
C) Chemical energy and human being

150 LIIKE JA ENERGIA

EXTRA

Vedestä energiaa

Korkealla vuoristojärvessä oleva vesi on ihmiselle hyöd A pääl kuin sama määrä vettä merenpinnan A. Vuoristossa sijaitsevan järven vedellä on runsaasti potentiaalienergiaa, jos vertailutasona on merenpinta. Potentiaalienergia muuttuu veden liike-energiaksi, kun vesi virtaa alas vuoristosta. Veden liike-energialla voidaan pyörittää turbiinia ja siihen yhdistettyä generaattoria. Generaattori synnyttää sähköä.

Virtaavan veden liike-energiaa käytetään hyödyksi sähkön tuotannossa: virtaava vesi pyörittää turbiinia, joka puolestaan pyörittää generaattoria.

Urheilijat hyödyntävät liike-energiaa

Korkeushyppääjät ottavat pitkän vauhdin, vaikka voisi kuvitella, että vauhti ei vaikuta ponnistukseen. Syy vauhdinottoon on siinä, että hyppääjä voi muuttaa sekä vauhdinotossa saamansa liike-energian että ponnistuksessa saamansa liike-energian potentiaalienergiaksi. Pituushyppääjät tekevät samoin, ja moni pikajuoksija pitääkin toisena lajinaan pituushyppyä.

LEHTIKUVA

B

Mitä suurempi nopeus, sitä suurempi liike-energia ja pitempi hyppy.

Kemiallinen energia ja ihminen

Elintoiminnot perustuvat soluissa tapahtuviin energiaa v C viin prosesseihin. Kasvit sitovat Auringon ener C yhteyttämisessä valmistamaansa sokeriin. Eläimet eivät sen sijaan pysty sitomaan suoraan Auringon energiaa, joten niiden on hankittava rakennusaineensa ja energiansa joko syömällä kasveja tai toisia eläimiä.

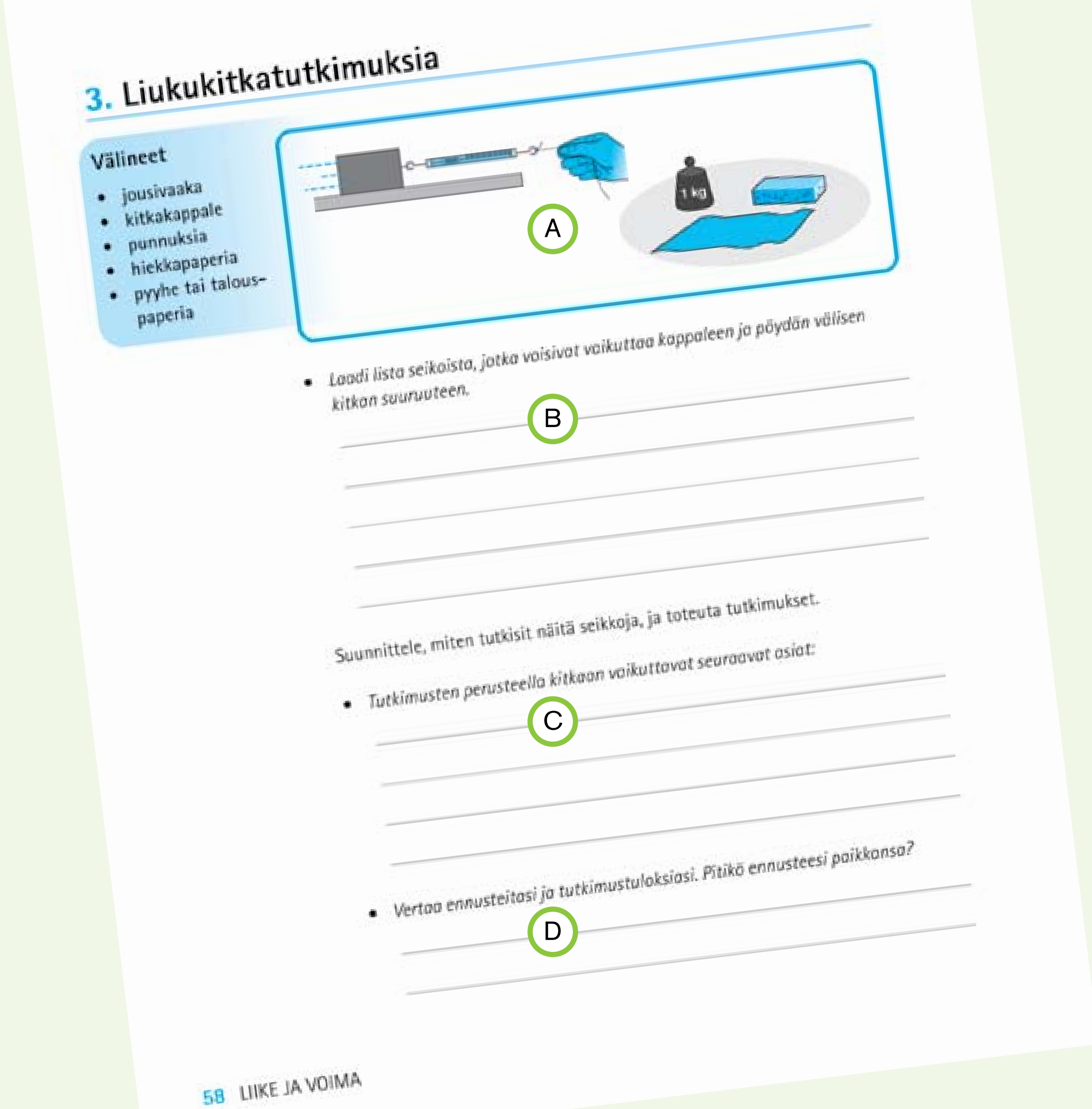
Lähes kaikkien solujen energiahuollon perustana on sokeri, glukoosi, josta energia siirtyy erityisiin energiaa sitoviin molekyyleihin. Näissä energia on sitoutuneena kemiallisiin sidoksiin ja helposti siirrettävissä ja tarpeen tullen vapautettavissa.

Ihminen tarvitsee energiaa aineenvaihduntaan, liikkumiseen, uusien yhdisteiden valmistamiseen sekä vanhenevien ja tuhoutuneiden solujen korvaamiseen uusilla. Osa energiasta vapautuu lämpöenergiana.

F 5.20 | A workbook page

The workbook guides students in small groups to plan and carry out a scientific investigation in which variables affecting natural phenomena are both held constant and varied and correlations among the variables are discovered. Students should present and test a hypothesis, make observations and measurements, compare, and classify observations and measurements, formulate simple models and use them in explaining the phenomena. Students should actively take part in group activities and support each other by discussing and sharing knowledge.

A) Some ideas how the phenomena will be
B) Students are asked to investigated think about possible reasons for friction
C) Students are asked to make conclusions based on their investigations
D) Students are asked to compare their conclusions and hypothesis



3. Liukukitkatutkimuksia

Välineet
- jousivaaka
- kitkakappale
- punnuksia
- hiekkapaperia
- pyyhe tai talouspaperia

- Laadi lista seikoista, jotka voisivat vaikuttaa kappaleen ja pöydän välisen kitkan suuruuteen.

B

Suunnittele, miten tutkisit näitä seikkoja, ja toteuta tutkimukset.

- Tutkimusten perusteella kitkaan vaikuttavat seuraavat asiat:

C

- Vertaa ennusteitasi ja tutkimustuloksiasi. Pitikö ennusteesi paikkansa?

D

58 LIIKE JA VOIMA

5|6 Science class

National curricula (FNBE, 1994; FNBE, 2004) have required that students should learn to make observations and learn science through observations and measurements. Students should also be able to plan and carry out simple experiments on natural phenomena. Therefore, in Finland practical work and demonstrations have long been accepted as an integral part of teaching and learning science subjects. There are different classifications of teaching methods where experiments are essential (Wellington, 1998, p. 12). In Finland classification is done according to the type of activity and, therefore, the concepts 'a practical work' and 'a demonstration' are used, and not the terms 'investigation' or 'inquiry'.

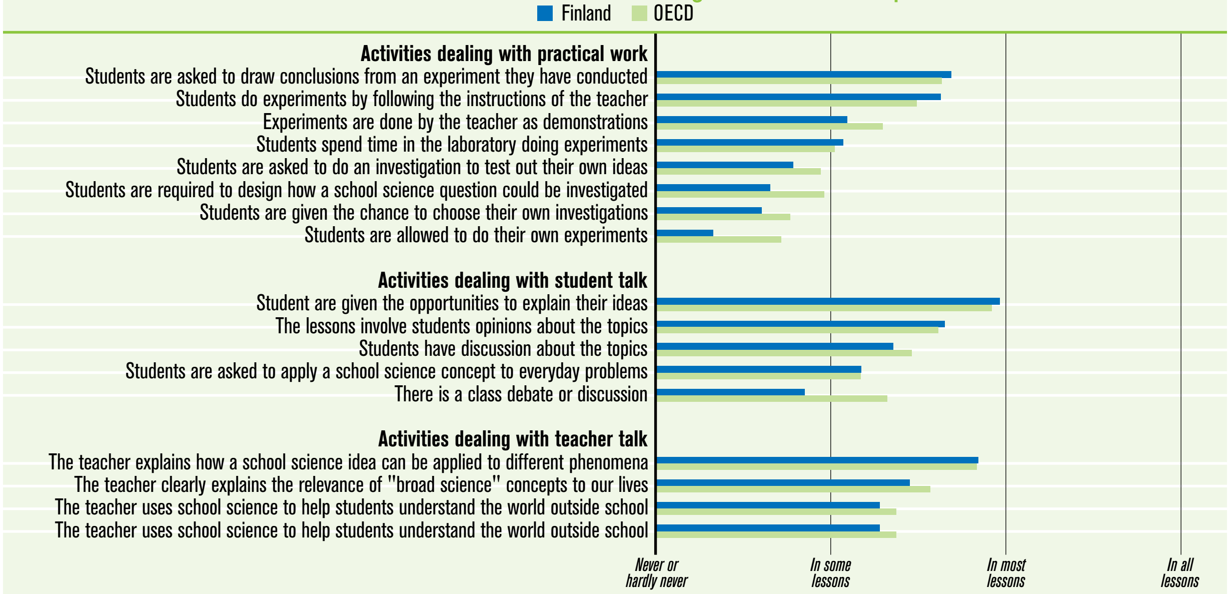
The concept "teaching method" is used in Finland as a synonym for a learning or instructional method/model/strategy or pupil activity or classroom practice designed to help pupils acquire concepts, ways of thinking, skills and values. Teaching methods are goal oriented and emphasise social interaction between pupils and teachers and between pupils (Leach & Scott, 2000, p. 54).

Teaching methods in science education in Finland

There is too little research on Finnish science classrooms. Classroom research has focused on social interaction and behaviour in the classroom (e.g. Syrjäläinen 1990, Patrikainen 1997). However, during the LUMA-project evaluation Norris, Asplund, MacDonald, Schostak and Zamorski (1996) observed science lessons and interviewed headmasters, teachers and students in 50 lower and upper secondary schools. They concluded that Finnish teachers were pedagogically conservative, and teaching and learning are traditional, mainly involving frontal teaching of the whole group of students. Nonetheless, during science lessons there was a lot of practical work. Simola (2005) explains that this kind of teacher behaviour is supported by social trust and teachers' high professional academic status. Therefore, it is possible to teach in the "traditional" way in Finland as teachers believe in their "traditional" role and pupils accept their "traditional" position.

Aksela and Juvonen (1999) studied chemistry teaching methods in Finland from teachers' perspective. Data for their study was obtained from postal questionnaires that were completed and returned by Finnish chemistry teachers (n = 399). About 76% of surveyed teachers pointed out that chemistry can be best learned by doing student-centred practical work (laboratory work).

F 5.21 | Students evaluating how often activities dealing with practical work, student talk or discussion and teacher talk occur when learning school science topics at school

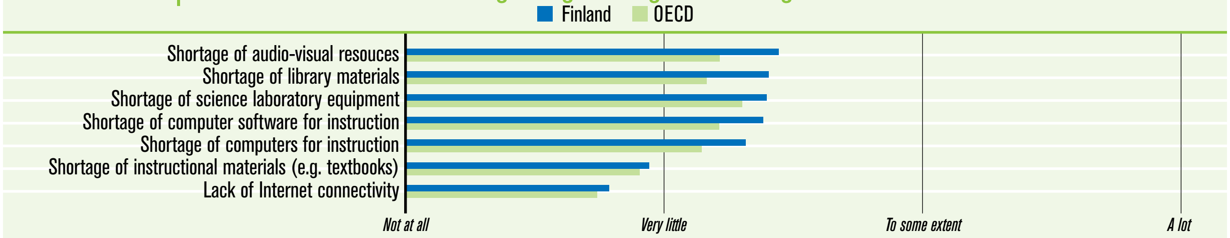


Five years later Lavonen, Juuti, Byman, Uitto & Meisalo (2004) published their study of teaching methods. They asked students about how physics and chemistry are taught at comprehensive school and how they would like it to be taught. A questionnaire was designed and distributed in spring 2003 to 75 randomly selected Finnish comprehensive schools. In all, 3626 pupils at the 9th grade level (aged 15-16) answered the questionnaire. Through this it was shown that the most popular teaching methods in physics and chemistry are teacher-delivered or directed instruction or presentation-recitation teaching where the teacher presents new material or solves problems on the blackboard. Demonstrations and practical work were the second most popular group of teaching methods The students were quite satisfied with the teaching methods currently used. However, students stated that they would prefer teachers to more frequently hold classroom discussions concerning difficult concepts and problems. The students would like to do more project work, discuss in small groups or participate in a teacher lead discussion. Students seemed to be satisfied with the amount of individual work (students working on their own), textbook reading, writing, as well as practical work and teacher demonstrations.

The students participating in the PISA 2006 Scientific Literacy Assessment were asked: “When learning school science topics at school, how often do the following activities occur?” In Figure 5.21 the students’ responses are classified into three groups: activities dealing with practical work, activities dealing with student talk or discussion, and activities dealing with teacher talk.

Finnish students consider that they frequently perform experiments and practical work by following the instructions of a teacher (or a workbook). Both teachers and workbooks guide students to make conclusions from experiments they have conducted. These activities happen on average more frequently in Fin-

F 5.22 | Evaluation of headmasters regarding shortage of learning materials for science education



land than in OECD countries. Teachers also actively present demonstrations, and students are seldom, in fact almost never, allowed to design their own experiments or do investigations to test their own ideas. These kinds of activities happen more frequently in other OECD countries.

Finnish students think that in most lessons they are given opportunities to explain their ideas and express their opinions about topics. This kind of atmosphere is important for learning and motivation. In the classroom, a class debate or discussion occurs in some lessons. Finnish students consider that teachers are active members of the science class. They frequently explain how science ideas can be applied to a number of different phenomena and for understanding the world at large. Students also encountered the relevance of "broad science" concepts to their lives through explanations by their classroom teachers.

Learning materials in science education in Finland

In principle, the lower secondary schools are well equipped and also have laboratories where practical work is organised. However, the amount and quality of equipment depends on local decision making. The headmasters of schools participating in PISA 2006 were asked to evaluate if there is a shortage of learning materials, like textbooks and laboratory equipment, used in science education (Figure 5.22).

On average, Finnish headmasters experience bigger shortages of relevant educational materials than headmasters in OECD countries. In particular, Finnish headmasters experience a lack of audio-visual resources, library materials, laboratory equipment and computers and computer software for instruction.

Teaching and learning in Finnish science classroom

Here we use the PISA data and data from the Lavonen, Juuti, Byman, Uitto and Meisalo (2004) survey. Teacher-delivered or directed instruction, demonstrations and practical work are frequently used teaching methods in Finland. Based on Lavonen et al.'s survey, students also perceive positively that new concepts are introduced by a teacher, an expert, who first presents new information and then demonstrates how this information is used for solving problems or performing tasks. Moreover, the students feel it to be appropriate that explanations and conclusions are formulated under the guidance of an expert. However, teacher-delivered or directed instruction is not enough. Finnish students perform experiments themselves following the instruction of a teacher and draw conclusions based on the experiments they have conducted. This happens more frequently in Finnish physics science classrooms than on average in OECD countries. Therefore, the combination of delivered or directed instruction and experiments conducted by the students is the main pedagogical approach in Finland in science education.

Consequently, it seems possible to argue that a combination of traditional teacher-delivered or directed instruction and the conducting of experiments by students results in higher academic performance than student-directed learning (compare Chall, 2000). However, a teacher's role in this type of learning is challenging. He or she should listen carefully to students and direct the students in observing, classifying, analysing, synthesising and interpreting. Students should be active in learning, even though a teacher is guiding the learning activities. It is obvious that sociocultural ideas of learning have too often focused only on pupil – pupil interaction while the teacher has a crucial role in acculturating pupils to the scientific way of thinking (Scott, 1998). This finding is consistent with the findings of Bahar (2003), suggesting that discussion strongly motivates pupils for science studies.

5|7 Conclusions

In the conclusion four areas are covered. Firstly, earlier PISA 2000 and 2003 assessments and created reflections are discussed. Secondly, we summarise a recent book where science and mathematics outcomes were discussed (Pehkonen, Ahtee & Lavonen, 2007). Thirdly, we summarise some international literature on Finnish education policy and PISA assessment. Finally, some reasons for Finnish students' success based on the PISA 2006 Scientific Literacy Assessment data are discussed.

Explanations on PISA 2000 and 2003

After the first PISA 2000 assessment the PISA researchers explained the Finnish students' success in PISA through comprehensive school pedagogy, students' own interests and leisure activities, the structure of the education system, teacher education, school practices, and Finnish culture, or in short – pedagogical philosophy and practice (Välijärvi, Linnakylä, Kupari, Reinikainen & Arffman, 2002).

The same arguments were given after the second PISA 2003 assessment results. Furthermore, the same reasons for success also appear to be the explanations for success in the 2006 Scientific Literacy Assessment. However, in the 2006 assessment some new data were acquired concerning interest in science and motivational issues. Based on that data, students' own interests and leisure activities are obviously not major reasons for the success. In addition, there are some features of the education policy and its implementation which are similar to those in most OECD countries and, consequently, cannot only be the reasons for success in Finland. In 2007 a recent book explaining the reasons for success was published by the PISA 2000 and 2003 researchers (Jyväskylä group) (Välijärvi, Kupari, Linnakylä, Reinikainen, Sulkunen, Törnroos & Arffman, 2007). On the basis of the multilevel modelling procedure they have found that affective factors, particularly students' self-concepts related to mathematics, were the strongest predictors of performance variation in mathematical literacy in Finland.

Kupari, Reinikainen, and Törnroos (2007) concluded that the good results of Finnish pupils should be taken as recognition of the high quality of Finnish schools. In addition to that, one reason for PISA results could be the Finnish curriculum planners' vision of the future of science teaching and learning that were already given before the beginning of the 1990s; these are coherent with the PISA framework, although the authors do not give enough evidence to back their claim. This issue was also analysed in the present chapter in detail and similar conclusions were drawn. Kupari, Reinikainen, and Törnroos (2007) suggest that the role of science teachers is also important for the success of Finnish students. Their argument is based on TIMSS and PISA data that in science teaching, the pedagogical orientation is subject-orientation both at the primary and lower secondary level. Therefore, teachers transmit the nature of science in their teaching. They argue further that experimentation and modelling are essential in science education because of the Finnish comprehensive school curriculum. Modelling is appreciated in Finnish science classrooms, it can be considered as an important step for understanding the nature of scientific processes and knowledge that were in turn among the main objectives of PISA 2003 assessment criteria.

Conclusions made based on the book "How Finns Learn Mathematics and Science?"

Pehkonen, Ahtee and Lavonen (2007) edited a book "How Finns Learn Mathematics and Science?" The authors of the book were 40 Finnish mathematics, physics and chemistry teachers' educators and researchers. There are chapters in the book concerning the Finnish education system and teacher education and descriptions of mathematics and science teaching and learning in Finnish classrooms. The aim of the book was to explain the Finnish students' success in the PISA assessment.

The editors suggest in their concluding chapter several reasons for the success. The suggested major reason for the success was the general education policy and its implementation strategies. The most important implementation strategies described in the book were the high quality teacher education, the national core curriculum and its implementation through science teaching in the classroom. An important issue in the implementation of the core curriculum is local level decision making. In the book it is described how teachers use their freedom and are responsible for developing the curriculum for their courses, choosing the teaching and evaluation methods based on the national guidelines and also selecting the learning materials. In Finland there are no inspectors, no national evaluation of learning materials, nor national assessment. In other words, Finnish teachers are educated to be autonomous and reflective academic experts. As a final conclusion, the editors state that there exists no clear single explanation, and that the true explanation might be a combination of several factors. We will return to this in the final chapter.

Explanations for Finnish students' success presented in books and journal articles

Some previous directors of the National Board of Education have published their analysis on the possible reasons for the PISA success (Aho, Pitkänen & Sahlberg, 2006). They suggest four broad reasons: a stable political environment for education reforms which have been based on a long-term vision, hard work, good will and consensus; political, cultural and economical success of the educational system and its interaction with other sectors; education reform has been evolutionary rather than revolutionary; and comprehensive school that offers all children the same top quality, publicly financed education. Laukkanen (2008), an officer of the Ministry of Education, discusses in his paper similar issues to those of Aho, Pitkänen and Sahlberg and presents the following reasons: high standards in education, support for special education, qualified teachers, and balancing decentralism and centralism.

Teacher education has been said to be, in several papers, one of the major explanations for students' PISA success in Finland. This is a claim which is not really based on any empirical studies but, however, is based on long-term experiences and, partly on special circumstances in the development of teacher education in Finland since the beginning of comprehensive school in 1968/1972 with the introduction of primary school teacher education in universities. To highlight this complex issue Jakku-Sihvonen and Niemi (2006) edited a book about teacher education in Finland. They take a broad view on teacher education, its philosophical basis and practical issues. They emphasise research-based teacher education. This means in the PISA-context that also in primary schools there are teachers who have done educational studies with experimental research methods and designs. The PISA kind of thinking as expressed in the PISA framework (OECD, 2006) is not alien to them, and therefore is also not alien to pupils and students.

Simola (2005) explains the Finnish students' success through analysing teaching and teacher education in a historical and sociological framework and gives several general historical and political reasons for the success, such as a homogeneous society (lack of minorities), hardship during the First and Second World War, and rapid development from poor agrarian state to a modern welfare democracy. He concludes that Finnish students' success in PISA may be seen as the curious contingency of traditional and post-traditional tendencies in the context of the modern welfare state and its comprehensive schooling. There is obviously a link between high-performing education and economy: Finland has been ranked the most competitive economy in the world three times between 2000 - 2004 by the World Economic Forum (Porter, Schwab, & Lopez-Claros, 2005). According to Simola (2005) Finnish teachers are politically and pedagogically rather conservative. Furthermore, Finnish teachers believe in their traditional role and pupils accept their traditional position.

Björkqvist (2006) has paid attention to special education. Special education in Finland is strongly intertwined with the ordinary education, and thus it offers better learning opportunities for low-achievers. Only 2% of Finnish pupils are in special teaching institutes (cf. Välijärvi & al. 2007). Those who are undergoing ordinary education in comprehensive school have carefully-tailored support that corresponds to pupils' needs (cf. also Vauras 2006). The relatively small scattering of Finnish PISA results can be understood through the support given to the lower-achieving pupils. The fact that the Finnish average performance in the lowest percentile groups is without any reservations the best in the world is evidence to back this claim.

Explanations made based on PISA 2006 results and relevant documents

According to previous review of education policy documents in this chapter, there are three leading principles in the educational policy of Finland. There is commitment to a vision of a knowledge-based-society. This vision can be found in the national documents published in the 70s, where implementation of common comprehensive school (Committee Report, 1970) and university level primary teacher education (KATU Project, 1978) were proceeding. Another long-term objective of Finnish education policy has been to raise the general standard of education and to promote educational equality. Basic decisions in this direction were made during the 1970s with the other Nordic countries when a change to a comprehensive obligatory school system was decided upon (Committee Report, 1970). According to this equality principle, education at all levels is free for everyone who lives in Finland and the structure and quality of the education system is of a high standard. In Finland, local authorities have strong autonomy, a lot of freedom, power and responsibility. This movement was strengthened in the 1994 curriculum (FNBE 1994) when schools were systemically guided through the process of preparing a school level curriculum. Therefore, the third general education policy principle in Finland is the devolution of decision power and responsibility at the local level. According to this principle professionals at all levels from primary education to universities are not implementers of decisions but partners in decision making. Furthermore, there are no school inspectors or national tests. These three basic components can be named on the general level as reasons for Finnish students' success in PISA.

Sahlberg (2004) compares Finnish education policy to the global education movements. He recognises several opposite trends. During the last two decades, there have been three common features in education policies and reforms globally that have aimed to improve the quality of education, especially to raise student achievement (Hargreaves, Earl, Shawn & Manning, 2001) but which have not yet become a part of Finnish educational policy. Outcome-based education reform became popular in the 1980s followed by standards-based education policies, including centrally prescribed performance standards for schools, teachers and students, in the 1990s originally in Anglo-Saxon countries. In Finland, flexibility and diversity have been the main guiding lines. The second common feature in global education policy has been emphasis on (scientific) literacy and numeracy. As a consequence, curriculum and, therefore, teaching in schools in many countries place a strong emphasis on structural knowledge of systems, technical skills, and cognition. In the Finnish national framework curriculum all school subjects are emphasised, giving equal value to all aspects of an individual's personal development, whether they be moral, creativity, knowledge or skills based. The third global trend has been consequential accountability systems for schools. Success or failure of schools and their teachers is often determined by standardised tests and external evaluations that only devote attention to limited aspects of schooling, such as student achievement in mathematical and reading literacy. Again in Finland another direction has been chosen: trust through professionalism. A culture of trust within the education system values teachers' and headmasters' professionalism in judging what is best for students and in reporting on progress of their learning.

Although Sweden has a similar society and has a similar education policy to Finland, there are relatively strong differences in science teaching. In Sweden the vision of a knowledge-based-society, educational equality and evolution of decision power and responsibility at the school level are also important. Both countries have very similar comprehensive school systems. However, Swedish comprehensive school is more political than the Finnish school and concentrates more on the socialisation of children (Strömdahl, 2006). The Finnish comprehensive school concentrates more on teaching subjects were the teacher is highly specialised in the subject. There are also differences in devolution of decision power and responsibility at the local level in teacher education in Finland and Sweden. In Sweden there is strong governmental guidance in teacher education. Moreover, the competence of class teachers is lower: they typically have only 3 to 4 years education. Lower secondary school teachers in Finland study more subject knowledge than in Sweden. During these subject courses the student teachers in Finland become familiar with the epistemological and ontological basis of the subject. This kind of knowledge is important at school, when teachers are guiding students in different kinds of activities where epistemological and ontological issues are discussed. Knowledge and skills learned in those activities are needed in PISA assessment. Although the students in the primary school teacher education program, in Finland, have only a small amount of mathematics and science studies, they still become familiar, in general, with epistemological and ontological issues within their education science studies. Finnish-Swedish comparison refers to that one of the major differences seem to be differences in teacher education. Based on that, it is possible to support the claim of the importance of good, science teacher education (see Chapter 5).

The teaching methods and learning materials in Finland are rather traditional and emphasise combination of teacher-delivered instruction and student conducted experiments (Chapters 6 and 7). The experiments in Finland are not designed by the students but strongly guided by the teacher. This kind of science teaching has lead to excellent performance in the PISA tasks. The students learn also important competencies as evidenced by PISA, such as to identify scientific issues, explain scientific phenomena, and draw evidence-based conclusions. One possible interpretation for this is that pupils perceive as being positive the fact that new concepts are introduced by a teacher, an expert, who first presents new information and then demonstrates how this information is used for solving problems or performing tasks. Moreover, students' experiments before and after the teacher-delivered sequences play an essential role in learning. Nevertheless, this does not mean that only teachers are talking, as there are also teacher-led discussions in science classes. Apparently, it is important that explanations of the discovered phenomena are presented and that conclusions are formulated, as well as their relevance to everyday life being shown built on the concepts, under the guidance of an expert (Bransford et al., 2000, p. 31). This works if the teacher has a central role in the classroom, which is also accepted by the majority of the students. According to Simola (2005) Finnish teachers believe in their traditional role and pupils accept their traditional position. There is also evidence at least at the primary school level that traditional teacher-centred instruction seems to result in higher academic performance than student-directed learning (Chall, 2000). Socio-cultural ideas of learning have too often focused on pupil – pupil interaction without paying attention to the fact that a teacher has a crucial role in acculturating pupils to the scientific way of thinking (Scott, 1998).

Reasons for the good PISA 2006 Science results which are rarely mentioned are the national curriculum, textbooks, and physics, chemistry and biology teachers as implementers of the national level guidelines. The National Core Curriculum for Basic Education 2004 (FNBE, 2004) and previous curricula are very compatible with the PISA 2006 framework (see Chapter 4). Moreover, science textbooks (Chapter 6) are designed based on the national core curriculum and are, therefore, also very compatible with the competencies and contents described in the PISA 2006 framework. The workbooks guide students to draw evidence-based conclusions and explain scientific phenomena. However, the basic decisions about the national level guidance were decided some ten years before the first PISA framework. These similarities certainly partially explain the Finnish students' success in the PISA Scientific Literacy Assessment. Nevertheless, these kinds of similarities certainly exist in several other countries as well. Finally, teachers as implementers of the national level guidance and users of textbooks have a great deal of freedom in decision making. Consequently they can concentrate on the issues they know well or would like to emphasise. This is possible due to there being no inspectors or national level testing.

Challenges for science education in Finland

Finnish students succeeded very well in the cognitive items of the PISA 2006 Scientific Literacy Assessment and, therefore, the challenge is to continue with a similar science education policy and its implementation (Schleicher, 2006). In particular, there were no gender differences in the PISA score and low achieving students were achieving much higher PISA scores than similar students in other OECD-countries. Furthermore, Finnish education policymakers should be very proud of the very low variation in PISA scores, especially in the variation between schools.

In addition to assessing how students have acquired scientific and technological knowledge and can apply this for personal, social and global benefit, PISA has devoted significant attention to obtaining data on students' attitudes to and engagement with science, both as part of the PISA 2006 assessment and through separate questionnaires.

The PISA affective domain evaluation revealed the already known basic fact: the majority of 15-year-olds agree with the important role that science plays in the world and that science in general is important, relevant and also interesting for them and, moreover, the majority thought that on the whole they are able to master the science problems they are given at school. However, school science does not stimulate all students' interest (Osborne, Simon & Collins, 2003; Schreiner & Sjøberg, 2005).

In some areas of the affective domain measurement Finnish students' scores were lower than the average in OECD countries. In particular, students' interests in science topics were low. In addition, large gender differences were found. Especially, female students' interest in physics and chemistry was much lower than male students' interest and vice versa, male students' interest was lower in human biology and plant biology. Thus, there is a challenge to make hard sciences more attractive for female students and life sciences more attractive for male students. One solution is to develop new contexts in science education.

For example, it is possible to increase the role of the human-being context, health education and examples of life sciences in physics and chemistry teaching. Ergonomics or anatomy and functioning of the human body might be possible areas. In chemistry, physiological effects of several chemicals can be discussed in the context of the human being.

The most dramatic indicators for lack of interest towards science were the items measuring students' interest in continuing their scientific studies or working in a science-related field. In Finland only 26% (in OECD on average 37%) would like to work in a career involving science and 23% (31%) would like to continue to study science after secondary school. However, in general, 63% of Finnish students perceived science to be useful to them and 51% of them perceived science to be helpful for their career prospects and future work. Consequently, there are challenges for science teachers to discuss about the career opportunities and characteristics of careers in science.

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The success of Finnish students in PISA mathematical literacy has been received with mixed feelings. The educational establishment is understandably proud of the results while the mathematical community calls into question the validity of the success as an indication of Finnish students' high level of mathematical competence.

Could both views be correct and justified at the same time?

6
Mathematical Literacy Assessment

Sirkku Kupiainen and Erkki Pehkonen

The PISA Framework defines mathematical literacy as "…an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen" (OECD, 2006a p. 72). This is fairly far removed from what most 15-year-olds – the designated target group of PISA – understand mathematics and its teaching at school to be about. Likewise, different national analyses and interpretations of the results from PISA 2000, 2003 and 2006 have demonstrated that there are clear differences in how close the OECD definition of mathematical literacy comes to the respective national understandings of the goals of mathematics teaching and the curricula for mathematics in different countries (e.g., Monnier 2007; Stephens & Coleman 2007).

What sets PISA apart from the more curricular assessments – the concept of literacy and the understanding given to it – has much in common with the general goals of the Finnish comprehensive school education. One of the objectives of this chapter is to offer a view of the relationship between the mathematical literacy measured in PISA and the Finnish mathematics curriculum. In Subchapter 6.1 we will present a short overview of the Finnish mathematics curriculum for comprehensive schools, of mathematics teaching, textbooks and other educational materials, and of the LUMA-programme, which was launched in the 1990s to raise the level of mathematics and science education in Finnish comprehensive schools. In Subchapter 6.2 we will look more closely at the results of mathematical literacy in PISA 2006, with an emphasis on the performance of Finnish students in different types of tasks. Finally, in Subchapter 6.3, we present a synthesis of Subchapters 6.1 and 6.2.

6|1 Mathematics teaching in the Finnish comprehensive school

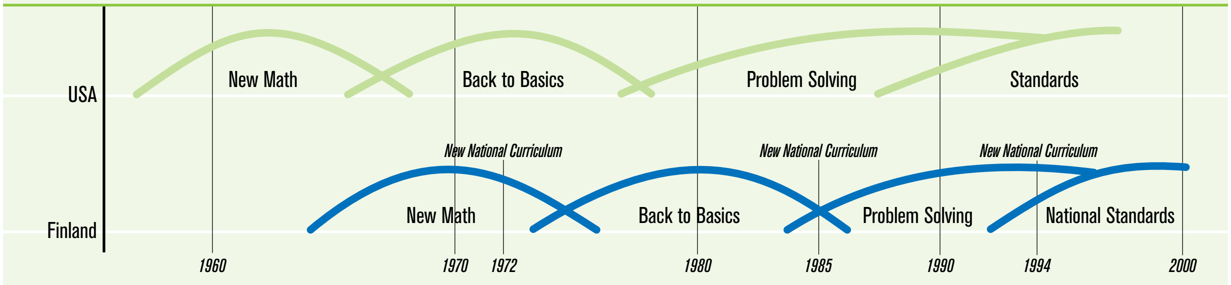
The students participating in PISA 2000, 2003 and 2006 had their comprehensive education in 1991–2000, 1994–2003 and 1997-2006, respectively, and were taught by teachers who received their education – and many also their teachers' credentials – in the 1980s or earlier. Therefore, to understand and interpret the Finnish results in mathematics we need to consider two successive curricula (The Finnish National Board of Education FNBE, 1985; FNBE, 1994) and the diverse factors leading to them. The latest curriculum (FNBE, 2004), has had hardly enough time to have a bearing on the results. Since the general outlines for the Finnish curricula are explained in Appendix 1, we will focus here on just the changes in the mathematics curricula within the last 30 years (cf. Pehkonen, 2008; for more details, see also e.g. Pehkonen, Ahtee & Lavonen, 2007).

Changes in the mathematics curricula

A general picture of the development of the Finnish mathematics curricula from the 1960s to around 2000 is presented in Figure 6.1. Changes adopted in the US curriculum played a central role in this development, with a delay of about 10 years. However, the principles of each trend were not taken as such but were modified in the process of implementation to better fit the Finnish education system. For example, the objectives and contents of teaching and learning in the "back to basics" -trend were deliberated thoroughly and given particular interpretations when fitted to the Finnish education system (Kupari, 1994).

During the 1980s the established view on learning began to change, including mathematics teaching. Cognitive psychology, emphasising students' own construction of knowledge and learning, began to replace the older behaviouristic paradigm. Consequently, the focus of learning shifted to students' activities and to their ways of perceiving and shaping the world around them (cf. Lehtinen, 1989). In the 1990s, responding to the new demand, a group of Finnish mathematics educators wrote a seminal book on mathematics teaching (Halinen & al., 1991), presenting a view very similar to the later concept of mathematical literacy in PISA. Besides traditional teachers' talk and pupils' independent calculations, other means of teaching and learning mathematics were to be used: problem solving, exploration, discussions about mathematics, and dealing with problems rising from everyday life. In implementing these ideas, two key points arose: understanding learning as an active endeavour, and mathematics as a skill to be used and applied in diverse situations. The former meant that students should have ample time for learning and for deliberating on what they had learnt, while the latter emphasised the importance of using problems rising from everyday life. This meant tasks where the level of mathematics was not necessarily so

F 6.1 | Development of trends in mathematics teaching in Finland and in the USA (Kupari 1999, 52)



high, but where students could apply the mathematics learnt at school in situations that were familiar and meaningful to them. For a more detailed description of the changes in Finnish mathematics teaching, see Pehkonen (2008) and Pehkonen & al. (2007).

Reflecting these changes, the main objective for mathematics instruction in the Finnish curricula of 1985 and 1994 was to offer students basic mathematical knowledge and skills to manage in everyday life situations and later in work life (FNBE, 1985; FNBE, 1994). The developing of students' mathematical thinking and their learning of mathematical concepts and problem-solving methods were also emphasised, as well as the role of mathematics in promoting students' intellectual growth and in increasing their potential for purposeful activity and social interaction in later life.

In the 1985 curriculum (FNBE, 1985), content requirements were given to each grade from 1 to 9, divided into four domains or content areas: the concept of number, expressions and equations, geometry, and applied mathematics. Focus was shifted from structure and basic concepts to application, problem solving, and everyday mathematics. In the 1994 curriculum (FNBE, 1994), no specific contents were mentioned any more. Instead, it was stressed how the traditional content areas must be reviewed critically, and knowledge which was not necessary for understanding mathematical structures and applications was left out. Regarding the lower grades of 1 to 6, with classroom teachers, it was emphasised that students should understand the basic concepts and be able to do basic calculations mentally, on paper, and with a calculator.

In the 1985 curriculum (FNBE, 1985), students' own experiences together with familiar and earlier learnt topics were taken as the starting points of teaching. The objective for stressing application and problem solving was to foster and further develop students' creativity and thinking skills on the one hand, and to diversify teaching methods on the other. The spirit of it was that there should be more student-centred activities during the lessons, shifting the focus from knowing to doing. Teachers were expected to pay special attention to individual students, and to offer each one the possibility of obtaining sufficient knowledge and skills in all core content areas. Following the socio-constructive paradigm, the reformed framework curriculum of 1994 (FNBE, 1994) underlined a new understanding of knowledge as one that is changing and relational with the emphasis on students' active role in constructing their own knowledge. To reflect this, learning situations were expected to be built around discussions, experiments and problem-solving, based on concrete everyday problems. Students of all grade levels should work and build models with their own hands. Calculators and computers should be used as natural aids of teaching and learning, beginning from the lowest grades. Also, mathematics instruction was to be integrated with other subjects and other work done in school.

The National Board of Education introduced new guidelines for student evaluation in spring 1999 (FNBE, 1999). These included, among other things, descriptions for 'good' performance (mark 8 on the marking scale from 4 'rejected' to 10 'excellent'). It was also stated that mathematics instruction must progress systematically and create a lasting foundation for the assimilation of mathematical concepts and structures. The practical hands-on nature of teaching was seen to play an important role in linking students' own experiences and ways of thinking to the abstract system of mathematics. Problems rising from everyday situations, which could be solved by mathematical thinking or operations, were to be utilised effectively.

Mathematics teaching

A typical Finnish mathematics lesson begins by checking and going through the last lesson's homework. Following this, the teacher introduces the new topic to be learnt, e.g. a new calculation method or a geometric concept, which will then be explored collectively with some examples. Then the teacher assigns students some problems from the textbook to solve individually, to make sure that everything has been understood about the underlining idea. At the end of the lesson he/she gives the students new homework from the textbook. This model was dominant in the 1980s and is still so today, despite the recurring curriculum reforms (Maijala, 2006; Savola, 2008). According to our experiences, though, this kind of textbook dependence is stronger in grades 1 to 6, i.e., for classroom teachers, than for the last three years of comprehensive school education with mathematics teachers.

At the end of the 1980s, the Board of General Education, the predecessor of the National Board of Education (NBE), began to publish small booklets promulgating the new constructivist understanding of learning (e.g. Lehtinen, 1989; Halinen & al., 1991 for mathematics). However, already in the early 1980s, a strong urge to revise the traditional teaching paradigm had emerged in the university departments of teacher education, with teacher in-service education focusing on new teaching methods and classroom practises. Especially during the 1980s, in-service courses were offered on the use of learning games, on problem solving, on ways to develop students' mathematical creativity, on using computers and calculators, and on constructive geometry teaching. In her dissertation, Tikkanen (2008), summarised the current methods used in mathematics teaching in the lower grades of Finnish comprehensive schools to three approaches: problem solving, 'real mathematics', and story telling (ibid, pp. 96–105).

Problem solving in school mathematics

Mathematical problem solving has been generally understood as a means for promoting thinking skills (e.g. Schoenfeld, 1985). Since the 1980s, this has been reflected in the curricular documents of most countries as an explicit or implicit emphasis on the importance of teaching students to become good problem solvers (cf. Pehkonen, 2001).

In accordance with this general trend, fostering students' problem solving skills has been one of the general objectives of the Finnish curricula now for more than twenty years (FNBE, 1985, 1994, 2004). However, the 1994 curriculum (FNBE, 1994) differed from the earlier one by providing only general guidelines, leaving their implementation mostly open with the expectation that each school would write its own, more detailed curriculum documents following these general guidelines (cf. Appendix 1). This was also the case for mathematical problem solving. Accordingly, success in the implementation of the general goals was left to the individual schools and teachers, relying on their professional knowledge and skills. In other words, the decentralisation of educational authority meant that teachers were given the opportunity – but also the responsibility – to participate in formulating the precise goals and methods for mathematics teaching and problem solving activities for the different grade levels, to guide and lead these activities, and to assess their outcomes.

However, already in 1986, the National Board of Education (FNBE) began to promote problem solving in school mathematics, arranging a seminar on the topic for teacher educators. Even if verbal tasks to be solved by equations had been a permanent part of the curriculum already before that, actual problem solving tasks had been rare in Finnish mathematics textbooks. Soon after the FNBE seminar, almost every printing house published a set of problems in the form of a booklet or a deck of cards, and with time, similar problems began to appear in regular textbooks. But, while the share of such tasks made up about 105 of all tasks in the Finnish textbooks for grade 7 at the end of the 1980s (Kari, 1991), later (non-systematic) studies by teacher students indicate that their share has increased little since that time, despite all the discussion.

Towards the end of the 1980s, extensive in-service training was organised for both classroom and subject teachers in comprehensive schools to promote problem solving and new teaching methods to enhance students' active involvement in their own learning. And, according to Kupari (1999), in ten years both classroom teachers and mathematics teachers regarded problem solving as an important aspect of mathematics teaching. But even after twenty years, only a small part of teachers have actually changed their teaching style. Even teachers who readily express beliefs emphasising the importance of problem solving, often fail to implement it in their own teaching (Perkkilä, 2002). This demonstrates the difficulty and slowness of bringing forth real change in teacher practises (cf. Pehkonen, 2006).

In an attempt to find new methods for mathematics teaching, the open approach method, e.g. the use of open-ended problems, was developed in Japan in the 1970s (Becker & Shimada, 1997). Open-ended problems, where the initial or the goal situation is not given in an exact form have been since understood to promote teaching that emphasises understanding and creativity (e.g. Silver, 1995; Stacey, 1995). Students are given a free hand to formulate the problem and to choose the methods to solve it, meaning that they may end up with different but equally valid solutions and argumentations, depending on the choices made during the process.

In Finland, these ideas have been advocated since the 1980s in in-service teacher courses, in teachers' journals, and in teacher pre-service education (e.g. Halinen & al., 1991). The leading idea has been to increase openness and creativity in mathematics teaching. Yet, despite all the effort, we could well borrow the words of Schroeder & Lester (1989) and say that still few Finnish teachers teach via problem solving even if most of them teach something about problem solving. In view of the strong professional education of Finnish teachers (see Appendix 2), this actual slowness of progress in implementing problem solving in mathematics classrooms raises questions. One reason seems to be classroom time management practices and assessment methods that do not favour the sustained engagement that problem solving calls for. Also, problem solving and open-ended problems do not fare well if students are afraid of making mistakes; still a common enough feature in Finnish schools.

Assessment in mathematics

There is no national testing in Finnish comprehensive schools. Yet, like in some other core subjects, the National Board of Education (FNBE) implements a biennial assessment of ninth graders' curricular competence in mathematics for a system-level evaluation of education with a random sample of approximately 4500 students in 130 schools. The results are analysed, published and discussed at the system level and look at regional, gender and in-between school differences, but no school-level data is disclosed (e.g. Mattila, 2002, 2005). However, municipalities can purchase these tests to assess their students for their own evaluation purposes, allowing comparison to the national level. A comparable study of sixth graders' performance in mathematics is also implemented by the FNBE every fifth year to evaluate learning results at the end of the lower level of comprehensive school (cf. Niemi, 2008).

Already long before the introduction of the FNBE assessments, a nation-wide voluntary test was implemented yearly by the Union of Mathematics Teachers for the students of the last year of comprehensive school (ninth grade). The results are published in the mathematics teachers' journal, so that teachers have the opportunity to compare their students' level of attainment to that of other students. However, these are rarely discussed more widely.

The LUMA programme

In 1996, the Finnish Ministry of Education announced an extensive programme called LUMA, a Finnish acronym standing for Science and Mathematics, to be run from 1996 to 2002, to promote the teaching and learning of these subjects (Heinonen, 1996). For the programme, the National Board of Education established 16 networks involving 78 local authorities with a total of 270 educational institutions under their jurisdiction. Schools of all levels, from the lower (classroom teacher) level of comprehensive school to general and vocational upper secondary schools, collaborated with each other and with other nearby educational institutions and enterprises, with teachers being offered opportunities for varied in-service training.

Despite teachers' and teacher educators' contentment with LUMA, the programme's later international evaluation saw that the implementation of its goals had not been as successful as the local educational policy discourse implied – which is, unfortunately, the fate of most educational programmes. Yet, even if earlier research demonstrated that it is difficult to change teachers' deep-rooted teaching methods via in-service training, their beliefs concerning effective teaching, or the ways they use (or do not use) learning materials and laboratory equipment (e.g. Willis, 1997; Pehkonen, 2006), LUMA succeeded in establishing a positive atmosphere for diverse discrete projects to enhance mathematics teaching and for in-service training programmes. Another important aspect in the success of LUMA was the active stance that many private organisations in high-tech industries and other related fields took toward cooperation with schools. This encouraged the adoption of educational innovations in the LUMA networks. All in all, the most important outcome of the LUMA programme seems to have been its success in attracting teachers and researchers in the related fields to join in a common effort to advance mathematics and science teaching in Finland (for more on the LUMA programme, see ME, 2002).

6|2 Finnish students' performance in PISA 2006 mathematical literacy

The overall results of mathematical literacy in PISA 2006 are presented comprehensively in the OECD's publication PISA 2006 Science Competencies for Tomorrows World (OECD, 2007a, 2007b). Only a short overview of the general results will be given here to ground the more detailed analysis of the Finnish students' performance in the different types of mathematical literacy tasks within this frame.

Mathematics was a minor domain in PISA 2006, meaning that students' mathematical literacy was measured with just 30 tasks, comprising 48 individual items selected from the 84 items of PISA 2003. In this selection process, also the distribution of these anchor items into the different classifications used in PISA 2003 – item format, item context, item strand, item topic and measured competency – has changed (OECD, 2004, pp. 37-42; OECD, 2007a, p. 312), complicating direct comparisons between the results of PISA 2003 and PISA 2006 (for the impact of item format, see e.g. Lafontaine & Monseur, 2007). Also, even if ten of the thirteen test booklets contained mathematics items, less than a third of the students in each country were presented a given item (in Finland, about 1400 students, meaning on average 9 students per school). As all mathematics items in PISA 2006 were link items to be re-used in PISA 2009 and PISA 2012 for trend analysis, no examples of the actual items that students responded to can be included here.

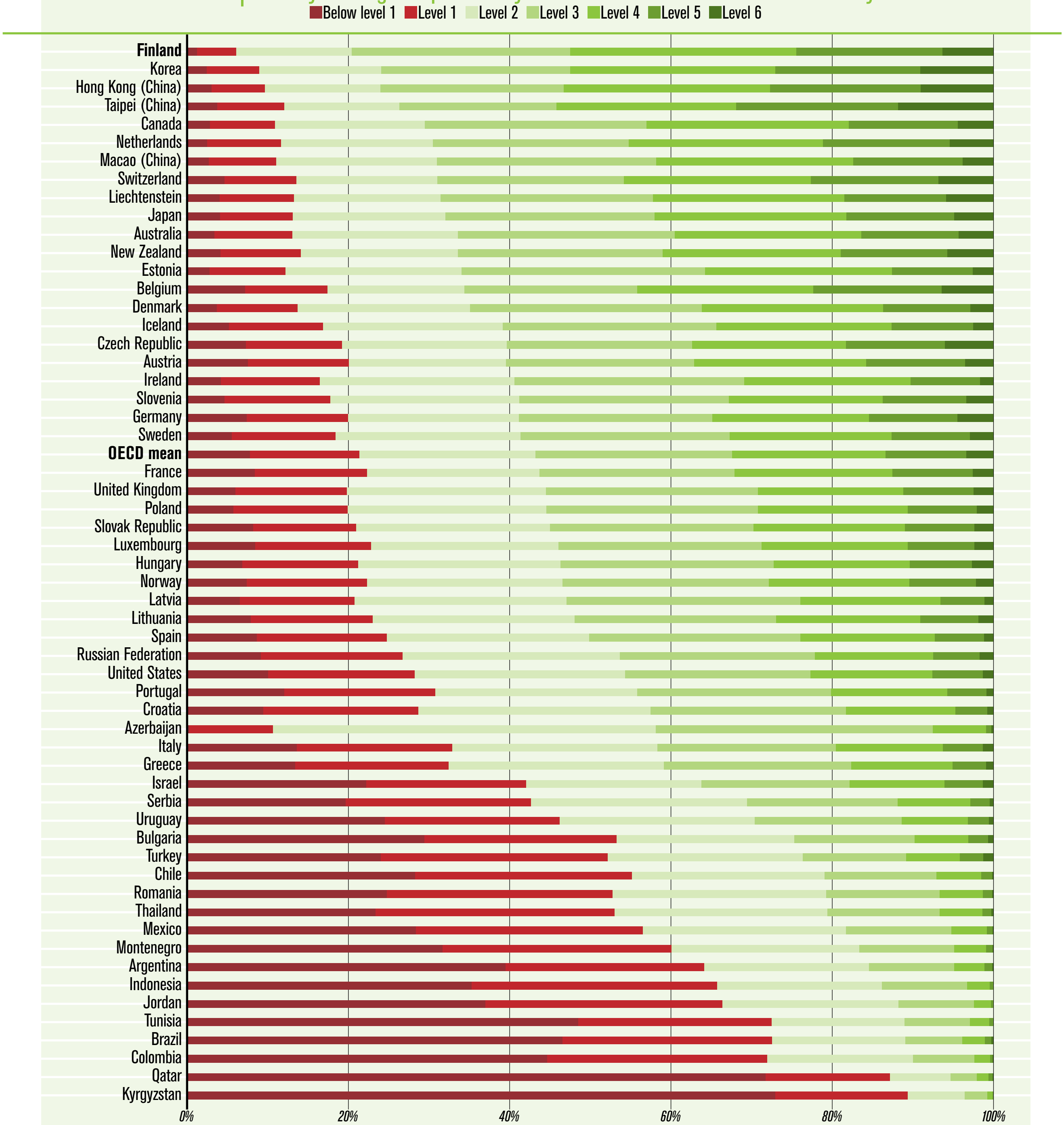
The performance of all the participating countries in PISA 2006 mathematical literacy is presented in Figure 6.2, showing the share of students at each of the six proficiency levels, arranged in order by the share of students above Level 2, understood as the minimum level of mathematical literacy necessary for a full participation in today's world (for a full description of the proficiency levels, see OECD, 2007a, p. 312).

The share of students performing below Level 2 is relatively small in all the top performing countries. It is smallest in Finland where only 6% of students fall into this category, less than a third of the OECD average of 22%. Besides this small share of weak students, Finland is also one of the seven countries where at least 20% of students perform at Level 5 or above (13% in the OECD). Nonetheless, there is no difference between the mean mathematical literacy performance of the four top performing countries, Chinese Taipei, Finland, Hong Kong-China and South Korea.

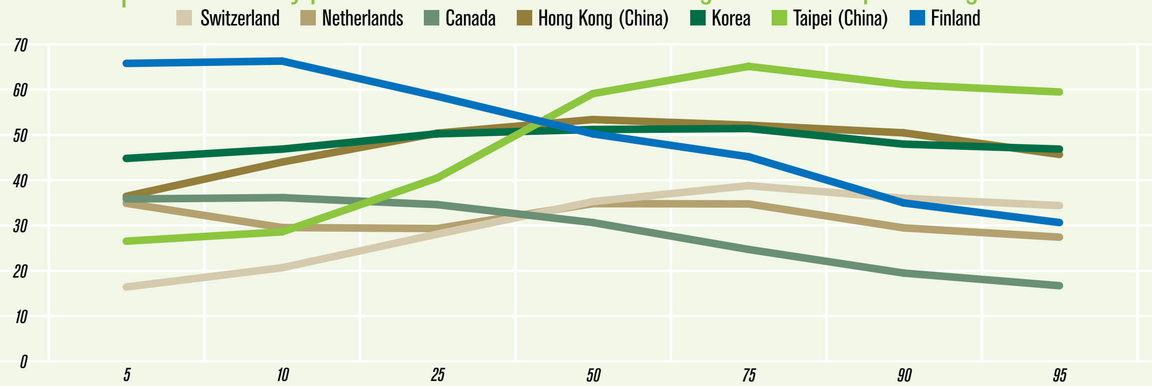
The small Finnish student variance

In Finland, the majority of children begin school in the autumn of the year they turn seven. Due to this late school start, common to the Nordic countries, PISA is implemented while the 15-year-olds are still ninth graders in comprehensive school. The main institutional factor responsible for between-school variance in many of the other participating countries is thus missing or was not yet functional in the Nordic countries

F 6.2 | Country ranking and proficiency level in PISA 2006 mathematical literacy



F 6.3 | Achievement by percentile relative to the OECD average for the best performing countries



at the time of the PISA survey. This has to be kept in mind when interpreting results regarding student variance, especially when comparing the between-school and within-school variances in the different countries (see Chapter 4). Also, in the Nordic countries, differences in wealth and cultural capital are relatively small compared to those in many other Western countries, and the principle of students from different backgrounds going together to the nearest school is common, at least during the comprehensive school years. Likewise, it has to be kept in mind that any systematic variance inside schools, due to streaming or other grouping principles, will not show up in PISA due to the random sampling of students inside schools (for the effects, see e.g., Duru-Bellat & Mingat, 1998).

The relatively low total variance of the Finnish results in PISA mathematics reflects small differences in achievement within the different parts of the country, relatively small gender differences, a relatively small impact of students' home background on their mathematics performance, and the relatively high performance of the weaker students. These are all interdependent factors that play a role in the good results of Finnish students also in the other PISA domains, and reflect the general objectives of the Finnish comprehensive school. To highlight the rather exceptional profile of the Finnish students' mathematics achievement, characteristic also to the two other domains, the relative proficiency of students of different achievement level (percentiles) is presented in Figure 6.3 for the seven best performing countries in mathematical literacy.

Even if the mean score for all percentile groups in the four top performing countries exceeds the OECD average for that group by more than 25 points, they clearly present three different country-level achievement profiles for high performance. While the driving force for the good results in Chinese Taipei is the superior performance of its top students and Finland's special asset is the relatively even more superior performance of its weakest students, in Hong Kong and especially in South Korea, students of all levels perform well above the OECD average for their respective percentile groups. The same profiles can be seen in weaker forms in the other top performing countries, with only Canada (together with Macao, Estonia, Denmark and Ireland with somewhat lower levels of performance) representing the same profile as Finland with relatively stronger students at the low end of the distribution. As Finland is the only country where this performance profile is consistent through all the literacy domains, combined with equally high results, focus on the performance of the weaker students seems to offer one key for trying to explain the Finnish success in PISA.

T 6.1 | The relationship of the percentage of correct responses (corr) and missing or invalid answers (miss) to item format for items of varying difficulty*

Item Format	*Easy 25 %*			*Mid-easy 25 %*			*Mid-diff 25*			*Diff 25 %*		
OECD	*corr*	*miss*	*N*	*corr*	*miss*	*N*	*corr*	*miss*	*N*	*corr*	*miss*	*N*
Multiple choice	76	2	5	51	4	3	40	5	4			
Complex multiple choice				53	3	3	44	3	4	23	4	2
Short response	67	9	3	56	13	3	30	18	1	29	28	3
Closed construct	83	2	3	60	8	1	41	9	2			
Open construct	63	19	1	63	15	2	36	27	1	19	29	7
Total	74	5	12	55	8	12	41	8	12	22	25	12
FINLAND												
Multiple choice	86	2	5	60	3	3	50	3	4			
Complex multiple choice				65	1	3	57	1	4	31	1	2
Short response	79	4	3	69	6	3	41	15	1	42	18	3
Closed construct	92	1	3	62	8	1	54	6	2			
Open construct	84	7	1	76	7	2	59	8	1	26	20	7
Total	86	3	12	66	4	12	53	4	12	31	17	12

*To minimize the effect of non-responding, the classification is based on the percentage of correct answers of the 10 top performing countries where the overall rate of non-responding is fairly low and hence probably less dependent on factors other than the difficulty of the task. Yet, as the content and topic of the items might have an effect, too, the results should be seen as only indicative of the way item format affects response rate. (OECD and Finland)

Interpreting students' performance in PISA mathematics

Weak performance can reflect students' lacking skills in mathematical literacy, but it can also be due to a lack of motivation or self-efficacy or to problems in understanding the language or setting of individual items, all prospective reasons for non-responding. On side of these more general factors, also item format and item content (its interest or relevance to the student) as well as its perceived difficulty affect students' willingness to tackle a problem. The intertwined relationships between correct answers, non-responding, item difficulty and item format for items belonging to different difficulty quartiles are shown in Table 6.1. To minimise the impact of non-responding, instead of the IRT-based proficiency levels the classification of difficulty is based on the percentage of correct answers of the students of the 10 best performing countries, where non-responding seems mainly to be restricted to items found too difficult even for these high-performing students.

At all difficulty levels, the share of missing and invalid answers is highest among items that ask for a constructed response. These are often items requiring some sort of computation while items of the other response types often rely more on students' ability to deduce from and work with facts given in the stimulus in either written form or in graphs and tables.

In Finland, like in most well performing countries, the number of students who do not even try to solve an item is relatively small for all item formats and difficulty levels. The most active responders are Dutch students with a missing rate of only 4%, with Canada and Finland following with a share of 7% (the OECD mean for missing and invalid responses is 12%). However, maybe reflecting a kind of go-ahead attitude in the Dutch students' answering, their share of incorrect answers is at the level of the OECD average. Japan, instead, seems to represent a very different culture with one of the lowest shares of incorrect answers

(35%) while the share of missing and invalid answers at 12% is the highest among the top performing countries. Students' diligence in answering seems thus not to be the only explanation for the achievement of the top performing countries but the confidence it reflects seems to be grounded on actual difference in knowledge and ability – at least in responding to the kinds of tasks used in PISA.

Finnish students' relative strengths and weaknesses in mathematics

For a closer look at the Finnish students' performance in PISA mathematical literacy, the Finnish results will mainly be compared to the OECD mean and to the performance of the other top performing countries: Chinese Taipei, Hong Kong China, South Korea, Netherlands, Switzerland, Canada, Macao China, Liechtenstein and Japan. The results will be viewed primarily according to item topic, item format and the measured competence (for the full item classification in mathematical literacy, see OECD, 2004, pp. 38-42). Due to the intertwining of these characteristics in the actual items, however, the most difficult items are not found by just looking at the individual qualities of the task, as could already be seen in Table 6.1 for item format.

What kinds of items are difficult for students?

In PISA 2006, the characteristics that seem to make an item in mathematics especially difficult for students are falling into the topic area of Space and Shape, measuring mathematical reflection, and requiring an open construct response. And, despite the general success of the Finnish students, the one item in PISA 2006 which shared all these characteristics proved to be difficult also for the great majority of them. While the average percentage of correct answers for the Finnish students was 59%, only 5% of the students solved this item correctly, with an additional 9% getting 'half credit' (together, these present a 'correct' percentage of 9%) while 16% of the students did not even try to solve the item (in Finland, the average percentage of non-responding was 7%).

To give an example of this kind of item that seems to fall beyond the competence of most 15-year-old students, we will use as a proxy a fairly similar item DISTANCE presented in the OECD Framework for PISA 2006 (OECD, 2006a, p.102).

Our understanding is that the majority of Finnish teachers would have reacted in quite the same way. Also, the Finnish students' scant success in the task could have been predicted based on earlier research, disclosing students' limited creativity and understanding in such tasks (cf. Pehkonen & Vaulamo, 1999).

This relatively hard item was one of the only two items in PISA 2006 where the percentage of correct answers among the Finnish students lagged behind the OECD average (9% vs. 12%). Yet, 50% of the students in Azerbaijan and the Chinese Taipei solved the item correctly and also the students of South Korea, Macao, Slovenia and the Slovak Republic performed well above the OECD average (from 38% to 21%, respectively). In this task, the difference between boys and girls was also exceptionally high with boys outperforming girls by almost 20% compared to their mean pre-eminence of 6%. However, the kind and level of mathematical thinking required by this item was clearly in a class of its own compared to most PISA items.

The relative difficulty of the items in the topic area Space and Shape is also in evidence in the percentage of missing and invalid answers among these items. The highest rate of such answers, an OECD average of a full 42%, was elicited by an item in this topic area. The item and the task it was part of shares many characteristics with the example task FARMS in the OECD Framework (2006a, p. 110), presented here as an example of the kind of task which seems to elicit a 'not-for-me-to-try' response from a good share of students even in the better performing countries. In this task which resembles a traditional 'school mathematics' task more than many others in PISA, the percentage of correct answers exceeded that of missing and invalid answers in just four countries, and even in three of them the share of students who did not even try to solve the problem rose to almost 30%.

Example task | Distance

Mathematics Example 18: DISTANCE

Mary lives two kilometres from school, Martin five.

Question 1: DISTANCE

How far do Mary and Martin live from each other?

When this problem was originally presented to teachers, many of them rejected it on the ground that it was too easy – one could easily see that the answer is three. Another group of teachers argued that this was not a good item because there was no answer – meaning there is not one single numerical answer. A third reaction was that it was not a good item because there were many possible answers, since without further information the most that can be concluded is that they live somewhere between three and seven kilometres apart, and that is not desirable for an item. A small group thought it was an excellent item, because you have to understand the question, it is real problem solving because there is no strategy known to the student, and it is beautiful mathematics, although you have no clue how students will solve the problem. It is this last interpretation that associates the problem with the *connections* cluster of competencies.

Yet, the item for which the FARMS task is here a proxy, elicited a slightly higher percentage of correct answers than the ones presented earlier (OECD mean 17%), with largely the same countries performing at the top. The Azerbaijan students showed again the best proficiency with 46% answering the item correctly while Hong Kong was a good second with the correct response rate of 42%. These two were also among the countries were the share of missing and invalid answers was well below the OECD average. Also the Finnish students performed fairly well with 24% solving the item correctly while the share of missing and invalid answers was 28%. Still, half of the students who tried their hands at solving the problem could not solve it.

Despite the general relative difficulty of the items in the topic area of Space and Shape, the item that proved to be the most difficult for students with only 7% in the OECD countries answering it correctly, was the only item in algebra in PISA 2006. It clearly was difficult even for the students of Hong Kong and the Chinese Taipei, the two countries with the best performance in the item, with only just over 20% of students answering the item correctly. Also in Korea, Belgium and Macao the share of students solving the item correctly was more than double that of the OECD average, while in Finland, 10% of the students succeeded in doing the same.

The impact of item topic

The percentages of correct answers by item topic are given in Table 6.2 for the OECD and for Finland.

Items classified into the area Quantity have been solved correctly more often than items in the other topic areas both in the OECD in general and by the Finnish students. There are, however, some differences even between the best performing countries as to the relative performance of their students in the different topic areas, possibly reflecting differences in the respective national mathematics curricula.

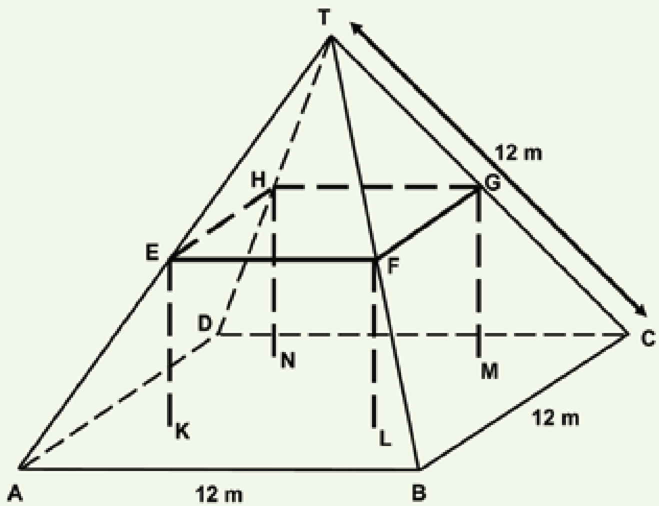
The students of the Chinese Taipei seem to be especially competent in the topic area of Space and

Example task | Farms

M037: Farms

Here you see a photograph of a farmhouse with a roof in the shape of a pyramid.

Below is a student's mathematical model of the farmhouse **roof** with measurements added.



Question 1: FARMS *M037Q01*

Calculate the area of the attic floor ABCD.

The area of the attic floor ABCD = ____________ m²

T 6.2 | Percentage of correct answers by item topic, OECD mean and Finland

		OECD			Finland	
	N	Mean	SD	SE	Mean	SE
Space and shape	11	43%	7.0	0.23	52%	1.18
Change and relationships	13	46%	7.7	0.21	59%	1.14
Quantity	13	57%	6.8	0.24	68%	1.20
Uncertainty	11	45%	6.5	0.24	55%	1.28

Shape with 58% of students answering the items correctly. Among the best performers in this topic area are also the students of the other top performing Far Eastern countries: Hong Kong, Korea, Japan and Macao as well as those of five European countries: Switzerland, Finland, Liechtenstein, Belgium and the Czech Republic, all with a correct response rate of near or over 50%.

The Finnish students' special strength seems to lie in the area of Change and Relationships with a correct response rate of 59%. In this topic area, only Hong Kong, Korea and Taipei among the five top performing Far Eastern countries belong to the 'top 10' with over 50% of students answering the items correctly, together with the three top performing English speaking countries Canada, New Zealand and Australia, and the Netherlands, Belgium and Estonia from among the top European countries.

The items in the topic area of Quantity seem to have been the easiest for most students, even if one among them elicited one of the biggest shares of missing and invalid responses with more than every second student leaving it unanswered. The item was not necessarily difficult but looked like it would require more computation than it actually did – if the student understood the underpinning idea and built on the work she/he had done in the previous item, both salient features of the best PISA tasks. Of the Finnish students, 42% answered the item correctly, with the OECD average at 35% and the correct response rate of best performing Azerbaijan a high 75%.

The topic of Uncertainty comprises items in the fields of probability and statistics, and might be the domain where differences among the curricula of the participating countries are greatest (e.g. Monnier & al., 2007, p. 25). However, these two might be the fields of mathematics which students meet most often in everyday life situations and in the media, from lotteries and card games to survey results and weather forecasts. The item AVERAGE AGE from the OECD Framework (OECD, 2006a, p. 93) and the released item COLOURED CANDIES from PISA 2003 (OECD, 2006b, p. 60) present good examples of items in this topic area.

Top performers in the topic area of Uncertainty were students from the Chinese Taipei (59%), with also Hong Kong, Korea and Macao being among the top Far Eastern countries. Among European countries, Finland, the Netherlands, Liechtenstein and Switzerland were at the top, and Canada and New Zealand were the top English speaking countries, all with 50% or more of the students answering correctly to the items in this topic area.

However, considering all the other characteristics the items in the different topic areas have and the varying difficulty of the items in each topic area, it is not clear whether the differences in students' performance are really due to the item topic or to just diverse contingent factors in the items.

The impact of the competence the item is set to measure

The percentages of correct answers by the measured competence are given in Table 6.3 for the OECD, for Finland and for the top 10 performing countries.

Even if the absolute difference between the OECD mean and the percentage of students in the top performing countries answering correctly the items measuring the different competences stays fairly constant at 7% to 8%, the more abstract thinking an item calls for, the bigger is the relative difference between them. There is a similar though weaker difference between the performance of the Finnish and the Far Eastern students among the top performers in their relative

Example task | Average age

Mathematical Example 10: AVERAGE AGE

Question 1: AVERAGE AGE

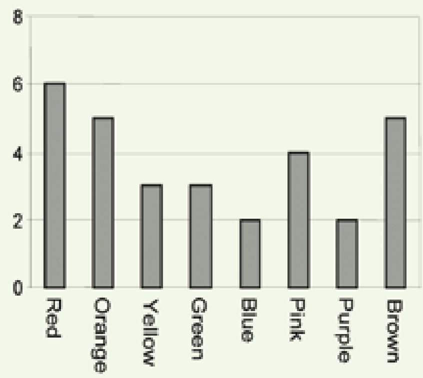
If 40% of the population of a country are at least 60 years old, is it then possible for the average age to be 30?

Example task | Coloured candies

M467: Coloured Candies

Question 1: COLOURED CANDIES *M467Q01*

Robert's mother lets him pick one candy from a bag. He can't see the candies. The number of candies of each colour in the bag is shown in the following graph.



What is the probability that Robert will pick a red candy?

A 10%
B 20%
C 25%
D 50%

T 6.3 | Percentage of correct answers by measured competence, OECD mean and Finland

		OECD			Finland	
	N	*Mean*	*SD*	*SE*	*Mean*	*SE*
Reproduction	11	67%	7.6	0.22	79%	0.98
Connections	24	48%	7.2	0.24	60%	1.29
Reflection	13	34%	5.6	0.21	41%	1.21

T 6.4 | Percentage of correct answers by item format, OECD mean and Finland

		OECD			Finland	
	N	*Mean*	*SD*	*SE*	*Mean*	*SE*
Multiple choice	12	55%	6.4	0.23	65%	1.15
Complex multiple choice	9	43%	7.1	0.24	54%	1.37
Short answer	10	49%	7.1	0.25	61%	1.23
Closed constructed	6	65%	7.9	0.21	74%	1.09
Open constructed	11	32%	7.4	0.21	44%	1.14

performance according to the measured competence (cf. Grønmo & Olsen, 2006 and Wu, 2008 for a similar finding when comparing PISA 2003 and TIMMS 2003 – 8 grade mathematics results for some Western and Far Eastern countries).

The mean share of students answering correctly the items measuring mathematical Reproduction was over 70% in 14 countries, with the mean of Finland at 79% the highest among them. Reflecting the high share of multiple choice items in this category (five out of eleven), the share of missing answers was well under the average with an OECD mean of 7%.

Items in the category Making connections were clearly found more difficult, with the OECD mean for correct responses at just under 50%. Yet, the response format in these items was also more demanding with just three (simple) multiple-choice items among the 24 in this category. The mean share of students not even trying to solve an item was also higher at 12% for the OECD and rising to over 20% in twelve countries. The Finnish students also performed best in the items of this category, with the mean share of correct responses being 60%.

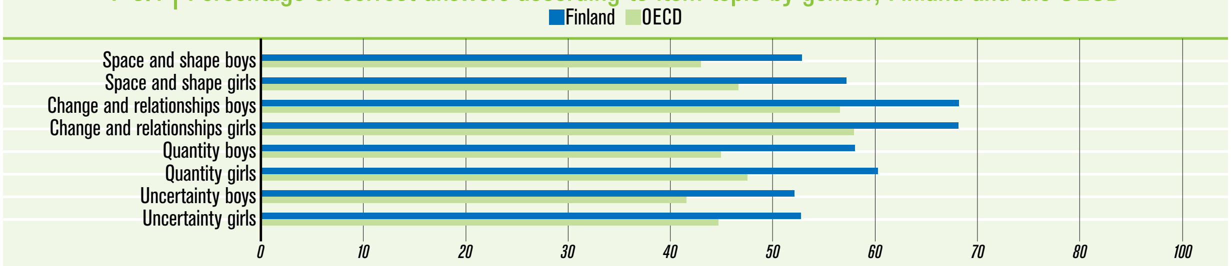
Items measuring students' skills in mathematical Reflection were the most difficult for all students. Finland is still among the top five countries in this category with 41% of correct answers, but falling clearly below the level of top performing Chinese Taipei where 48% of students solved the items correctly. Differences in the way students react to problems that they cannot solve easily are noticeable in this category even among the top performing countries. Whilst Japan and the Netherlands have practically the same share of correct answers (41% vs. 40%), the rate of missing and invalid answers is 16% in Japan but only 5% in the Netherlands. In Finland, the share of missing and invalid answers is 10%, which is also the mean for the top 10 countries. By and large, well over half of the students of even the 10 best performing countries in PISA mathematics either answered incorrectly or did not answer at all to the items measuring their proficiency in mathematical reflection.

The impact of item format

Item format has a clear effect on students' readiness to answer a problem, as shown above in Table 6.1. This is especially true in the case of simple multiple-choice items, where an item's actual difficulty, as measured by the percentage of correct answers, has hardly any impact on students' readiness to tick one of the offered boxes to an answer, increasing the share of guessed correct responses. The percentages of correct answers by item format are given in Table 6.4 for the OECD and for Finland.

However, the easiness to choose and tick a multiple-choice answer is not the only reason item format may affect the answering of – and the subsequent possible success in – an item. The complex multiple-choice items and short response items seem to work in a fairly straightforward way in this respect, the first requiring often four or five straight correct responses

F 6.4 | Percentage of correct answers according to item topic by gender, Finland and the OECD



to yes/no questions and the latter a numerical answer that most often is either correct or incorrect with little space for contingency.

The many allowances made in coding as to what counts for a correct answer in the items asking for an open constructed response do raise some questions, however. Accepting responses that do not fulfil the stated requirement of showing the reasoning behind one's answer and other allowances made in the more demanding 'school-math' type items might give an extra advantage to students who do not leave a question unanswered even if the attempted answer were just a numerical value without reasoning or a fraction when percentages are asked for – the latter a topic that has traditionally proved hard for many Finnish students.

The impact of the item's level of difficulty

The uneven share of items of different formats in the cross-categories of item topic and measured competence complicates comparisons among the categories. Hence, we will end by looking shortly at the results according to item difficulty, based on the performance of the top 10 countries (Table 6.5).

Among the top performing countries, Finnish students perform relatively better in the tasks belonging to the easiest 25%, with a rate of 86% of correct responses compared to the mean of 81% for the 'top 10' . On the other hand, students from the Chinese Taipei and from Hong Kong outperform the other top performers with the same margin in the items forming the most difficult quarter of the tasks (36% and 34%, respectively, compared to the mean of 30% for the total 'top 10'). Yet, the results might have been even poorer without the allowances made in many of the harder items, with even half a credit awarded in one item for a response with the numerator and the indicator mixed in a fraction.

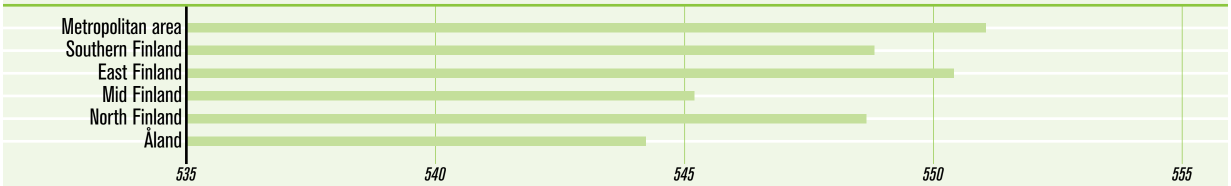
T 6.5 | Percentage of correct answers by item difficulty, OECD mean and Finland

		OECD			Finland	
	N	*Mean*	*SD*	*SE*	*Mean*	*SE*
Easy 25 %	12	74%	7,0	0,21	86%	0,88
Mid-easy 25 %	12	55%	7,6	0,25	66%	1,32
Mid-difficult 25 %	12	41%	7,3	0,25	53%	1,40
Difficult 25 %	12	22%	5,7	0,20	31%	1,19
Total	48	48%	6,8	0,23	59%	1,20

Gender differences in students' mathematical literacy

In Finland, as in most other countries (see OECD, 2007a, p. 320-21), boys outperformed girls in PISA 2006 mathematical literacy, with the difference in Finland at the mean OECD level of 12 score points. The Finnish score points of 554 vs. 543 represent the percentages of correct responses of 60% (SE 1.7%) for boys and 58% (SE 1.6%) for girls.

F 6.5 | Mathematics performance in the Finnish EU-areas



The Finnish gender difference reaches statistical significance only at the level of the total score point sum, but seems to increase with item difficulty. While there is no difference in the items belonging to the easiest quartile (86% vs. 85%), there is a difference of 33% vs. 29% in the items in the most difficult quartile. However, as it is not easy to differentiate the impact of the various factors affecting item difficulty in PISA, it is not clear whether it is explicitly the (mathematical) difficulty of the task that is central to the gender difference or some other factor. When students' reading proficiency is taken into account, however, the gender difference increases from 11 to 58 points, reflecting the much greater difference between Finnish girls and boys in reading literacy. Gender differences by topic area are presented in Figure 6.4, showing that whereas the difference in the OECD means is fairly even across the categories, in Finland, only the difference in the topic area of Uncertainty (57% vs. 53%) is of any consequence.

Boys' better performance was most prominent in an apparently quite difficult item in the topic area of Uncertainty, regarding the very basics of statistics. In this item, the best performers were boys from Hong Kong and Finland with 33% and 32% of correct answers, while only 18% of the Finnish girls answered the item correctly. A comparable item STUDENT HEIGHTS from the PISA 2006 Framework (OECD, 2006a, pp. 104-105) is presented here to act as a proxy for the type of task that many students found difficult but which can be seen to represent one of the ways in which mathematics penetrates today's everyday life.

The only two items where Finnish girls clearly outperformed boys (55% vs. 43% and 69% vs. 54%) were pictorial tasks, both asking for a Closed constructed response but with no other discernible connection between them, the other representing the topic area of Space and shape and the other Quantity. Boys were generally better than girls in simple and complex multiple-choice items as well as in items asking for an open constructed respond. They also outperformed girls in items more reminiscent of traditional school maths problems. This seems to be contrary to girls having on average slightly higher marks than boys in mathematics on the 9th grade report cards but, on the other hand, boys have performed either at the level of or better than girls in the latest national sample-based mathematics assessments (Mattila, 2002, 2005; Niemi, 2008).

Students' home background and their proficiency in mathematical literacy

In PISA 2006, the performance of Finnish students in mathematics is very even across the country and the small differences between the six regional areas used in sampling are not statistically significant (Figure 6.5).

The difference between the students of urban and rural schools (550 vs. 542 score points, respectively) is, however, just enough to surpass the threshold for statistical significance. This result differs from the results of the latest national sample-based mathematics assessment of 6th graders in 2007, but agrees with the earlier results of the assessment of 9th graders in 2004 (Mattila, 2005; Niemi, 2008).

Example task | Students heights

STUDENT HEIGHTS

Question 1: STUDENT HEIGHTS ***M479Q01***

In a mathematics class one day, the heights of all students were measured. The average height of boys was 160 cm, and the average height of girls was 150 cm. Alena was the tallest – her height was 180 cm. Zdenek was the shortest – his height was 130 cm.

Two students were absent from class that day, but they were in class the next day. Their heights were measured, and the averages were recalculated. Amazingly, the average height of the girls and the average height of the boys did not change.

Which of the following conclusions can be drawn from this information?

Circle 'Yes' or 'No' for each conclusion.

Conclusion	**Can this conclusion be drawn?**
Both students are girls.	Yes / No
One of the students is a boy and the other is a girl.	Yes / No
Both students have the same height.	Yes / No
The average height of all students did not change.	Yes / No
Zdenek is still the shortest.	Yes / No

The classification used in PISA for parents' education differs from that used in the different Finnish national studies, leading to a lower estimate for its role in students' achievement, and not allowing easy comparisons between PISA and the national assessment results. Based on the school marks which Finnish students reported as a national option, mothers' education is slightly more strongly correlated with students' success in PISA than it is with students' achievement in mathematics (3.7% vs. 2.8%).

While in earlier Finnish studies mathematics has shown to be less dependent on students' home background than e.g. reading comprehension, the differences between the three PISA domains are small and the correlation between parents' occupational status and students' performance is even slightly higher for

T 6.6 | Students' proficiency in mathematical literacy in PISA 2006 and their school achievement* in mathematics according to the occupational status of their parents

(for the classification of occupations, see OECD 2007a, p. 332) *In Finland, school marking ranges from 4 (rejected) to 10 (excellent).

	PISA						School mark in math			
	Mother			Father			Mother		Father	
	Mean	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*Mean*	*SD*
White collar high skilled	569	74.4	1939	571	74	1622	7.9	1.4	8.0	1.4
White collar low skilled	5399	72.3	1622	537	71	303	7.5	1.4	7.5	1.4
Blue collar high skilled	548	70.7	291	539	72	1388	7.5	1.4	7.5	1.4
Blue collar low skilled	519	72.6	404	535	76	742	7.2	1.4	7.5	1.4

mathematics than for the other literacies (r=.27 vs. r=.25 and r=.24 for reading and science). A somewhat higher estimate for the role of home background is achieved by taking into consideration all the three factors used in PISA, parents' occupational status, education and home cultural possessions. The role of the first one is shown in Table 6.6.

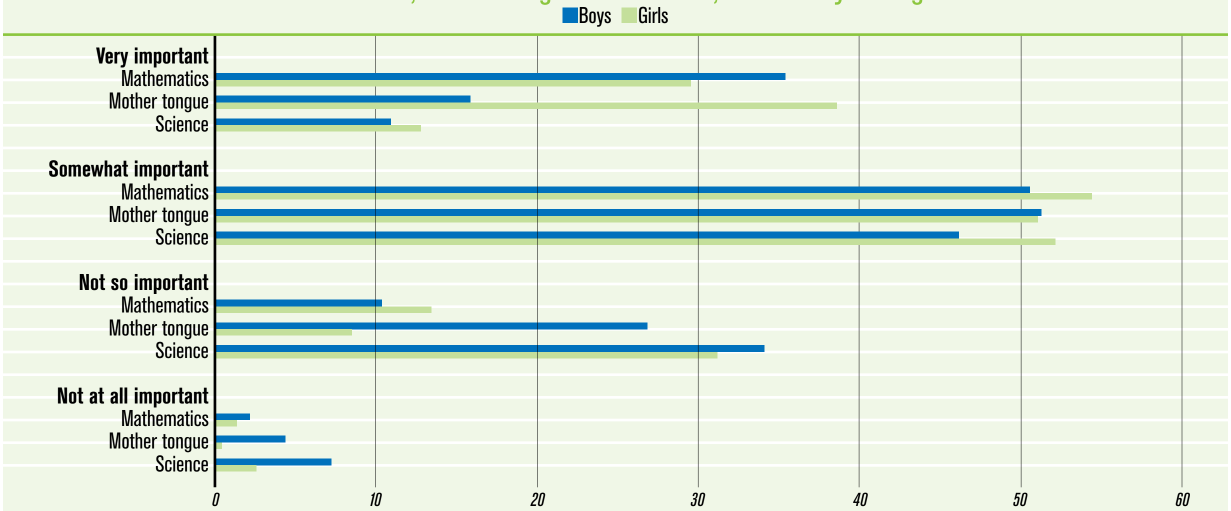
The apparent difference in the impact of mothers' and fathers' occupation on their children's mathematical proficiency is, however, probably not of psychological or educational origin but a sociological (arte) fact, reflecting the gender-split nature of the Finnish job market. Irrespective of the rapidly growing share of women who are more educated than men, it is still more difficult for them to reach high-skill positions, a phenomenon visible in the differences in the share of mothers and fathers in the groups of low-skilled white collar and high-skilled blue collar workers.

Only the combined index of parents' education, their occupational status and home cultural possessions raises the explanatory power of home background in PISA close to that of earlier Finnish studies where the length of parents' academic education has traditionally been the most salient explanatory factor for children's academic success and choices (e.g., Hautamäki & al. 2003, 2005; Kauppinen, 2004). However, even when seen from this perspective, the role of home background in Finnish children's achievement stays well below the OECD average, supporting the view that the Finnish school system is based on equality – at least as long as students are enrolled in comprehensive school. The last remark is warranted, as just as the in-between school variance in achievement grows considerably after students move to the Finnish dual system of general (academic) and vocational institutions of upper secondary education, achievement differences related to students' home background – the most salient factor influencing the choice – grow as well, a few months after participation in PISA.

Mathematical literacy, school achievement and the importance of doing well in mathematics

To relate the Finnish PISA results more closely to students' curricular achievement, a question concerning their school marks in the subjects related to the three PISA domains was added to the PISA 2006 student questionnaire as a national option. Traditionally, girls outperform boys in almost all subjects in Finnish comprehensive schools, including mathematics, even if the results of the national assessments do not always support the difference. Girls' better marks were confirmed also with the present data, even if the difference is smaller in mathematics than in most other subjects. Students' marks in different subjects are also strongly correlated, from r=.56 between mathematics and mother tongue to r=.83 between physics and chemistry (all p<.001). The correlations differ by gender, with marks in Finnish being more closely tied with those in

F 6.6 | Self-reported importance of doing well in Mathematics, Mother tongue and Science, Finnish boys and girls



mathematics and science for boys than for girls, reflecting students' gender-divided attitudes toward the different subjects taught at school ($p<.001$) (Figure 6.6).

Among the school subjects corresponding to the three PISA domains, mathematics is clearly for boys the one where doing well is most important, while for girls the difference between the importance of doing well in mother tongue and mathematics is much smaller. While doing well in mathematics is very important for about a third of both boys and girls, the greater relative importance it has for boys compared to doing well in mother tongue may reflect differences in boys' and girls' later mathematics-related choices. Traditionally, boys choose the more demanding calculus courses in the academic upper secondary schools or technical programmes in the vocational schools significantly more often than girls (cf. Minkkinen & Pehkonen, 2007).

The correlations between students' school marks and their performance in the different PISA literacies are little weaker than the mutual correlations of either. This reinforces the notion of a relatively strong common factor in the different literacies, even if the data does not answer to the question whether the 'sameness' is due to the basic concept of literacy or just to the fairly similar way the respective literacies have been operationalised into tasks and items – or the amount of written text the items are imbedded in. For example, while the correlation between the Finnish students' marks in chemistry and the other subjects varies from $r=.61$ $r=.83$ (the extremes being mother tongue and physics, respectively), reflecting the differences in their internal requirements and students' interests, there is hardly any differences between its correlation with the different PISA literacies ($r=.58$ with PISA science, $r=.56$ with PISA math and $r=.54$ with PISA reading). For students' marks in mathematics, the difference is a little smaller with correlations to other school marks varying from $r=.56$ to $r=.73$ (the extremes being again mother tongue and physics) while correlations with the different PISA literacies are $r=.51$ for reading, $r=.57$ for science, and $r=.58$ for mathematics.

6|3 Conclusions

The Finnish success in PISA mathematical literacy has been received with mixed feelings. While the educational establishment has understandably been content and even proud of the results, the academic mathematical community's reaction has been more divided and even sceptical, questioning the validity of PISA as a measurement of the success of mathematics teaching in the Finnish comprehensive school (e.g. Astala & al. 2005a; Tarvainen & Kivelä, 2005). Both views seem to get at least partially validated by the results of PISA 2006 reported above. As a whole, Finnish students performed better than the students of most other participating countries but at the same time, many of them had difficulties in solving problems that at the outset should not have been beyond the competence of a student soon to enter upper secondary education.

The PISA mathematics items which elicit a low rate of correct answers and a high rate of missing and invalid answers in Finland as well as in most OECD countries seem to have common characteristics. Firstly, they are often items that most resemble tasks found in traditional mathematics books in many countries. Secondly, they often require – or at least seem at the outset to require – computation of some sort. Compared to the students of most other top performing countries, Finnish students seem to perform at their best, and are more willing to attempt, answering problems that do not look too 'mathematical' but rather require a more common sense approach. With regards to this, the Finnish results seem to be in accordance with the findings of Grønmo & Olsen (2006) and Wu (2008) regarding differences between Western and Far Eastern students in PISA 2003 and TIMSS 2003. However, in PISA 2006, also the students of some Western European countries performed better than their Finnish peers in some of the items requiring more advanced mathematical thinking or computational skills. And earlier, regarding the international KASSEL-project, it has been proposed that the Finnish students' strength was rather in problem solving and in their ability to use common sense reasoning than in tasks requiring computation and more exact mathematical knowledge (Soro & Pehkonen 1998, p. 50).

Of special concern for the Finnish educational community is that, despite the Finnish students' success in PISA 2000, 2003 and 2006, the item-level results clearly support earlier research pointing to severe gaps in the mathematical skills and knowledge of even the best students, especially in what could be called 'real mathematical understanding' (e.g. Merenluoto & Pehkonen, 2002; Hannula & al., 2006; Hellinen & Pehkonen, 2008). There are not many such tasks in PISA 2006, but the low share of correct answers in the few there are seem to attest that Finnish students' level of conceptual understanding and mathematical thinking are at an alarmingly low level (cf. Huhtala, 2000). Likewise, the results of Merenluoto (2001) on conceptual change in Finnish students' mathematical thinking suggest a poor transfer from natural numbers to real numbers, even among students who choose the more advanced mathematics courses in the (academic) general upper secondary schools.

Explaining the Finnish success in PISA mathematical literacy

In the national reporting of the results of PISA 2000 and 2003, the Finnish success in mathematics was explained by factors ranging from the Finnish education system and teacher education to students' personal interest and leisure activities (e.g. Välijärvi & al., 2002; Kupari & Välijärvi, 2005). In How Finns Learn Mathematics and Science (Pehkonen & al., 2007), the authors sum up explanations for the Finnish success, grouping them into three categories: teachers and teacher education, schools and the curriculum, and miscellaneous factors like ICT and the LUMA programme. We will centre here on some general observations concerning the Finnish success and point out some individual factors that may have received less attention elsewhere, while referring to the closing chapter of Pehkonen & al. (2007) for a more detailed discussion of the explanations mentioned above.

The most salient feature of the Finnish PISA success is undoubtedly the uniformity of the high level of the Finnish students' performance, with one of the smallest in-between student and in-between school deviations. No doubt, this reflects first and foremost general factors imbedded in Finnish history and culture, but also the Finnish education system's success in implementing the vision and goals of the comprehensive school reform of the 1970s (for a more in-depth discussion, see Chapter 9).

One factor, the importance of which for the Finnish success in PISA mathematics might not have been emphasised enough in the general discussion, is the central role of reading in all the three PISA literacy domains. Most of the tasks are imbedded in a good amount of written text, and in many occasions mere insightful reading may render even a difficult-looking problem (computationally) trivial. However, Finland is not the only country were students are also top performers in reading literacy as two of the other four top performers in mathematics – Korea and Hong Kong – also perform at the top in reading, too, with very similar profiles of (relatively) especially good weaker readers. In this respect, what would be needed is systematic analysis of the individual PISA items to show the different cognitive competences they measure – a project that can only be fully executed once the anchor items have been made open to researchers to be used in combination with other types of cognitive measurements.

However, maybe the most salient individual factor behind the Finnish students' success in PISA is the Finnish comprehensive school curriculum. Apparently, the scenario of the future of mathematics and science education that was formulated in the Finnish national curriculum already in the mid-1980, laid the groundwork for the Finnish success (see Chapter 9). These curricula (NBE, 1985; NBE, 1994) contained many, at that time, novel aspects which are to a great degree in accordance with the basic tenets of the PISA Framework. Where PISA set to measure 15-year-old students' ability to use their knowledge and skills in varied everyday life situations – in reading graphs, tables and other scientific presentations, in using scientific language to formulate problems, and in applying their mathematical skills not just for solving pre-given equations but to finding what kind of equations to formulate for the problem at hand – the Finnish comprehensive school mathematics curriculum puts an emphasis on the application of learnt knowledge and on problem solving. As a consequence, Finnish teacher educators' thinking was already working along these lines at the beginning of the 1990s, as could be seen in Halinen et al. (1991).

A less emphasised factor contributing to the Finnish success is special education, which probably plays a decisive role in the narrow distribution of Finnish students' proficiency and in the especially high relative proficiency of the weakest Finnish students (see Figure 6.3). Since streaming in key subjects was abandoned in Finnish comprehensive schools in 1985, the role of special education and the number of special education teachers has increased constantly to help teachers cope with the heterogeneous classes comprising the whole age cohort. However, only two percent of students attend special education institutions as all efforts are made to tailor support according to the specific educational needs of the student (cf. Vauras, 2006). Further analysis would be needed, however, to establish the specifics of how and to what degree special education has contributed to the Finnish success in PISA. Is the relative excellence of the weakest Finnish students in PISA mathematics due to special education efforts in mathematics or is it rather due to students' enhanced general literacy skills brought about by remedial reading (the relative preeminence of the Finnish students is most prominent in reading, with the lowest 5 % of students performing at 91 score points above the OECD average, compared to the 66 score points difference in mathematics and 77 in Science)?

It might also be due to the heterogeneous teaching groups of about 20 students, where teachers are forced to look for teaching methods that allow everybody to learn the topic at hand, focusing on the basic curricular contents and procedures. Also, from the very beginning, Finnish students are taught to believe in the role of applying their own effort. This is visible now, nine years later, in the low percentage of those non-responding in PISA.

But, when looking at the tasks and items where the great majority of students – even of the relatively well performing Finnish students – have had difficulties, a new question arises. Maybe the point is not to find an explanation for the good Finnish performance but to ask why the performance of the students of so many other developed countries lagged far behind. Why is it so hard for the world's 15-year-olds to solve the PISA tasks? Are students lacking in basic mathematical skills or are they having difficulties in applying their knowledge to solving the less academic-looking tasks presented to them in PISA? Or are they just not motivated in tackling problems that are not high stakes, offering no personal reward?

There is also an apparent paradox in the PISA mathematics results. According to PISA 2003, in Finland, the number of mathematics lessons per year is one of the smallest among the participating countries (OECD, 2004, p. 431). But, the Finnish students' achievement in PISA mathematical literacy has been among the best in the world in 2000, 2003 and 2006. The question is, are Finnish students successful in PISA despite – or because of – the scant amount of mathematics teaching? If the former, does it mean that success in PISA mathematical literacy is, in fact, not so much dependent on mathematics learnt at school but rather relies on a sound mastery of basic arithmetic, combined with good reading skills – including the reading of tables and graphs – acquired across the curriculum? Comparisons made between the results of PISA 2003 and TIMMS 2003 Grade 8 (e.g. Grønmo & Olsen, 2006; Wu, 2008), as well as a comparison of the PISA mathematics tasks and the French curricula for different grade levels (Monnier & al., 2007) seem to propose so.

Or, could it be that Finnish teachers have succeeded in turning a deficit to an advantage by learning to concentrate on the essential and not to teach 'too much', leading in turn to students not having already prepared calculation algorithms in their heads, but instead being forced to learn to be inventive in finding the best ones to use, and to trust the use of common sense in solving novel tasks.

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Reading has always been highly appreciated in Finnish society.

Already in the 18th century, it was required to know how to read to attain confirmation in the Lutheran church and therefore full membership amongst the adults.

7
Reading Literacy Assessment

Elina Harjunen and Tommi Karjalainen

There are historical, cultural and linguistic reasons which explain Finland's positive attitudes towards reading. In the first Finnish novel, Aleksis Kivi's *Seven Brothers* (1929; first published in 1870), the brothers, who were being taught the ABCs by a clergyman, preferred escaping through a window to a forest than studying how to read; but they had to learn to read before they could receive church confirmation and therefore official adulthood. The tradition of confirmation classes is one of the educational benefits brought to Finland by the reformation. According to the privileges granted to the clergy in 1723, the priesthood had to supervise knowledge of Christian doctrine and the progress of the ability to read, and consequently, parents were responsible for teaching their children to read. To ensure this duty many parents delegated reading instruction to parish officers who performed reading exercises. Additionally, priests also assessed reading skills with varying degrees of exactness in confirmation books (see e.g. Laine, 2000). It is precisely this historical and cultural tradition, described by Kivi in his novel, which can partially account for Finland's excellent reading skills nowadays.

While reading skills were emphasised, writing skills, which could have empowered common people, were deemed unnecessary in folk education by the upper class. This separation of skills and the scepticism towards writing were maintained until the late middle part of the 19th century. (Mäkinen, 2007; Leino-Kaukiainen, 2007.) It is worth noting, however, that a similar emphasis on reading and text comprehension skills still persists in text books and the contents of curricula in the mother tongue (Finnish) and literature.

Furthermore, according to researchers, Finnish, unlike English, is an easy language to learn to read and to advance reading due to its spelling and phonology, i.e. a close correspondence between the graphic and phonic representations, thus allowing a strictly phonetic based reading instruction of Finnish children (Aro & Wimmer, 2003; Goswami, 2005). This linguistic feature of Finnish might have a hand to play in the development of the positive attitudes towards reading and make people feel comfortable with reading materials even after schooling is over.

In addition, especially during recent years, part-time special education has been allocated for grades 1–2 in comprehensive school: in 2002–2003, every third pupil received special education on a part-time basis, mainly on the grounds of dyslexia or dysphemia, at the very beginning of his/her school history (Statistics Finland: Educational Statistics). This means that reading problems are immediately tackled as soon as they occur, which must have more of an impact on Finnish students' reading literacy than the supposed easiness of the language.

However, if we want to discover why Finnish students' performance in PISA 2006 reading literacy was again a success story, we should look at the framework of the Finnish curriculum for the comprehensive school. Due to Finland having two official languages, Finnish and Swedish, also the mother tongue (Swedish) is taken into account. This chapter reviews the results obtained by Finnish 15-year-olds in reading literacy by presenting a descriptive analysis of their performance, an explanation of the overall results based on a comparison of the PISA 2006 reading literacy framework with the Finnish core curriculum, and some explanations for gender differences in performance. PISA 2006 reading literacy results are also compared with the work of the Finnish National Board of Education: the evaluations of learning outcomes in mother tongue and literacy in comprehensive school.

7|1 Reading literacy in Finland still at the top

In PISA, Finnish students' performance in reading literacy has remained at a high level: the mean scores have stayed at almost the same level since the first survey (see Chapter 1). The variation between PISA 2000, 2003 and 2006 surveys is the smallest among all countries which have participated in PISA, showing no statistically significant differences worth reporting (Arinen & Karjalainen, 2007, p. 34).

In PISA 2006 assessment, however, this was not enough so as to maintain first place among OECD countries. According to the national average scores, the Finnish students were the second best in reading literacy (see Figure 7.1). The Finnish result (547) is weaker than the Korean's (556) but it is statistically significantly better than the results obtained by any other country participating in PISA 2006, including both OECD countries and partner countries. Among the other well-performing OECD countries, Finland shows the narrowest distribution of results (with a standard deviation of 81) which speaks very highly of the consistency of performance among Finnish youth. (Arinen & Karjalainen, 2007, p. 28.)

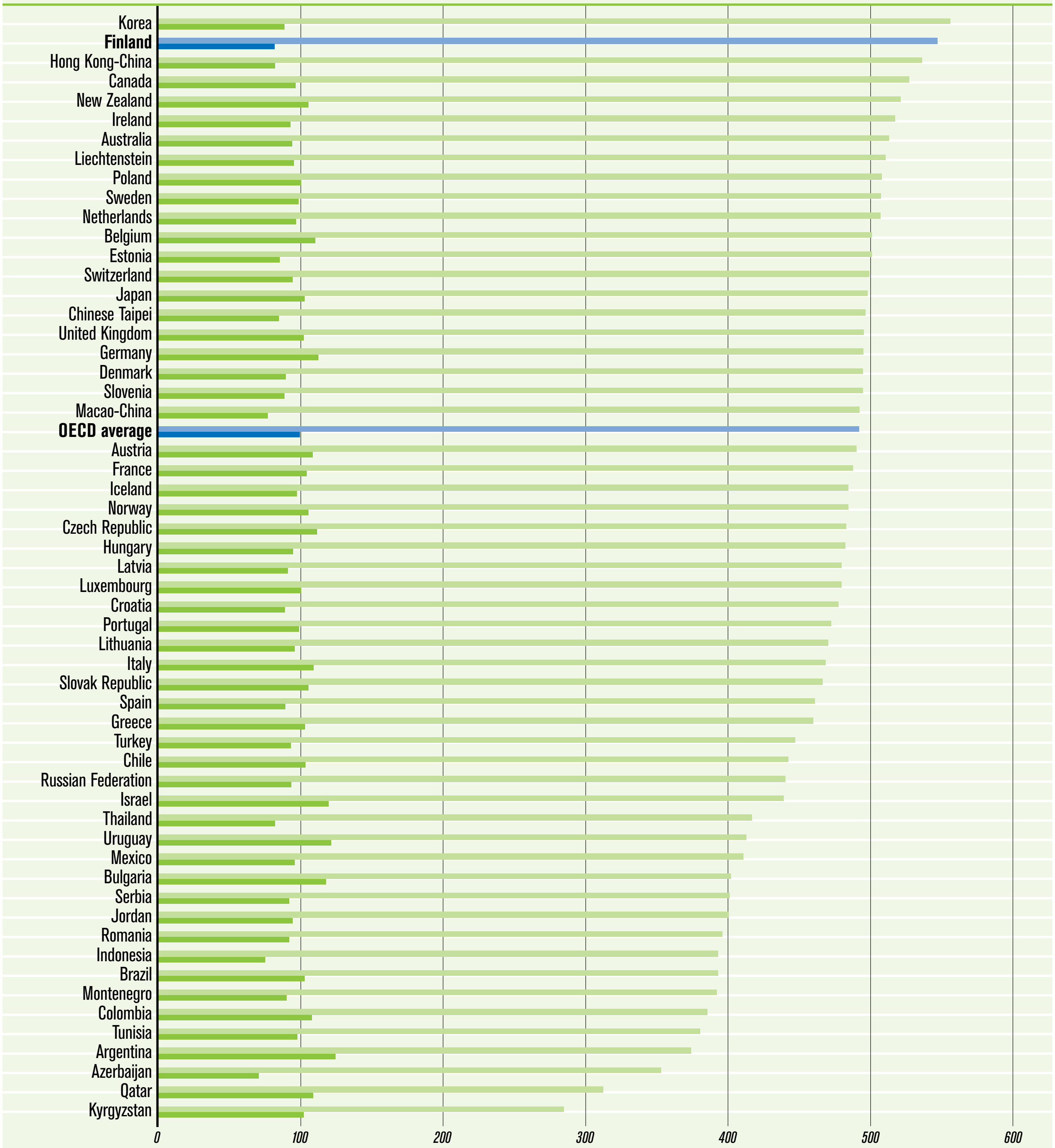
The above notwithstanding, Finnish students' performance scores have changed somewhat; the mean score of the best 25% of Finnish students has risen 20 score points from PISA 2003, but was still 16 score points better in PISA 2000; while the mean score of the weakest 25% has risen 14 score points from PISA 2003 – and 33 score points from PISA 2000 (OECD 2007b, pp. 237–238). According to PISA 2006 reading literacy, Finnish 15-year-olds maintain their reputation as excellent readers.

The five proficiency levels on the reading scale in the PISA 2006 are the same as in previous PISA test rotation designs (see Table 7.1). Students reaching the proficiency Level 5 on the reading literacy scale are described as capable of completing sophisticated reading tasks, while those at Level 4 are able to handle difficult reading tasks, and those at Level 3 reading tasks of moderate complexity (OECD 2007a, pp. 293–294). As in previous PISA assessments, 80% of Finnish students achieved Level 3 in reading literacy, which is considered sufficient for living a fulfilled life in our information society. In Korea, 21.7% of the students were at Level 5, which is more than in any other country (see Figure 7.2). The second best result was Finland with 16.7% of students, which is almost two times the OECD average of 8.6%. Finnish performance was also among the best at Levels 4 and 3: excellent reading performance was achieved by 31.8% (OECD average 20.7%) of students and good performance by 31.2% (OECD average 27.8%) of students. (OECD 2007b, p. 222; Arinen & Karjalainen, 2007, p. 28–31.)

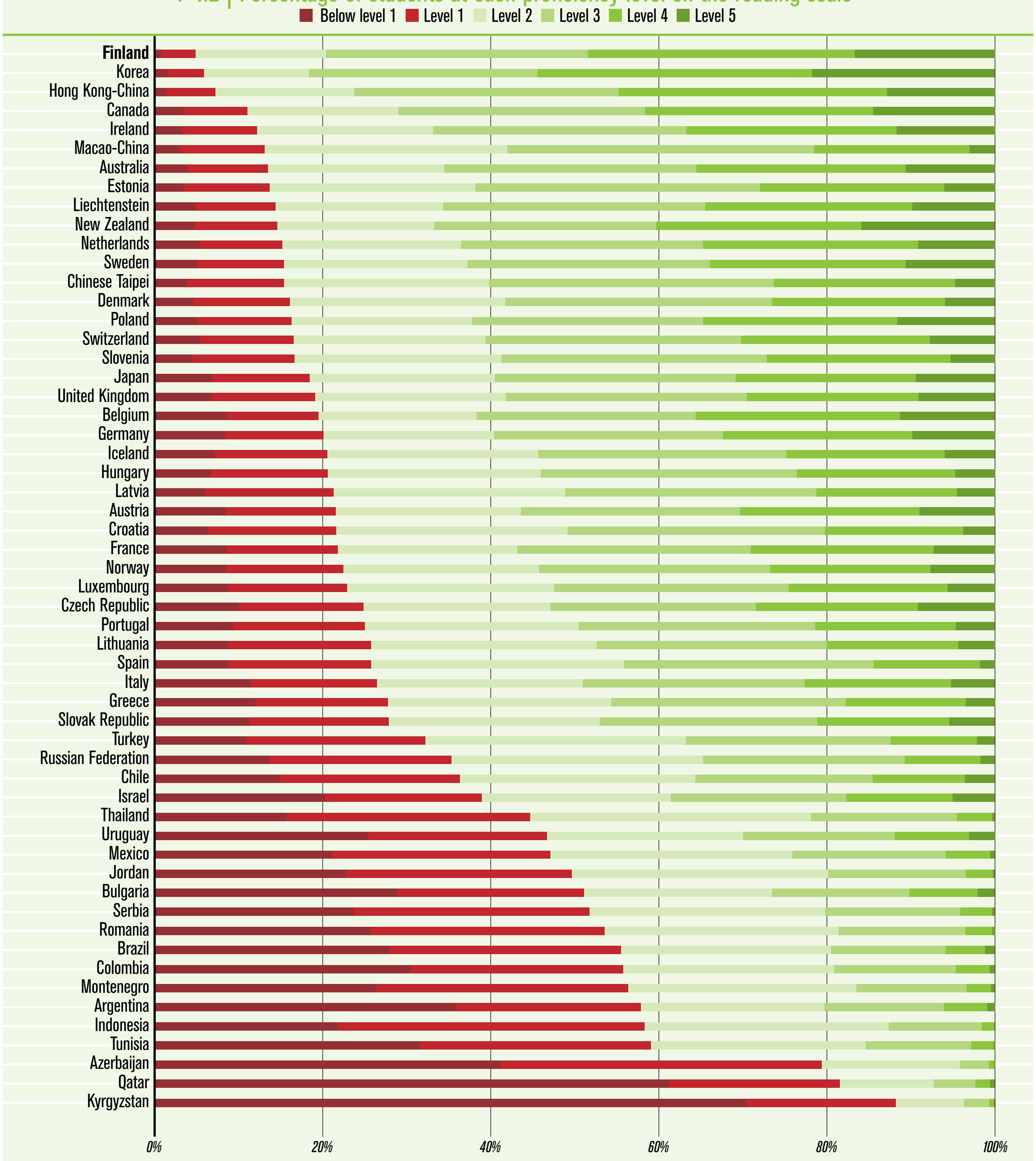
Students proficient at Level 2 are capable of basic reading tasks, and the simplest reading tasks can

F 7.1 | Mean performance on the reading scale

Mean Standard Deviation



F 7.2 | Percentage of students at each proficiency level on the reading scale



T 7.1 | Proficiency levels in reading literacy (OECD 2006a, p. 60)

Level	*Score points on the PISA scale*
5	More than 625
4	553 to 625
3	481 to 552
2	408 to 480
1	315 to 407

still be performed by students at Level 1. As reading literacy in PISA is defined as, and focuses on, the knowledge and skills to be applied to reading for learning rather than on the technical skills for learning to read, students whose performance falls below Level 1 are not likely to demonstrate success in the most basic type of reading skills that PISA seeks to measure. In Finland, 95.2% of students are at Level 2 or above while the OECD average is 79.8%. (OECD 2007a, pp. 294–295; 2007b, p. 222.)

7|2 Comparing the Finnish Framework curriculum for the comprehensive school with the PISA 2006 reading literacy framework

Even if PISA does not measure how well students have achieved curricular aims, one reason behind the excellent results can be found when comparing the Finnish curriculum for mother tongue and literature with the PISA reading literacy framework. However, this comparison only provides background information on the Finnish students' studies at comprehensive school. 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", the PISA reading literacy framework (OECD 2006a, p. 46) focuses on the ability of students to use written information in situations which they encounter in everyday life. Reading literacy is viewed as "an expanding set of knowledge, skills and strategies which individuals build on throughout life in various situations, and through interaction with their peers and with the larger communities in which they participate" (OECD 2006a, p. 46).

So, it is no wonder that PISA reading literacy contributes to other PISA literacies (mathematics and science), as in PISA assessment students must follow written instructions in the tasks of all domains. These literacies seem to be strongly related to the Framework Curriculum for the Comprehensive School 1994 (FNBE 1994), which emphasises the role of mother tongue as a pragmatic and instrumental, but also fundamental, school subject: laying the ground for learning to learn, and for active and life-long learning. To illustrate that this is the only subject at school that has particular responsibility for basic reading literacy, reading literature, cultural heritage and transference, this subject was renamed "Mother tongue and literature" in 1998 (ME 2000, p. 48).

Forming active readers and life-long learners

The 1994 framework curriculum, according to which the Finnish students participating in PISA 2006 had been studying for almost all of their school years, states that "mother tongue teaching carries the main responsibility for teaching basic linguistic skills and their development, and thus lays the ground for learning to learn" (FNBE 1994, p. 47). However, a similar section on mother tongue (Swedish) widens the scope of the goal set for this subject: it bears the primary responsibility for every generation of children attaining reading and writing skills, and also the necessary language skills and communication skills in working life, leisure time and in society at large and cultural life (FNBE 1994, p. 52). The main focus of the 1994 framework curriculum is constructivist understanding of learning with the student seen as an active learner whose main role is that of speaker, reader and writer. Even if the focus is more on the individual's learning than on participating in society, as is in the more sociocultural PISA framework, the latter aspect is visible in the Finnish curriculum, too: “The student develops as a person who participates in the communication environment and who influences it so that he becomes aware of his chances to influence matters, as a member of society” (FNBE 1994, p. 49).

The curriculum provides quite narrow guidelines for every subject and descriptions of the basic values, general themes and subject-specific aims of actual teaching. In the case of the mother tongue (Finnish), the stress is on language as a factor that makes people human, on the student’s development into a self-confident person and skilful communicator and on the cultural task of trying to reinforce, through language and literature, the students’ identity, and to give a foundation for them to grow as Finns (FNBE 1994, p. 47). Additionally, the core curriculum specifies the nature of studying and the starting points for teaching, by stating the need to see the different types of knowledge and skills in different mother tongue areas as being intertwined, the need to associate language analysis with the use of language and the need to think of the student as an active learner. It further states that the student should be able to evaluate the practical value of his/her reading and writing skills and to develop them, that the student’s possibilities for investigative, problem-oriented, and independent learning should be guided in a conscious manner, and that the student should construct his/her understanding of reality through speaking, reading, and writing; but also through observing and investigating language and its phenomena. (FNBE 1994, p. 51.) Unlike in the Finnish section, mother tongue (Swedish) provides further practical reference to teaching methods which cater to students’ emotional and skill-related needs, such as “work-centred activities, thematic tasks, team work, process-oriented and interdisciplinary work forms” (FNBE 1994, p. 56).

In the context of the PISA framework, the definition of reading literacy involves the understanding, using and reflecting on written information for a variety of purposes which take into account the active and interactive role of the reader in achieving such diversity (OECD 2006a, p. 46). The mother tongue sections in the 1994 framework curriculum have a very similar, active view of reading and interpreting texts. It states that the basic idea of speaking, reading comprehension and writing is to detect connotations and interpret them (FNBE 1994, p. 51). According to the part of the curriculum concerning upper grades (grades 7–9), it is important for students to understand different kinds of texts, to draw conclusions, and to select and evaluate a variety of texts including media texts (FNBE 1994, p. 50). Mother tongue (Swedish) stresses students’ development into information-seeking individuals with inquisitive minds, who can analyse different kind of texts (FNBE 1994, p. 55). In the lower grades of comprehensive school (grades 1–6), more emphasis is placed on literature; students should get sufficient guidance from the teacher in choosing what literature to read, in becoming active users of the library, and in identifying with the text, so as to take a particular stance on it, and to ponder over the ideas provoked by it (FNBE 1994, pp. 48–49). What this all boils down to is that students were already exposed to all kinds of continuous and probably also non-continuous text formats in the media, and non-fiction and fiction genres during the lower grades of comprehensive school, where “reading and writing skills are practised in all subjects” (FNBE 1994, p. 49).

A curriculum provides ideal goals for teaching and learning, but their implementation is a different story. The Finnish National Board of Education has assessed learning outcomes in the mother tongue and literature since 1999, and the results show, among other things, that students borrowing of books for leisure time reading activities has a positive correlation with good reading competence in national assessment results (Lappalainen, 2000, 2006; Silverström, 2006). However, young people’s, especially 14–15 year-old boys, interest in reading literature declined during the 1960–1990 period in Finland (Saarinen & Korkiakangas, 1997, 189). In fact, girls in the fourth grade are more motivated than boys to read books and visit libraries (Merisuo-Storm, 2004).

In despite of this, national assessment results in Finland show good reading competence of students in the 9th grade of comprehensive school. One reason for that, according to teachers, is the general availability of written texts and samples of literature in textbooks used in mother tongue and literature lessons (Finnish). According to the questions attached to background information obtained for the 2001 assessment of learning outcomes in mother tongue, half of the text content of the most popular textbooks was related to reading of media texts and literature, whereas only 1/6 of the content was related to the study of writing skills. Similarly, mother tongue and literature teachers whose schools took part in the 2003 assessment reported that in 2000–2003, knowledge of literature and diversity of reading interests had been the main focus in most schools. In the 2005 assessment of learning outcomes, it turned out that 2002–2005 literature and reading had been the focus in 90% of the sample comprehensive schools participating in the study. (Lappalainen, 2001, 2004, 2006.)

A diversity of texts, situations and processes to be measured by different tasks

PISA reading literacy framework focuses on the dynamic process of seeking to use and understand the reading. Some factors of that process are manipulated in the PISA assessments: the reading situation, the structure of the text, and the characteristics of the questions that are asked about the text. (OECD 2006a, pp. 46–48; see Table 7.2) Many aspects contained in the PISA reading literacy framework match quite well with those in the 1994 framework curriculum, even though the part of mother tongue is not widely concerned with reading and reading literacy. For example, the 1994 framework curriculum does not provide as much detailed information on continuous and non-continuous text types as the PISA reading literacy framework does (OECD 2006a, pp. 46–48). However, it refers to narrative, descriptive, expository and argumentative text types, and emphasises the need to adopt active listening, speaking, reading, and writing strategies, and mentions the need to develop the ability to select a style of reading suitable for the task at hand, as well as the need to perceive reading, writing and speaking as processes (FNBE 1994, pp. 47, 49–52, 55–56).

The 1994 framework curriculum does not explicate what active reading processes and strategies mean. Instead, the National Board of Education published views on the mother tongue curriculum (Sinko, 1994) to illustrate, e.g. the reading processes, strategies and understanding skills, which have also been included in different textbooks. They were also supposed to be clarified and specified in individual curriculum for the schools but were not, especially in the lower grades of comprehensive school (ME 2002, pp. 50–51). Yet a Ministry of Education working group report (ME 2002) noted that reading and writing skills were unconnected and that grammar was overemphasised in the individual curriculums for lower grades of comprehensive schools. Faced with the lack of clear and specific criteria, class teachers found it difficult to piece together the diversity and complexity of mother tongue as a subject and ended up teaching it via the textbook (ME 2002, pp. 50–51). However, if the goal is to empower students by developing their reading and writing skills, learning and other capacities, human dignity, self-esteem and self-confidence, then the framework curriculum should emphasise that the role of education in this context goes far beyond formal schooling: it should embrace the broad range of life experiences and learning processes which have to do with the diversity of texts, situations and processes and which enable children and youth, individually and collectively, to develop their personalities, talents and abilities and to live a full and satisfying life within society. Therefore, the framework curriculum probably should explicate what active reading processes and strategies mean, so that its guidelines are easier to implement by teachers.

The fact is that the qualifications for class teachers contain only limited studies in mother tongue and literature education (8 study points at the University of Helsinki), whereas the qualifications for subject teachers teaching mother tongue and literature in upper

T 7.2 | Distribution of reading literacy tasks, by text format and type, situation and reading process (aspect) in 2000, 2003 and 2006 (OECD 2006a, pp. 49, 53, 55)

Text format and type	*2000*	*03 | 06*
Percentage of items by text format and type, based on the whole test		
Continuous texts		
Narrative	14	11
Expository	24	43
Descriptive	9	11
Argumentative and persuasive	13	–[1]
Injunctive	7	–
Total [2]	68	64
Non-continuous		
Charts and graphs	12	7
Tables	9	14
Diagrams	4	–
Maps	3	4
Forms	3	11
Advertisements	1	–
Total	74	37
All texts total	100	100

Text format and type	*2000*	*03 | 06*
Situation	*Percentage of items*	
Personal	20	21
Public	38	25
Occupational	14	25
Educational	28	29
Total	100	100
Reading process (aspect)	*Percentage of items*	
Retrieving information	29	29
Interpreting	49	50
Reflection and evaluation	22	21
Total	100	100
Item types	*Percentage of items*	
Multiple choice	42	29
Complex multiple choice	6	7
Closed constructed response	9	21
Open constructed response [3]	44	43
Total	100	100

1) Tasks did not contain any texts or items of this type.
2) These percentages may not always add up to the totals indicated due to rounding.
3) This category includes short-response items.

grades of comprehensive school requires studies of 60 study points both in Finnish (or Swedish) and literature. Subject teachers, therefore, have a better basis for dealing with the subject. However, in Finnish comprehensive schools, 80% of mother tongue lessons are taught in lower classes (grades 1–6). (See Appendix 1 and Appendix 2.)

So, it is no wonder that in the new National Core Curriculum for Basic Education 2004, the subject – mother tongue (Finnish or Swedish) and literature – which is based on a broad, multimodal idea of texts, emphasises text knowledge, literacy and reading strategies, and regards reading and writing as a single process. In the core contents for grades 6–9, text comprehension includes also the process of evaluating the form of the text and more exact descriptions of reading literacy in main content areas, such as "summarizing text content, recognising opinion materials and the author's intentions and techniques, analysis and assessment from the standpoint of impact, comparison of texts meaning" (FNBE 2004, p. 52). Finnish students participating in PISA 2006 studied according to this curriculum from the beginning of the 8th grade.

These brief references to the Framework Curriculum for the Comprehensive School 1994, as well as the emphasis of becoming an active and critical reader, mentioned earlier, can also be seen to relate to the reading processes associated with achieving a full understanding of a text (OECD 2006a, pp. 48–49). In PISA these processes play an important role and, al-

T 7.3 | Distribution of reading literacy tasks in PISA 2006, by item type and reading process, text format and type and situation

Item types		*Percentage of retrieving information items*	*interpreting items*	*reflection and*
Reading process		*(N=7)*	*(N=14)*	*evaluation items (N=7)*
Multiple choice		-	64	-
Complex multiple choice14		-	-	-
Open constructed response		-	21	100
Short response		43	7	-
Closed constructed response		43	7	-
Total (N=28)		100	100	100
Text format and type (continuous)		*Percentage of narrative texts (N=3)*	*expository texts (N=12)*	*descriptive texts (N=3)*
Multiple choice		33	50	33
Complex multiple choice		-	-	33
Open constructed response		66	50	33
Short response		-	-	-
Closed constructed response		-	-	-
Total (N=18)		100	100	100
Text format and type (non-continuous)	*Percentage of chart and graphs (N=2)*	*tables (N=2)*	*forms (N=4)*	*maps (N=1)*
Multiple choice	50	-	-	-
Complex multiple choice	-	-	-	-
Open constructed response	-	-	33	-
Short response	50	25	33	100
Closed constructed response	-	75	33	-
Total (N=9	100	100	100	10
Situation	*Percentage of public (N=7)*	*personal (N=6)*	*educational (N=8)*	*occupational (N=7)*
Multiple choice	14	33	63	14
Complex multiple choice	-	-	-	14
Open constructed response	43	50	25	29
Short response	14	-	13	29
Closed constructed response	29	17	-	14
Total (N=28)	100	100	100	100

though appropriate reading strategies are not actually discussed in PISA, different reading tasks call for different approaches and competencies. Table 7.2 shows the distribution of reading literacy tasks by text format and text type, reading situation and each of the three subscales generated from the five reading processes (aspects) defined above: retrieving information, interpreting texts (forming a broad general understanding and developing an interpretation) and reflection and evaluation. PISA 2000 contained 37 tasks and 141 items, out of which 8 tasks and 28 items were also selected for use in PISA 2003 and PISA 2006. Table 7.3 shows the distribution of reading literacy tasks in PISA 2006 by item type and reading process, text format and type and situation.

7|3 An in-depth analysis of the PISA 2006 reading literacy results

Although Finnish students are excellent readers according to PISA, their reading performance is certainly not evenly distributed when analysed in detail. Table 7.4 summarises the distribution of the PISA reading literacy tasks by the percentage of correct answers, showing Finnish students' ability to read all kinds of differently structured texts. The table also shows some strengths and weaknesses between Finnish and OECD averages, differences between Finnish boys and girls, and the profile of PISA reading literacy. So, let us turn now to what the results can tell us about reading activities among Finnish students.

Some notions about the nature of PISA reading literacy

Reading at school has probably been so diverse due to the fact that Finnish students read almost equally well continuous and non-continuous text formats, and the situation variable defined as "reading for education" is the strongest of the four reading situations compared to the OECD average (see Table 7.4). At the same time, a question arises: was it capable of only comparing the PISA reading literacy framework to the mother tongue section (FNBE 1994)?

Many of the themes contained in the PISA 2006 reading literacy texts match the variety of issues in the 1994 framework curriculum, such as consumer and international education, rather than what is emphasised in the mother tongue readings (see Linnakylä & Sulkunen, 2005, p. 63). In addition, the nature of some of the PISA 2006 texts classified for "reading for education" was such that students do not usually encounter them at all in mother tongue and literature lessons; for example, the unit, in which students had to draw something on a map according to a task based on an expository text and a map, a typical task in a geography or biology class (see Table 7.3, maps), where map-reading skills are required by the National Core Curriculum for Basic Education (FNBE 2004, pp. 177, 183). Although 13% of Finnish students did not answer this task at all, 66% did it correctly (OECD average 42%). This task, being quite difficult, is at Level 4 in retrieving information, with 581 OECD average score points. Supposedly, the 1994 and 2004 framework curricula which emphasise reading comprehension in several subjects, written in the spirit of socio-constructivism, and language laden, as curricula used to be in Finland, are one of main reasons behind the reading literacy results: PISA assesses literacies, which the Finnish education system has emphasised in comprehensive school – for many years before the existence of PISA.

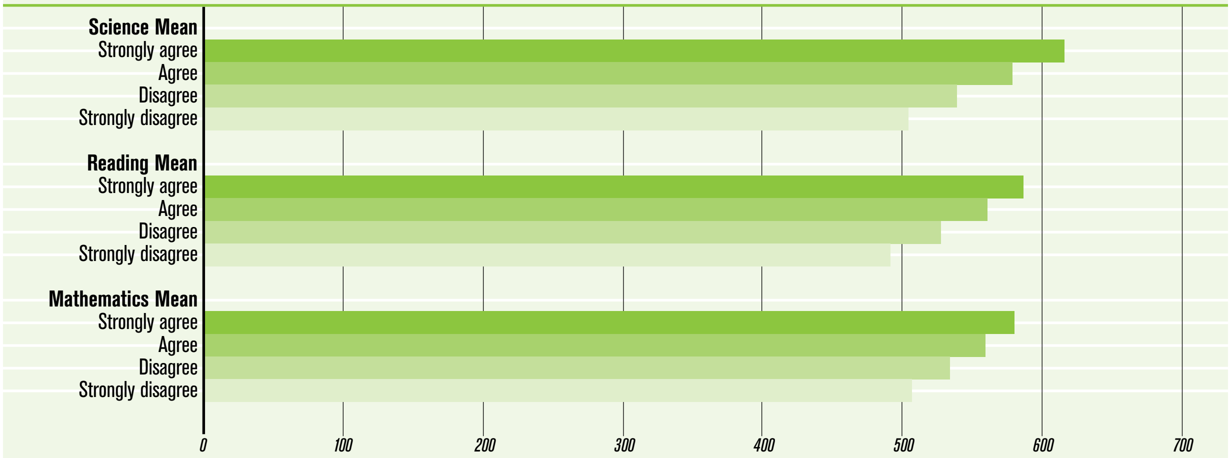
It is notable that PISA assesses reading in all the literacy domains. Consequently, students' attitudes towards reading probably have some affect on their success in all the literacy domains. Those Finnish stu-

T 7.4 | Distribution of reading literacy tasks, by correct answers of Finns total, gender and OECD average and by text format and type, situation and reading process (aspect) in 2006

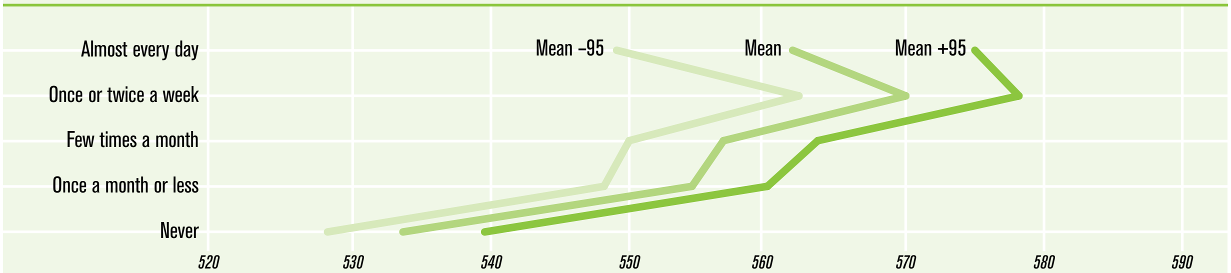
	Percentage of correct answers							
Text format and type	*FINNS*	*OECD*	*DIFF.*	*BOYS*	*OECD*	*GIRLS*	*OECD*	*DIFF*
Continuous		*AVG*	*FIN*	*AVG*	*FIN*	*AVG*	*F G–B*	
Narrative (3)[1]	77	70	7	71	65	84	75	13
Expository(12)	74	60	14	69	56	78	63	9
Descriptive (3)	63	53	9	56	49	69	58	13
Continuous total (18)	72[2]	60	12	67	57	78	64	11
Non-continuous								
Charts and graphs (2)	80	65	15	76	62	84	68	8
Tables (4)	52	45	7	50	43	54	47	4
Forms (3)	82	69	14	79	65	86	72	7
Maps (1)	66	42	24	65	44	68	40	3
Non-continuous total (9)	68[3]	56	13	65	54	71	58	6
Situation								
Personal (6)	72	61	11	68	58	77	64	9
Public (7)	65	56	9	62	54	69	59	7
Occupational (7)	75	62	12	69	58	80	66	12
Educational (8)	72	56	16	67	53	76	59	9
Reading process (aspect)								
Retrieving information (7)	62	51	11	58	50	65	53	7
Interpreting (14)	79	65	14	76	62	82	67	6
Reflection and evaluation (7)	64	54	10	56	48	72	59	16
Item types								
Multiple choice (9)	83	71	13	81	68	86	73	5
Complex multiple choice (1)	52	55	-3	46	51	57	59	11
Open constructed response (10)	66	54	13	60	49	73	58	13
Short response (4)	67	51	16	63	49	71	53	8
Closed constructed response (4)	63	54	9	61	52	65	56	4

1) Figures in parentheses indicate the number of items in each category.
2) These percentage totals do not tally according to the numbers above them, which are rounded, but are calculated from the round-off accumulation of all continuous text format types.
3)These percentage totals do not tally according to the numbers above them, which are rounded, but are calculated from the round-off accumulation of all non-continuous text format types.

F 7.3 | The correspondence between attitudes towards reading about science and PISA 2006 reading, scientific and mathematical literacy results among Finnish students



F 7.4 | The relation between reading from the Internet and PISA 2006 reading literacy results among Finnish students



dents who agreed that they like reading about science (see Figure 7.3) obtained higher average score points in scientific, reading and mathematical literacy, whereas those who disagreed obtained lower score points in all the literacy domains. The more positive the attitude towards reading was, the better the results in PISA were. In addition, the answers to questions about the "use of the computer to read short stories, tales and books" and "reading Internet journals" show that (see Figure 7.4) that the correlation between reading, scientific and mathematical literacy results and reading from the Internet parallel previous findings: those Finnish students who had positive attitudes towards reading or who read journals or fiction from the Internet occasionally, performed better in PISA 2006 than those who had a negative attitude towards read-

T 7.5 | Reading literacy and home background

	Home educational resources (1)	*Cultural possessions home (2)*	*Level (3)*	*Balance (4)*	*mean READ (5)*
1	1	.352	.103	-.045	.085
		0	0	0.002	0
	4702	4694	4702	4702	4702
2	.352	1	285	.132	.315
		0	0	0	0
	4694	4694	4694	4694	4694
3	.103	.285	1	0	.920
	0	0		1	0
	4702	4694	4714	4714	4714
4	-.045	.132	0	1	.385
	0.002	0	1		0
	4702	4694	4714	4714	4714
5	.085	.315	.920	.385	1
	0	0	0	0	
	4702	4694	4714	4714	4714

ing or who did not read any fiction from the Internet at all, although in the latter case, the only statistically significant correlation is between those students with low achievement in PISA who never used the Internet at all (see also Leino, 2003, p. 78).

Similar correlations can be seen also by studying students' cultural possessions at home (see also Jensen & Turmo, 2003), namely whether they had classic literature, poetry books, works of art (e.g. paintings) and how many books they had (see Table 7.5). The correlation between cultural possessions and excellent PISA reading literacy (Level 5) is medium (0.32), but cultural possessions play a very important role in determining the level and balance of PISA competencies (see Chapter 3): those who had many cultural possessions at home had a high correlation (.92) between excellent PISA reading, scientific and mathematical literacy results (Level 5). They also tend to use reading literacy in terms of mathematical and scientific literacy tasks in PISA (balance .39): knowing how to read well also helps in the other areas.

The strengths and weaknesses of Finnish students compared to OECD average in PISA 2006 reading literacy

A closer look at different reading items and their percentages of correct answers provides further information about the nature of reading literacy by Finnish students. In Table 7.3 the percentage of correct answers to individual items by Finnish students, OECD average and their difference are shown. Table 7.6 also reveals that for Finnish students, in comparison to OECD average, items 8 and 20 were the easiest, while items 6, 12, 13, and especially 26 were the most difficult.

As shown in Table 7.6, item 8, the easiest for Finnish students when compared to OECD average (diff. 25.75%), called for interpreting the expository text in an open constructed response. The difference between Finnish boys and girls was only 4.99% (boys 55.16%, girls 60.15%). Being the most difficult text-interpreting item in general, it rose to Level 5 with a score of 627, a level requiring to "either construe the meaning of nuanced language or demonstrate a full and detailed understanding of a text" (OECD 2006a, p. 61). The third, fourth and fifth easiest items for Finnish students when compared to OECD average, respectively, required interpretation as well. Item 20, the second easiest, described in section 7.3 above, required retrieving information in a short response.

Item 26 (see Table 7.6), the only one in which Finnish students performed worse than OECD average, was a complex multiple choice item type which required retrieving information from a descriptive text. The item required at least dealing with competing information and locating and combining multiple pieces of embedded information, each of which may need multiple criteria and interpretation (see OECD 2006a, p. 61). The text is divided in columns and different pieces of texts, for example subtitles, boxes and pictures: the discourse structure of the text is not clearly marked. Complex multiple choice items contain a series of statements, and the student has to choose the right alternative answer (e.g. "yes" or "no"/"true" or "false") for each statement. Both genders performed below OECD gender average in this task: Finnish boys fell 5.17% below male average, and Finnish girls were 1.59% below female average, although the difference between genders was 11.73% (boys 45.64%, girls 57.37%) in the Finnish answers. Actually, this task was not among the most difficult tasks of OECD average. While complex multiple choice items are dichotomously scored (e.g. "yes" or "no") a number of correct responses allow partial credit or no credit scoring in addition to the full-credit category, thus indicating different levels of difficulty. This is the case of task 26, which yielded responses at two levels of difficulty: the full-credit response category rising within Level 4 with a score of 604 and the partial-credit category (giving at least five correct answers out of seven) falling within Level 2 with a score of 415.

The other two most difficult tasks for Finnish students were in the unit containing a numeric table and written instructions. Students had to answer with numbers either by combining several separate facts from a table and instructions (item 12, close constructed response) or by finding out a single piece of information with the same meaning (item 13, short response). Both were the most difficult information-retrieving items in OECD: the easier item (item 12) rose to Level 4 with a score of 605, and the totally correct answer of the more difficult task (item 13) to Level 5 with a surprisingly high score of 772 and a partial-credit response within Level 4 with a score of 572. The difference between Finnish boys and girls was 7.85% (boys 23.98%, girls 31.83%) in the easier item and 1.85% (boys 35.54%, girls 37.39%) in the more difficult one.

These three items had one thing in common: a student had to select and/or combine several pieces of information to come up with the relevant response, and s/he had to piece together all parts and details to fully understand the text and answer the tasks (see OECD

T 7.6 | Percentages of correct answers of PISA 2006 reading literacy profiled according to Finnish students, OECD average and the difference between them in items 1–28*

Item	*FIN %*	*AVG %*	*Diff.*
1	91.27	80.94	10.33
2	56.31	46.89	9.42
3	68.08	57.50	10.58
4	87.17	71.08	16.10
5	94.79	88.15	6.64
6	60.44	55.61	4.83
7	76.84	65.98	10.86
8	57.63	31.88	25.75
9	53.33	43.34	9.98
10	91.32	82.97	8.35
11	90.52	80.41	10.12
12	36.48	32.96	3.52
13	27.97	22.68	5.29
14	77.85	63.41	14.44
15	49.87	33.81	16.06
16	49.76	40.67	9.09
17	86.76	68.84	17.92
18	71.45	57.51	13.95
19	89.12	79.07	10.05
20	66.41	42.22	24.18
21	73.88	61.11	12.77
22	79.33	58.90	20.43
23	94.85	80.89	13.96
24	79.89	65.93	13.96
25	67.49	52.09	15.40
26	51.61	54.86	-3.24
27	68.73	53.24	15.49
28	86.21	69.27	16.94

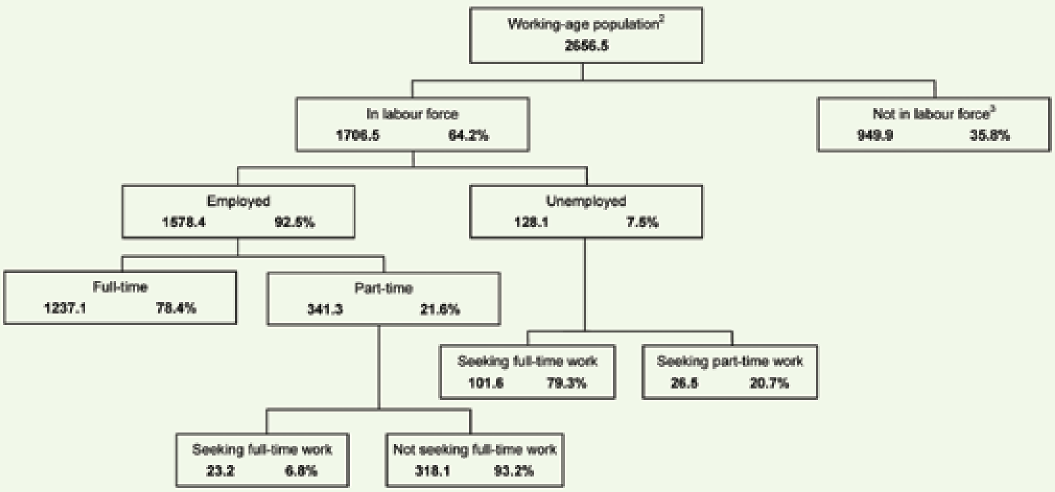
*The items are in the order of the tasks.

F 7.5 | Example task | Labour

LABOUR

The tree diagram below shows the structure of a country's labour force or "working-age population". The total population of the country in 1995 was about 3.4 million.

The Labour Force Structure year ended 31 March 1995 (000s)[1]



Notes
1. Numbers of people are given in thousands (000s).
2. The working-age population is defined as people between the ages of 15 and 65.
3. People "Not in labour force" are those not actively seeking work and/or not available for work.

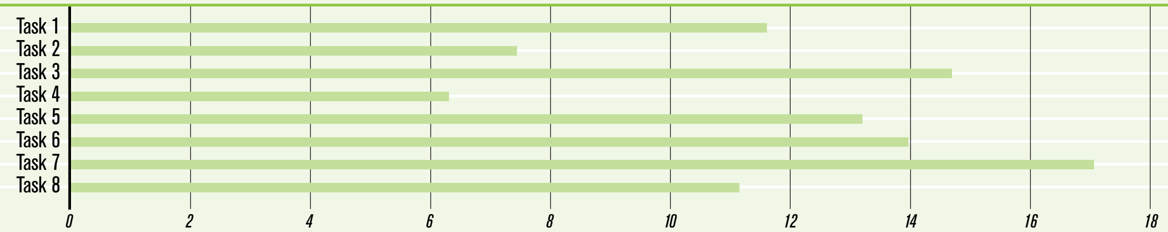
Question 3: LABOUR R088Q03- 0 1 2 9

How many people of working age were not in the labour force? (Write the **number** of people, not the percentage.)

2006a, p. 61). It can be argued that there are also some other reasons for the difficultness of the tasks: for example, some students do not bother to read long or complicated texts thoroughly. These tasks call at the very least for concentration and exactness in reading. An example of these kinds of units is Labour (PISA 2000). In question 3 students had to find out the correct numerical value from a diagram and combine it with the footnote information, whose content had to be interpreted in the correct way (see Figure 7.5). This question also yields credits at two levels with a partial-credit response falling within Level 3 with a score of 485 and a full-credit rising to Level 5 with a score of 631 (OECD 2007a, p. 288).

As in PISA 2003, PISA 2006 reading literacy assessment contained only 8 units with 28 separate items representing a limited set of item categories (see Table 7.2, 7.3 and 7.4). Accordingly, when comparing the results, it must be remembered, that success in an item can also be affected by many factors such as

F 7.6 | Estimated marginal means of benefiting Finnish students



item type or text authenticity. Figure 7.6 shows the estimated marginal means of Finnish students in every task. The easiest task for them, compared to OECD average, was task 7 (17.06 score points above OECD average) which contained mainly text-interpreting multiple choice items and one short response item, with the process classified as retrieving information. The most difficult task for Finnish students was task 4 perhaps partly due to the two difficult information-retrieving items – described above. Interestingly, the stimulus of task 4, instructions for telephone user, was among the most inauthentic texts of PISA 2000 among Finnish 15-years-olds. Both genders considered that the topic and the genre as well as the layout and language of the text were untypical and uninteresting, whereas the stimulus of task 7, a text on conquering the South Pole (see pp. 158, 161), belonged to the most authentic texts – for boys. In addition, also an article about men's shirts was also obviously a boy's text (see task 3, Figure 7.6). (Sulkunen, 2007, pp. 145–147.)

However, the item category for interpretation was the easiest for Finnish students in PISA 2006 reading literacy, whereas the category for retrieving information was the most difficult, even a little bit more difficult than the category for reflection and evaluation. All multiple choice items represented text-interpretation (See Table 7.7.) PISA 2006 results are interesting when compared to those of PISA 2003 assessment, because the same exact items were used (see Table 7.7). In terms of these results, Finnish performance increased in interpretation and in reflection and evaluation (about +2% in both processes), and decreased in retrieving information (-3.56%). Although these changes are not significant, they persist.

T 7.7 | Distribution of category for reading process by correct answers of Finnish students in 2003 and 2006

	Finnish students' percentage of correct answers		
Reading process	*2003*	*2006*	*Difference*
Retrieving information	65.08	61.52	-3.56
Interpretation	76.92	78.83	+1.91
Reflection and evaluation	61.98	64.44	+2.46

PISA 2000 and 2003 reading literacy assessments showed that Finnish students did not achieve a high performance in tasks which were classified as reflection and evaluation – and which required critical evaluation and own argumentation (Linnakylä & Sulkunen, 2002, pp. 35–36; 2005, pp. 62–63). This was explained by Sulkunen (2004, p. 44) due to the framework curriculum (FNBE 1994) in which reflecting on and evaluating the form of a text is not explicitly required for upper classes (grades 7–9). In PISA 2000, Finnish students were remarkably better than others in retrieving information and interpretation: they scored especially high in retrieving information (556 points) and interpreting texts (555 points), but the performance in reflection and evaluation was not as strong

(533 points) (Välijärvi et al., 2002, p. 5). A similar trend was detected in PISA 2003 (Linnakylä & Sulkunen, 2003, p. 63). In PISA 2006, Finnish students had more problems in retrieving information than in previous assessments, although little can be concluded from such a small number of units and items.

The 1999 national assessment by the Finnish National Board of Education of 15-year-olds already found the same results and phenomena in students' reading skills which were confirmed later by the results of PISA 2000 and 2003 surveys (Lappalainen, 2000). In 1999 it was apparent that comprehension of texts, in general, was easy for Finnish 15-year-olds. The selection of explicit pieces of information from various texts, grasping the global meaning of the text and identifying the topic in the text, the recognition of the narrator's point view and the potential audience of the text were not problematic for the students. Finnish pupils were also capable of relating separate pieces of information ("cross reading") and extracting implicit arguments from the text. (Lappalainen, 2000.)

However, the difficult aspects of reading comprehension (in which the pupils in the national sample were able to score only half of the maximum points or even less) were in part the same as those they encountered in PISA 2006 information-retrieving items, which required the processing of implicit or explicit information from different sources in order to find the most sensible solution between several right alternatives and to summarise it. Other difficulties occurred in tasks in which students, for example, had to draw conclusions from linguistic constructions which influenced the emotional tone of the text and from the discourse structures used by the writer to construct the text, to draw conclusions and interpret the essential content based on the whole text, or to find several joint themes in writings that represent various text genres. (Lappalainen, 2000, pp. 80–83, 137.)

Also in PISA 2006 reading literacy assessment, two items (items 15 and 16) which required reflection and evaluation, were among the most difficult items for Finnish students (below 50% of correct answers) (see Table 7.6). In these open constructed responses students had to either evaluate the form or the content of an expository text. Item 15 – which was actually the easier one of these items for Finnish students – was the most difficult reflection and evaluation task in OECD, the full-credit answer rose to Level 5 with a score of 671, and the full-credit answer of item 16 rose to Level 4 with a score of 581, being the third most difficult task in the same process in OECD. The difference between genders was one of the largest among Finnish students in both tasks: about 19% in both items (boys 40.23%, girls 59.18% in item 15; boys 39.91%, girls 59.29% in item 16). It can be argued that the performance in these items reflect the general gender difference, but the difficulty of items calling for retrieving complex and implicit information tells something about reading literacy of both genders in Finland.

Examples of these kinds of items can be seen in unit Flu (PISA 2000). In the first example, question 3, a student had to reflect the form of the information sheet: "identifying features relating the style and purpose of a text" (OECD 2006b, p. 10). In the other example (question 5) s/he had to evaluate the appropriateness of a section of the text in relation to its overall meaning and purpose (OECD 2006b, p. 12). (See Figure 7.7.)

One reason for the problems of items which require reflecting on and evaluating can also be in text genres which exhibit variations across cultures. The rhetorical structures of language differ, and thus the linguistic realisation of some utterances can also differ (Bhatia, 1993; Swales, 1990). In addition, the translation requirements and the tendency to achieve a formally corresponding text, in spite of the differences between source and target languages, may lead to unfamiliar ways of expressing ideas (see OECD 2004). Although the information sheet Flu, must have been in its authentic context a typical representative of the genre, for a Finnish reader – as a translation of a translation – it differs quite a lot from a typical Finnish applicable and declaratory information sheet about flu vaccination. The PISA text contains, for example, descriptiveness, personalisation and dramatisation

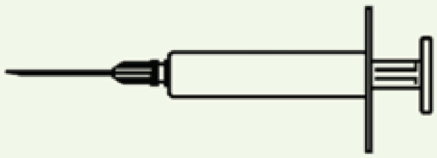
F 7.7 | Example task | Flu

R077: Flu

ACOL VOLUNTARY FLU IMMUNISATION PROGRAM

As you are no doubt aware the flu can strike rapidly and extensively during winter. It can leave its victims ill for weeks.

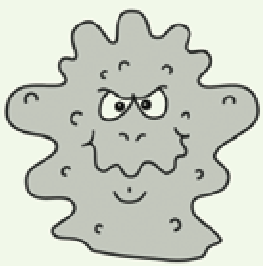
The best way to fight the virus is to have a fit and healthy body. Daily exercise and a diet including plenty of fruit and vegetables are highly recommended to assist the immune system to fight this invading virus.



ACOL has decided to offer staff the opportunity to be immunised against the flu as an additional way to prevent this insidious virus from spreading amongst us. ACOL has arranged for a nurse to administer the immunisations at ACOL, during a half-day session in work hours in the week of May 17. This program is free and available to all members of staff.

Participation is voluntary. Staff taking up the option will be asked to sign a consent form indicating that they do not have any allergies, and that they understand they may experience minor side effects.

Medical advice indicates that the immunisation does not produce influenza. However, it may cause some side effects such as fatigue, mild fever and tenderness of the arm.



F 7.7 continue | Example task | Flu

WHO SHOULD BE IMMUNISED?

Anyone interested in being protected against the virus.

This immunisation is especially recommended for people over the age of 65. But regardless of age, ANYONE who has a chronic debilitating disease, especially cardiac, pulmonary, bronchial or diabetic conditions.

In an office environment ALL staff are at risk of catching the flu.

WHO SHOULD NOT BE IMMUNISED?

Individuals hypersensitive to eggs, people suffering from an acute feverish illness and pregnant women.

Check with your doctor if you are taking any medication or have had a previous reaction to a flu injection.

If you would like to be immunised in the week of May 17 please advise the personnel officer, Fiona McSweeney, by Friday May 7. The date and time will be set according to the availability of the nurse, the number of participants and the time convenient for most staff. If you would like to be immunised for this winter but cannot attend at the arranged time please let Fiona know. An alternative session may be arranged if there are sufficient numbers.

For further information please contact Fiona on ext. 5577.

Enjoy
Good Health

F 7.7 continue | Example task | Flu

Fiona McSweeney, the personnel officer at a company called ACOL, prepared the information sheet on the previous two pages for ACOL staff. Refer to the information sheet to answer the questions which follow.

Question 3: FLU R077Q03- 0 1 2 9

We can talk about the **content** of a piece of writing (what it says).

We can talk about its **style** (the way it is presented).

Fiona wanted the **style** of this information sheet to be friendly and encouraging.

Do you think she succeeded?

Explain your answer by referring in detail to the layout, style of writing, pictures or other graphics.

....

Question 5: FLU R077Q05- 0 1 2 9

Part of the information sheet says:

WHO SHOULD BE IMMUNISED?
Anyone interested in being protected against the virus.

After Fiona had circulated the information sheet, a colleague told her that she should have left out the words "Anyone interested in being protected against the virus" because they were misleading.

Do you agree that these words are misleading and should have been left out?

Explain your answer.

....

("the flu can strike rapidly - - It can leave its victims ill for weeks; "ANYONE", "ALL"), and reader's addressing (the use of "you") which were translated into Finnish, too. Yet, the linguistic realisation of common genre is different in different cultures. (Harjunen, 2007.) A Finnish reader might be surprised when s/he finds out that Fiona wanted to be polite and encouraging, as the text may appear rather instructive and frightening in his/her mind: politeness is an universal phenomenon of social interaction, but the cultural context has an effect on its manners and manifestations (Brown & Levinson, pp. 187, 283; Watts, 2003, pp. 12, 20–23, see question 3). Textual and stylistic problems are often close to impossible to avoid and solve in translations (Arffman, 2007, p. 179), but even so the reading skills of the students' are assessed on the basis of these translations.

PISA translations do not try to achieve total cultural neutrality: "How literate would the youth of 2000 be if their competence did not allow for insight into cultures other than their own?" (OECD 2004, p. 21). Although the information sheet Flu was not valued among the most untypical and uninteresting texts of the PISA 2000 for a group of Finnish 15-years-old-students, it was among the not so authentic ones with a typicality value of 2.30 (in the variation between 2.94 and 1.81) (Sulkunen, 2007, pp. 88–89). Finnish students must have been able to appreciate other cultures when coping with PISA tasks.

Gender differences in PISA 2006 results

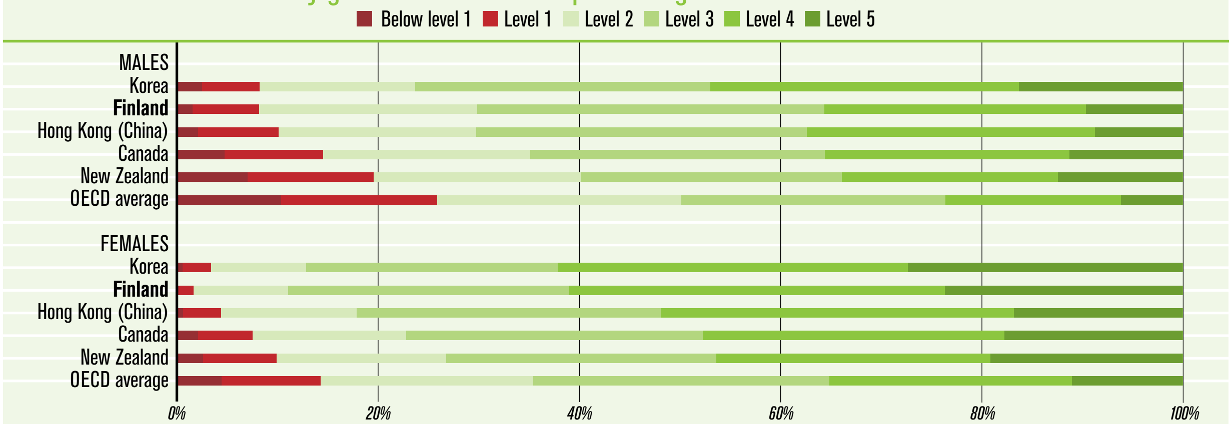
Although overall performance for Finnish boys and girls is excellent, the difference between their proficiency in reading literacy is significant and the second largest in OECD countries: girls have 51 score points higher than boys, while OECD average was 38 points and the largest difference was in Greece (57 points). The difference is as large as it was in the first survey (PISA 2000), but in contrast with PISA 2003, girls increased their average by 7 points up to 572 points, and boys remained at the same level (521 score points), and therefore the gender difference went up 7 points. (OECD 2007b, pp. 223–226, 232–234.)

It is worth mentioning that Finnish girls mastered the most demanding reading tasks: 23.7% of them achieved Level 5, while only Korean girls were better (see Figure 7.8.) Among Finnish boys 9.6% of them achieved Level 5, with that percentage being the fourth highest of boys in PISA 2006. It is significant that most of the weakest Finnish readers were boys. However, when compared to all OECD and partner countries the percentage of Finnish boys at Level 1 or below was the smallest. (See Figure 7.8). Both genders were second best after Korea: Korean males obtained 539 average score points and females 574 score points (OECD 2007b, p. 225).

A closer look at the results shows that continuous text formats were more difficult for Finnish boys than girls (see Table 7.4). For boys it was also more difficult to find answers to items that were categorised as occupational situations, which can be more due to the fact that these tasks consisted of mainly different kinds of item types than multiple choices. The gender difference in item type was lowest on closed constructed response and multiple choice items, and highest on open constructed response tasks (See Table 7.4.) Items classified as reflection and evaluation were more difficult for boys than retrieving information and interpreting, which could be due to the fact that all tasks in this process were open constructed response items, the most difficult item type for boys (see Table 7.4 and Table 7.3). This result may be due to the fact that reading and writing skills are closely related, although writing skills are not assessed in PISA. Consequently, the easiness of non-continuous texts for boys may be a consequence of there being only one item requiring an open constructed response in which students had to write more than a few words (see Table 7.3).

In the Finnish national assessments of 9th grade students' reading skills in 1999–2005 (e.g. Hannén, 2000; Lappalainen, 2006; Silverström, 2000), the differences between boys and girls varied between 7–12 percentage points, but in writing skills the difference

F 7.8 | Percentage of students at each proficiency Level on the reading scale, by gender in the five best performing countries in PISA 2006



was between 15–23 percentage points, i.e. twice as large as in reading. Yet, there are considerable variations in writing skills among boys and girls and also between schools. In an evaluation report on the 1999 results the problem of reliable assessment of the combined use of reading and writing skills has been discussed and it was concluded that, on average, boys might have acquired weaker results in such test items where the answer is to be given in writing because of their weaker writing skills and writing motivation (Lappalainen, 2000, p. 137). On average one out of three boys had poor writing skills as the national assessment carried out in the last grade of comprehensive school in 2005 showed. The major differences in writing skills between girls and boys remained unchanged when compared with earlier assessments in the last grade of basic school. Differences have actually increased by four percentage points in grades 7–9 of comprehensive education. (Lappalainen, 2006.)

It is self-evident that the most difficult task for Finnish boys compared to girls was the open constructed response to the narrative text Aesop which was described to require reflection and evaluation (with the difference of 21.48%; boys 66.17%, girls 87.65%). The simplest task for boys was the close constructed response to the table which was classified as requiring interpretation (with a difference of 1.46%; boys 52.60%, girls 54.06%).

Probably due to the small number of tasks, these results are quite similar to those obtained in PISA 2000 by Nordic countries (Roe & Taube, 2003) and by Finland (Linnakylä, Kupari & Reinikainen 2002, pp. 74–82). They suggest that boys are neither so used to reflecting on and evaluating texts nor to expressing their understanding or reflection in their own words as girls (see Roe & Taube 2003, pp. 35–36). It also might mean that PISA reading literacy has something to do with writing skills.

Another reason for gender differences can be found in the attitudes toward and interests in the subject, too: “gender differences in performance in reading and mathematical literacy are closely mirrored in student interest in the respective subject areas” (OECD 2001, p. 129). Those Finnish girls who considered “doing well in language” as very important got an average of 585 score points (Level 4) from read-

T 7.8 | Finnish attitudes towards "doing well in language" by gender in PISA 2006

Percent and frequency	*Boys*	*Girls*
Very important	16.12 (369)	39.17 (920)
Important	52.16 (1194)	51.81 (1217)
Of little importance	27.26 (624)	8.60 (202)
Not important at all	4.46 (102)	0.43 (10)
Total	100 (2289)	100 (2349)

ing literacy, and boys 540 score points (Level 3) (see Table 7.8 and Table 7.8). On the whole, 90.98% of Finnish females and 68.28% of males considered "doing well in language" as important or very important. In contrast to the total average score points of both genders in Finland (females 572, males 521), the information about attitudes towards mother tongue and literature brings out the fact that attitudes have a correspondence with success in PISA reading literacy, and that mother tongue (Finnish) and literature seems to be a more acceptable subject for girls than boys.

An interesting point is that in the 2005 Finnish national assessment of reading and writing skills 50% of the girls felt that mother tongue (Finnish) and literature had been an interesting school subject, whereas only 24% of boys shared that opinion. Gender differences in attitudes towards the interest and usefulness of this subject have been substantially greater than in those towards mathematics. (Lappalainen, 2006, pp. 14, 34–37.) The conclusion is, obviously, that mother tongue and literature is considered an important subject by both genders, but not very interesting and useful from the point of view of boys.

The place of residence has a bigger effect on boys than on girls as shown by the difference in performance between rural and urban males: average score points were 526 for urban boys and 506 for rural boys, but 575 for urban girls and 562 for rural girls. This feature might be related to "the Jokkmokk effect" reported by the Nordic PISA working groups who studied rural boys' and girls' performance in the town of Jokkmokk in Northern Sweden: boys were quite weak in mathematics and physics and girls were good. In the sparsely populated regions of Northern Sweden boys are more committed to traditional occupations, such as agriculture and forestry, in which school success is not always considered very important, whereas girls are more academic oriented and more willing to move away from remote districts (Steinthorsdóttir & Sriraman, 2007). In Finnish national testing the Jokkmokk effect was reported for the first time in the analysis of results obtained from the 1999 mother tongue assessment (Kuusela, 2006, p. 43; Lappalainen, 2000).

Of course, finding reasons for gender differences in language learning concerns everyone, not only Finnish students. Xin Ma (2007, pp. 82–92) gives several reasons for that inequity on the grounds of international and also regional student assessment. He claims that in spite of the psychological basis for a male advantage in nonverbal cognitive skills and a female advantage in verbal cognitive skills, and a cultural basis for gender stereotypes, the biggest reasons for gender differences in language, mathematics and science are the result of how boys and girls learn school subjects in educational systems and of educational interventions on school policies and classroom practices aimed at reducing gender differences. These gender differences did not go unnoticed, however, by the Finnish educational authorities. The National Board of Education's Reading-Finland Project in 2001–2004 was aimed, precisely, at bridging the gap between male and female reading skills, a problem already detected in the 1999 national assessment by the FNBE of 15-year-olds and PISA 2000. Out of this project came the concept of "boy pedagogy" which was developed to find workable methods and contents especially for boys (Sinko et al., 2005). However, it seems that results from this project are not yet visible in the PISA 2006 assessment. It has also been noticed that Finnish boys and girls are assessed differently in mother tongue and literature, receiving marks based on different criteria in their reports: in the 9th grade boys get better marks than girls in comparison to their competence level in national assessment of learning outcomes, specifically concerning their writing skills (Lappalainen, 2006, pp. 68–69).

Obviously, the goal of bridging the gender gap is in the mind of many teachers, and many strategies have been proposed. In Opettaja ("Teacher"), a journal published by the Trade Union of Education in Finland, there has recently been a discussion about problems in classroom discipline caused by boys. In a letter to the editor, titled "A teacher who has taught teenage boys for years", it is argued that a teacher has to motivate boys in simple ways by, for example, telling them: "Listen, do you want to end up in the gutter or do you want to have a girlfriend and a good car?" (*Opettaja* 7/2008). Similarly, in Kivi's novel the seven brothers learned to read on their own, and by the end of the novel most of them became responsible members of the community and family men. And still we have to remember that Finnish boys performed better than boys in other countries, except for Korean boys.

I cannot help smiling and thinking that the world has not changed that much: students need meaningful goals which they must strive to achieve. The Finnish educational system may have been successful precisely because of this mission, and it would not be a bad idea to remind everybody of it. A reminder aimed especially at boys and, in particular, to the boys who are afraid to be called sissies by their classmates if they find out that the boys enjoy reading and writing (see Merisuo-Storm, 2004).

7|4 Conclusions

Before PISA assessments very few people were interested in Finland. But now it is on the map and the limelight is on it. As a hard-working nation, Finns are proud of a job well-done, and teachers feel it is their duty to do what they have to do, well.

Historical and cultural values and background, fictional characters and certain linguistic features of the Finnish language have all contributed historically to the development of positive attitudes towards reading among Finland's citizens. Although they are difficult to quantify, these attitudes have a lot to do with the excellent results achieved in PISA surveys.

PISA 2006 results have shown, once again, that Finnish students' reading literacy is at the top because its educational system (teachers and curriculum) and teacher education programmes are doing what they are supposed to do to foster the excellent performance of Finnish youth. Besides the good job of teachers, it is argued that the framework curriculum (FNBE 1994, 2004) provides one of the main reasons behind the excellent results by 15-year-olds. The goal of the curriculum is to form active, life-long readers and learners by exposing them to a variety of text formats and types matching the PISA 2006 reading literacy framework and thus contributing to the results obtained by Finnish 15-year-olds. This feature is visible not only in the sections of mother tongue, but also in other school subjects and textbooks as well.

A closer look at the nature of PISA reading literacy tasks reveals some of the difficulties encountered by Finnish students and how different factors determine how successful task performance actually was. Girls outperformed boys as in the previous surveys. This phenomenon has been also visible in Finnish national assessments of mother tongue and literature learning outcomes. However, the results in PISA 2006 reading literacy were quite the same as in PISA 2000 and PISA 2003.

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adidas

In Finland, the extreme values of interest and attitude scales are less used.

But, when Finnish students admit to strongly agreeing, their PISA scores are very high.

8
Interests and Attitudes

Jarkko Hautamäki, Seppo Laaksonen and Sirkku Kupiainen

In PISA, attitudes are seen as a key component of an individual's science competence and include an individual's beliefs, motivational orientations and sense of self-efficacy (OECD, 2007, p. 122).

Attitudes and beliefs, or personal dispositions, are mental constructs that affect human behaviour. However, the link between a given disposition and behaviour is neither direct nor the same for all. In PISA, like in most large scale surveys, dispositions are elicited and made quantifiable and comparable using self-report questionnaires. But how closely are students' self-reported attitudes related to their actual learning activity at school, or to their later choices and actions in working life? Or to students' readiness to solve the PISA tasks without giving up? By using just the data from the self-report questionnaires, many questions are left open. It is one thing to tick a box to indicate one's interest in something and to actually solve the related tasks, and quite another to tick a box and not solve them, and still another to admit that one is not very interested at all – but still do the tasks, even if just because the tasks are given by a teacher (or the OECD).

On the whole, self-report questionnaires rely on the truthful self-evaluation by respondents with regards to statements' relevance, and on their ability and willingness to respond in a way that corresponds not only to their actual beliefs, but also to their behaviour. The latter expectation is based on the understanding that attitudes and beliefs as generalised anticipated emotions. They are formed by earlier encounters in similar situations, and comprise of evaluations of their outcomes with regards to responses to the social context, parents, siblings, teachers and friends. Attitudes can thus be understood as personal consolidations of past events encountered in public and semi-public performance contexts. Accordingly, an assessment of students' feelings concerning the issues aroused by the items is expected to give an indication of their likely performance in new situations. Their answers, the 'ticks in the boxes' may give an indication, but they may also contain other elements, such as social desirability or even mischief toward PISA data collectors.

Attitudes are assessed in PISA by two types of questions and questionnaires. One type comprises questions closely related to individual science tasks and imbedded in the test booklets, while the other type are compiled in a separate booklet, containing several sets of questions related to science and science learning. Together, the questions fall into four general categories: support for scientific enquiry, self-belief as science learners, interest in science, and responsibility towards resources and environments (OECD 2007, Chapter 3). Support for scientific enquiry is seen to be an important objective of science education, and aims to make students value scientific ways of gathering evidence, reason rationally, respond critically and give conclusions about their confrontations with life situations related to science. Self-belief as science learners assesses students' appraisals of their own abilities in science while interest in science is believed to be a predictor for later engagement in science related careers. Responsibility towards resources and environments, on the other hand, is included due to the growing global concern for environmental issues and the need for sustainable development.

Interpreting students' self-reported attitudes

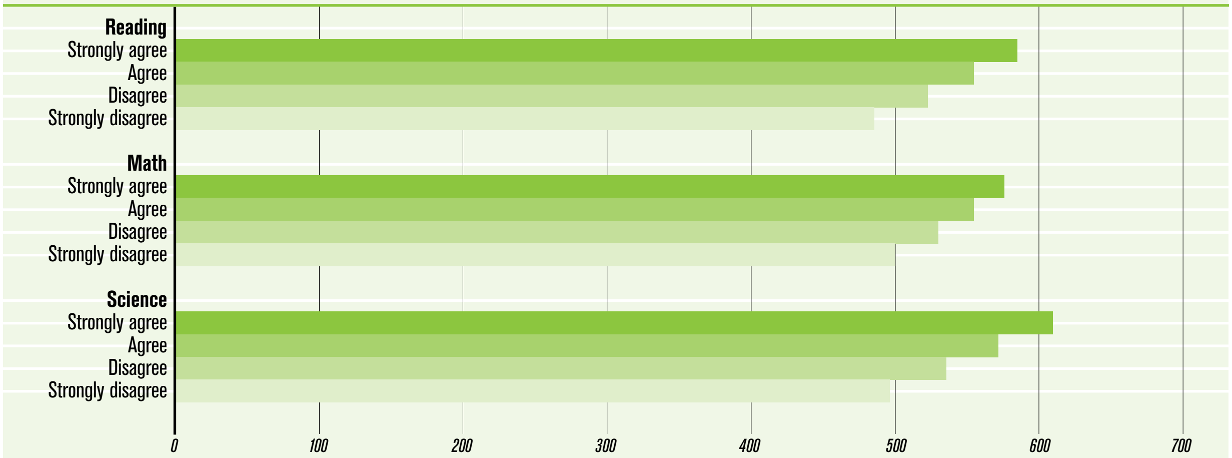
In PISA, the measured attitudes are reported in three ways: 1) By using the original measurement scale, which more often than not is a four-point Likert scale, with values ranging from strongly agree to strongly disagree 2) By using an index with the OECD mean at zero and SD at one, and 3) By using the PISA score index used in the competence domains, with OECD mean at 500 and SD at 100. It is to be noted, however, that unlike the use of the original values, both indices pose a problem for the interpretation of the results. A negative value in the first, or a value below 500 in the other, does not necessarily mean a negative attitude, but just donates a country mean falling below that of the OECD countries, reflecting either real differences in students' attitudes or just differences in their ways of using the four-point scale (e.g., using 'agree' instead of 'strongly agree').

Based on the somewhat surprising results of correlative analysis between students' attitudes and proficiency in PISA 2003 – despite the positive correlation inside countries, the correlation is negative at country level – Turmo and Lie (2007) analysed more closely the cross-country comparability of self-reported scales. They proposed that the reason for the negative country-level relation is due to differing national tendencies with regards agreeing with a (progressive or positive) statement, related to factors such as the level of literacy and other developmental indices. They refer to Hofstede's model of dimensions which differentiate cultures (Hofstede, 2001). Turmo and Lie conclude that the general agreement tendency should be taken into consideration when comparing mean construct values in PISA between countries. They also propose that it is more reliable to compare countries with similar general agreement tendencies, for example, the Nordic countries.

Due to the problems related to mean-based indices we have chosen to look at students' science-related attitudes by both using the original scale values and using the two indices described above. Going back to the original values seems especially salient for Finland where it was clear that students choose the extreme values not as often as students in many other countries. However, despite the more even use of the scale in Finland, the single item "I am interested in learning about science" suffices to show that within the country students' self-reported attitudes correlate highly with their PISA scores – in all domains (Figure 8.1).

In Finland, the share of students choosing the different options of strongly agree, agree, disagree, and strongly disagree (frequency distribution is 13%, 56%, 27% and 5%, respectively) is different from the OECD average so that the extreme values of the scale are less used in Finland (OECD frequency distribution is 18%, 45%, 27% and 9%, respectively). But, when Finnish students admit to strongly agreeing with the statement, their PISA scores are high in all three domains, with a score point average of over 600 in science. And even if the scores for students who admit to being less interested are also above or close to the OECD mean of 500, they are consistently lower than for those with more interest. Already this one example shows the importance of comparing not only the country level means but country-level correlations and portions of explained variances. However, this will not be done any further in this chapter, which is intended to supplement the previous chapters for PISA science, PISA mathematics and PISA reading.

F 8.1 | Mean PISA reading, math and science scores according to students' agreement with the item I am interested in learning about science



Finnish students' science-related attitudes and beliefs

The means for Finnish students in general value of science, general interest in learning science and a future oriented science motivation are given in Table 8.1, based on the index of OECD mean at 0 and SD 1. The Finnish mean is either close to zero or clearly negative, indicating that Finnish students' attitudes are in most cases less positive than those of students in most other OECD countries (the OECD mean stands for 0 for all scales). Despite the problems concerning the comparability of attitudes, the results give reason for some national concern. There is, after all, an increasing need for scientifically and technically oriented people also in the more developed countries to respond to the varied economic and other challenges of tomorrow's world.

As an example, we will present a more detailed analysis concerning the index Future oriented science motivation. The index is comprised of four items: I would like to work in a career involving science, I would like to study science after secondary school, I would like to work on a science project as an adult, and I would like to spend my life doing advances science. The percentages of Finnish students who agree or strongly agree with the statements are, respectively, 26%, 23%, 21% and 12%, compared to the OECD means of 37%, 31%, 27%, and 21%. (OECD, 2007, p. 149). With only 12% of Finnish students interested in orienting themselves toward advanced science, the future of the Finnish economy is possibly heading toward some sort of a concern. Likewise, in Finland, the share of students expecting to be in any science-related career at the age of 30 is 18 %, which is one of the lowest among the participating countries – even if it exceeds that of Japan, also among the top performers, by a full 10% (OECD, 2007, p. 151).

Finnish students' responses to the more personal attitude questions are given in Table 8.2. Again, the perceived personal value of science shows a negative index value, but Finnish students still seem to enjoy learning science somewhat above the OECD average. Also the indicators reflecting students' school-related attitudes toward science – science self-efficacy and science self-concept – have a (weak) positive mean value.

T 8.1 | The Finnish students' attitudes toward science (OECD mean 0, SD 1)

	Mean	*SE*	*SD*
General value of science	.07	.01	.89
General interest in learning science	-.24	.01	.94
Future oriented science motivation	-.17	.01	.86

T 8.2 | The Finnish students' personal science-related attitudes (OECD mean 0, SD 1)

	Mean	*SE*	*SD*
Personal value of science	-.09	.01	.88
Enjoyment of science	.11	.01	.89
Science self-efficacy	.03	.01	.92
Science self concept	.07	.01	.85

T 8.3 | The Finnish students' environmental attitudes (OECD mean 0, SD 1)

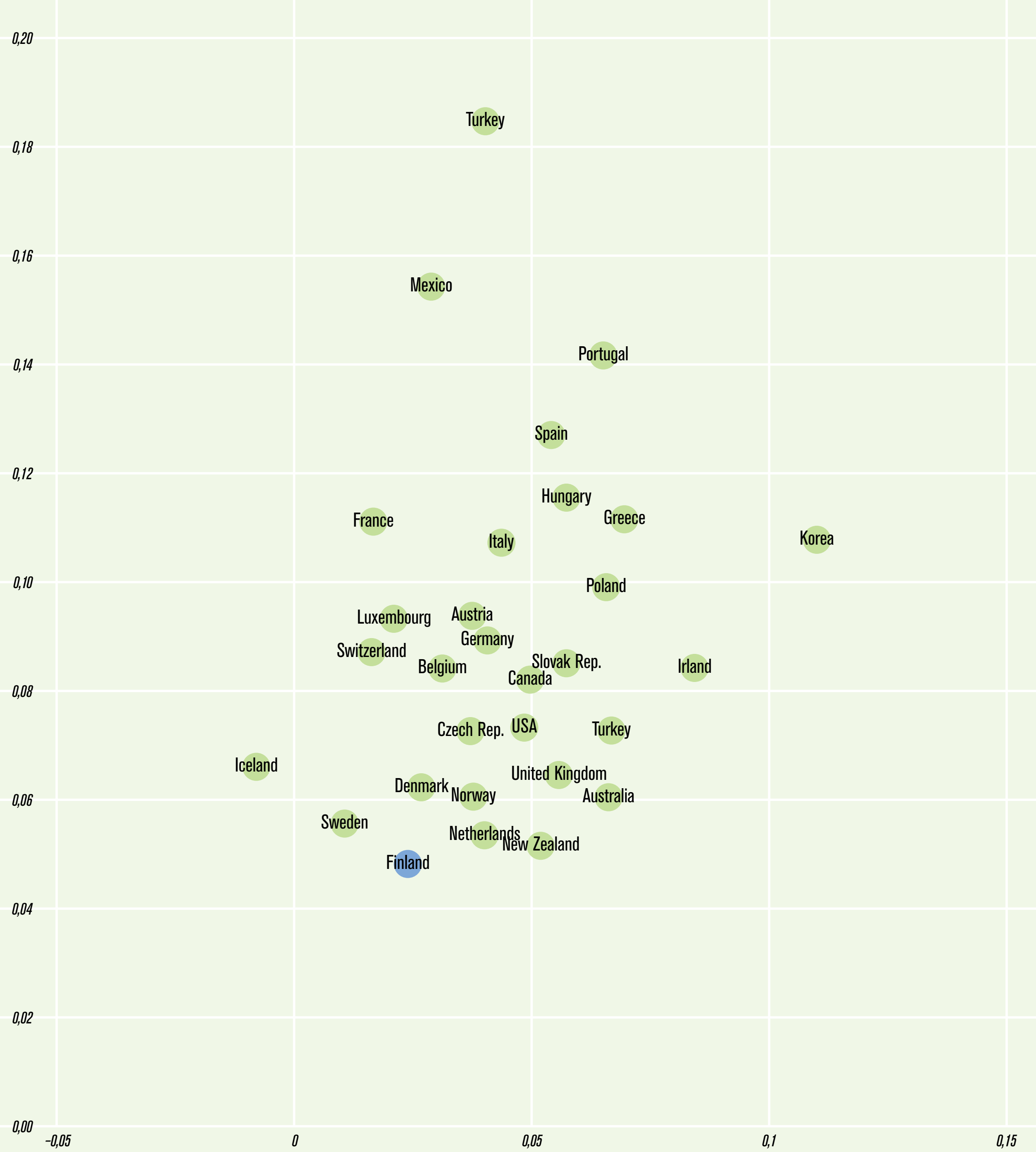
	Mean	*SE*	*SD*
Awareness of environmental issues	-.02	.02	.86
Environmental optimism	.00	.01	.85
Perception of environmental issues	-.52	.01	.83
Responsibility for sustainable development	-.10	.02	1.02

As above, to look beyond the means, we will present as an example of a more detailed analysis regarding one of the indices, Self-efficacy in science. The index comprises eight items, with the percentages of Finnish students who believe they can perform the task easily or with a bit of effort in parenthesis: Explain why earthquakes occur more frequently in some areas than in others (83%), Recognize the science question that underlies a newspaper report on a health issue (77%), Interpret the scientific information provided on the labeling of food items (68%), Discuss how new evidence can lead to changing your understanding regarding the possibility of life on Mars (64%), Identify the science question associated with the disposal of garbage (63%), Predict how changes to an environment will affect the survival of certain species (56%), Describe the role of antibiotics in the treatment of disease (53%), and Identify the better of two explanations for the formation of acid rain (48%). Given Finnish students' high scores in PISA science and the general relation between their attitudes and proficiency (Figure 8.1), there seems to be good reason to believe in their self-appraisals.

In the PISA 2006 Framework, scientific literacy is defined so as to include also the environment. Therefore, special attention has been given to environmental consciousness with students' environmental attitudes forming one set of the attitudinal indices. The Finnish students' positions in the four subscales are given in Table 8.3.

Students' Perception of environmental issues has a disconcertingly low mean, and is apparently the lowest among the PISA 2006 sample. An analysis of the responses at item level, however, gives a nationally relevant explanation for this 'negativity' (Table 8.4). Firstly, the item is given, and then, secondly, the percentage of students who believe that the issue mentioned is a serious concern for themselves or other people in their country.

F 8.2 | A bi-dimensional symbolic map of 30 OECD countries based on their students' environmental attitudes



T 8.4 | Items in the index Concern for environmental issues, with the percentage of students seeing the issue as 'a serious concern for themselves or for other people in their country', Finland and the OECD mean (OECD 2007, p. 159)

Item	*Finnish*	*OECD*
Air pollution	88 %	92 %
Extinction of plants and animals	74 %	84 %
Clearing of forests for other land use	76 %	83 %
Energy shortage	67 %	82 %
Nuclear waste	74 %	78 %
Water shortage	45 %	76 %

The Finnish students' concerns differ from those of the OECD average especially in two issues, regarding forest clearing and water shortage. However, taking into consideration that one of the alternatives in the scale was for the issue to be 'a serious concern for the citizens of other countries', the Finnish result is more than understandable. After all, shortage of fresh water and the clearing of forest for purposes other than forest industry (one of the oldest staples of the Finnish economy) are widely discussed in the Finnish press – but for good reasons mainly in the context of countries where they are an acute threat. Accordingly, in light of the results, there seems to be nothing ungrounded or too pessimistic in the Finnish students' views regarding environmental issues. Rather, it could be said that the scale, with its options for concern for 'me/us' or 'others', lends itself poorly to comparisons between countries with differing environmental concerns. Rather the 'low' Finnish mean could be seen to show that the students know their own country but have also read about global environmental problems in school and in newspapers.

Overall, the Finnish students' environmental attitudes are not very different from those of the other Scandinavian countries, maybe reflecting similar national concerns and special circumstances. In Figure 8.2, the 30 OECD countries are set on a bi-dimensional map, based on the frequency distributions of students' environmental attitudes. The scales used in the mapping comprise environmental awareness (ST22Q, 5 items), environmental issues (ST24Q, six items), environmental improvement (ST25Q, six items), and environmental responsibility (ST26Q, seven items), with the multidimensional model projected on a bi-dimensional map. The map is produced by using symbolic data analysis with SODAS software (Diday & Noirhomme-Fraiture, 2008; Laaksonen, 2008). The map illustrates how close to each other the different OECD countries are based on their students' environmental views, and, as can be seen, the Scandinavian countries fall all fairly close to each other, but also some other countries are located in the same 'niche'. The dimensions are not named as they are abstract dimensions upon which multidimensional locations of OECD countries have been projected.

Attitudes in relation to science competence

The PISA 2006 data offers another good way for looking at the meanings of the Finnish students' attitudes. Based on the PISA 2006 framework, the beliefs and attitudes on the one hand, and science related competencies on the other hand, have been classified by OECD (OECD, 2006) into: interest in science, support for scientific inquiry for attitudes and explaining scientifically, identifying scientific issues, and using scientific evidence for science competencies. These indexes are calculated with the OECD mean at 500 with a SD of 100. The means for Finland are given in Table 8.4.

It is interesting to see that while Finnish students have the top competence in scientific literacy (the mean for explaining, identifying and using are all well above that OECD average), they admit to not being personally very interested in science (interest and support are both slightly below the OECD average).

These attitudes explain, in the statistical sense, the Finnish results of PISA scientific literacy, but not very strongly. The correlations of these five indices with PISA Science are shown in Table 8.5. The last column contains the regression coefficients of two attitudes and three competencies regressed upon the PISA Science score, where the relations between the indices have been taken into account.

It can be seen that mainly the sub-areas of science competence - identifying scientific issues, explaining phenomena scientifically, and using scientific evidence - have independent power when analysed together with the attitudinal indices. This can be analysed further by condensing the five areas into two principal components, competence in science (with high loadings on explaining, identifying and using evidence, but also moderately on interest and support) and interest in science (positive loadings on interest and support, and negative loadings on explaining, identifying and using evidence). In Table 8.6, correlations are given for these five attitude indices, the two principal components, and PISA reading, PISA science and PISA mathematics.

The principal components are here useful for showing that generally expressed interest is not directly related to doing well in PISA tasks. Even more, the correlations of the second principal component are negative, not strongly explaining lower scores, and

T 8.5 | Means for two major attitude indexes and three science related indexes for Finland with 95% confidence limits (OECD mean 500, SD 100)

	Mean	*Upper*	*Lower*
Interest in science	488	492	484
Support for scientific inquiry	479	483	475
Explaining scientifically	566	570	562
Identifying scientific issue	555	559	550
Using scientific evidence	567	572	563

T 8.6 | Correlations between Finnish students' PISA science scores and their science related attitudes (five indices)

	r with science score	*se*	*regression coefficient*
Interest in science - attitude	0.21	0.0096	-0.00
Support for scientific inquiry - attitude	0.35	0.0027	0.04
Explaining scientifically - competence	0.88	0.0022	0.38
Identifying scientific issue - competence	0.83	0.0013	0.14
Using scientific evidence -competence	0.84	0.0011	0.35

T 8.7 | Correlations of five (two for attitudes, three for competence) indexes, two principal components of these, and PISA literacy areas

	Using science	*Interest in science*	*READ*	*SCIENCE*	*MATH*
Interest	0.39	0.85	0.21	0.23	0.16
Support	0.55	0.71	0.42	0.39	0.28
Explaining	0.95	-0.15	0.76	0.95	0.84
Identifying	0.92	-0.20	0.83	0.91	0.80
Using evidence	0.96	-0.19	0.83	0.96	0.87
Using science (1. PC)	1.00	0.00	0.84	0.97	0.85
Interest in science (2. PC)	0.00	1.00	-0.10	-0.18	-0.22

clearly showing an aspect of interests and attitudes that are separate from competencies. Expressing interests thus seems to imply an at least bi-dimensional structure, with one dimension increasing performance if combined with doing well in science tasks, and the other going hand-in-hand with a low level of performance. This seems to strengthen the idea that there are two distinct aspects of attitudes. The first one is related more directly to an assessment occasion when PISA tasks are given to students, e.g., whether they do the tasks or not do. The other one is a kind of a general tendency to speak favourably about oneself without real commitment.

Using the similarity-dissimilarity method of symbolic data analysis (SODAS) presented above, the 30 OECD countries have been mapped for the two attitudinal indices in Figure 8.3.As in Fig. 8.2, the bi-dimensional map is an abstraction where the dimensions cannot easily be interpreted; the configuration is the result.

Finland is in the middle with the Netherlands, Denmark, England, Sweden, New Zealand and Japan. In Figure 8.4, the bi-dimensional map of the three science competencies – explaining, identifying and using evidence – is presented. Finland is here clearly different from all the other OECD countries, mainly due to the high value of all the three indexes related to shown competence in PISA science.

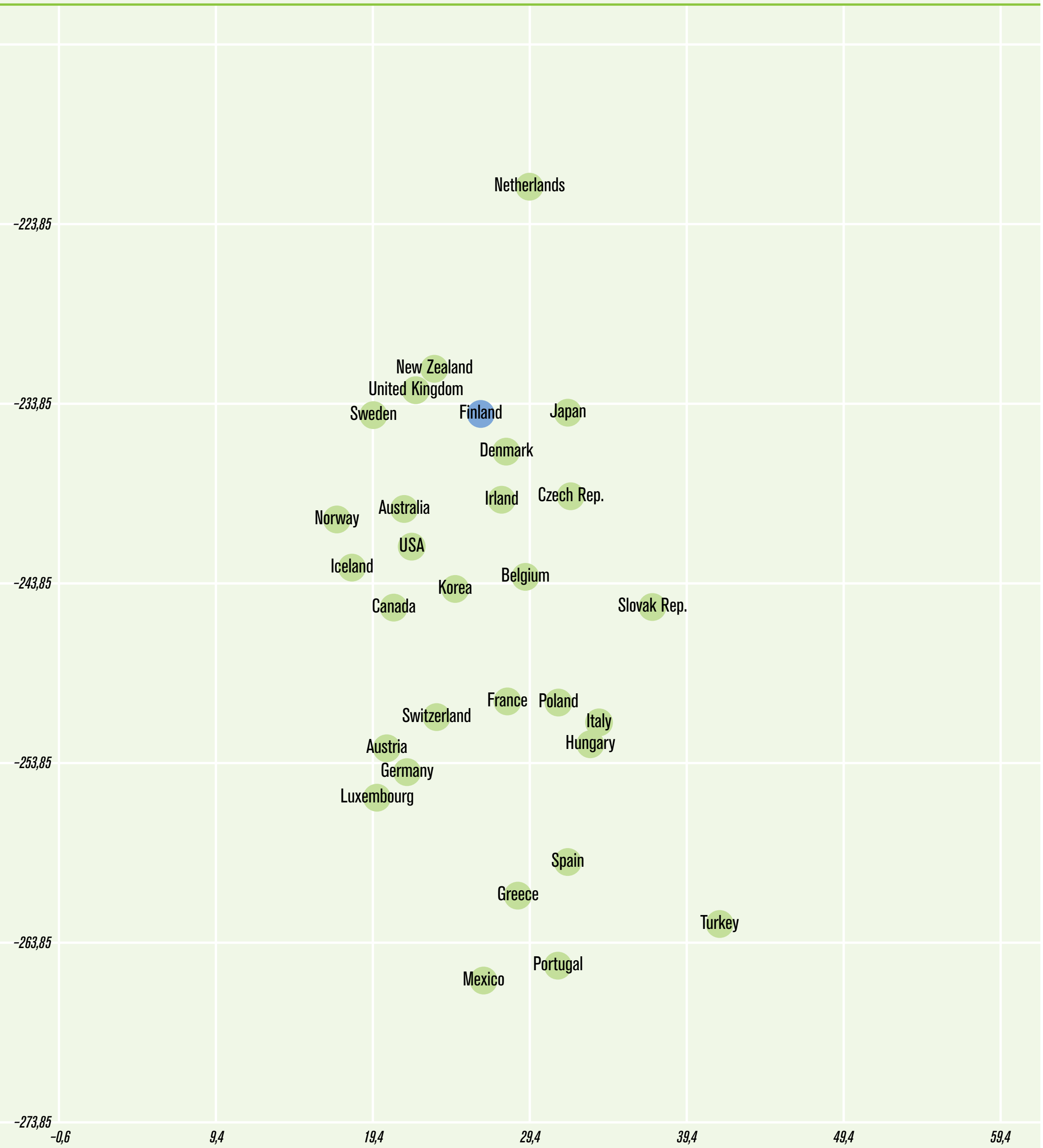
In Figure 8.5 both the two attitudes and the three science competencies are combined to produce the bi-dimensional map of science related beliefs and science competence for 30 OECD countries. Here Finland can be found among the top performing countries of Australia, Canada, the Netherlands, and New Zealand: high competence level and moderate attitudes.

Conclusions

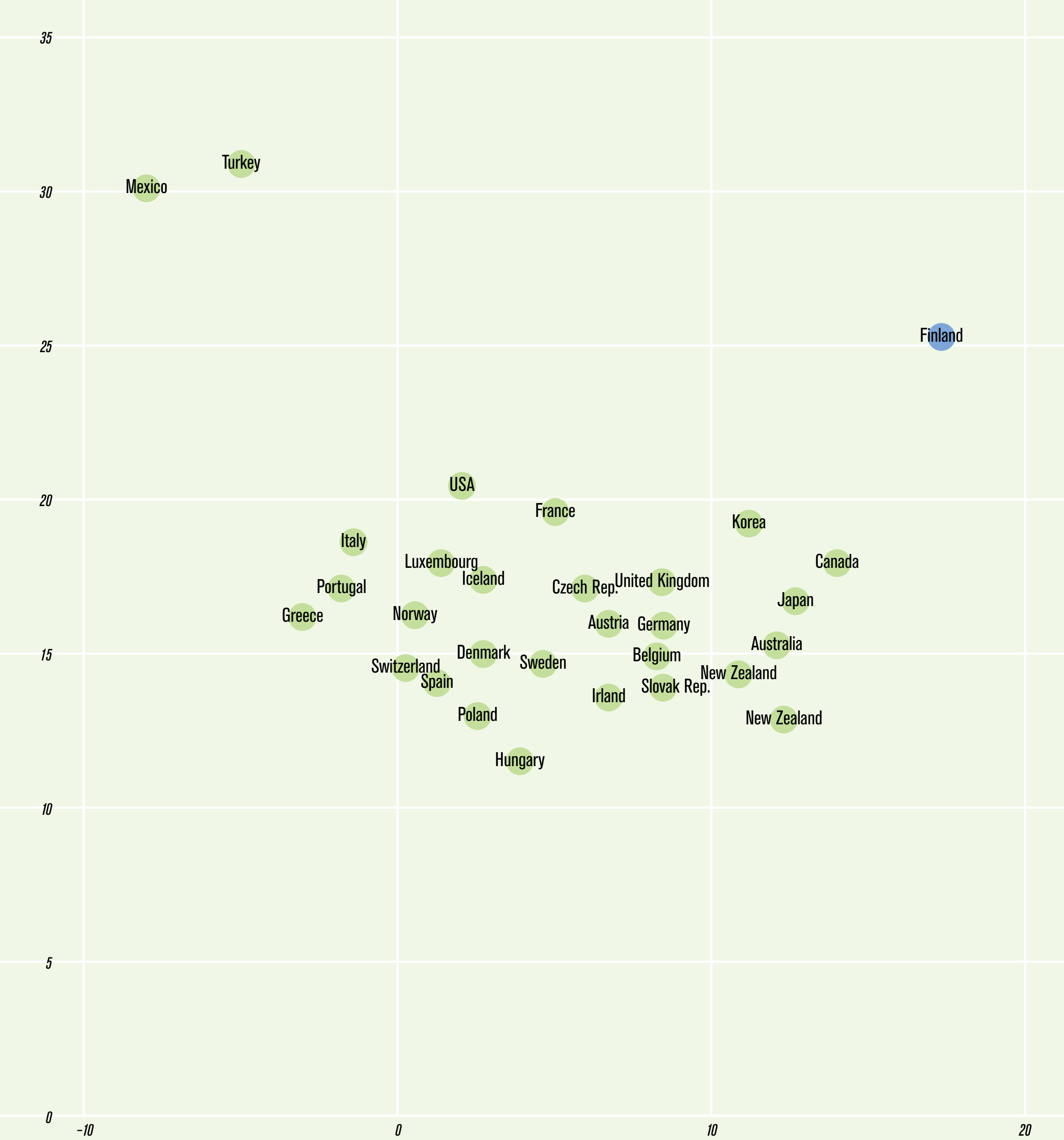
In light of the different questionnaires in PISA 2006, Finnish students' attitudes regarding science and environmental issues seem problematic. Partially these seem to be related to the differing national habits of students in using the four point Likert scale, i.e., the tendency to (just) 'agree' or to 'strongly agree' with a statement. However, despite the Finnish scale means mostly falling near or below the OECD means, most of the scales seem to work well in relation to students' performance in the PISA tasks. Also, in the one area where the difference between the Finnish students and those of most other OECD countries is greatest – concern for environmental issues – the difference seems to indicate differences in the importance for the environmental concerns for the different countries in question, combined with a scale of options that in no way forms a continuum to be used for calculating a mean. After all, you need not do well in PISA science to know that water shortage is a problem affecting everyday life in Spain in a way it might never do in Finland or Sweden. However, multidimensional similarity analyses show that countries can be compared also in the realm of attitudes, and that meaningful groups of countries can be identified among them. And while differences in general agreement tendencies undoubtedly complicate international comparisons of attitudes and beliefs, more reliable comparisons can still be made among countries sharing more similar national mental frameworks.

The many attitudes assessed in PISA call for and deserve extended analyses at the national level and internationally; using both the correlations between and the absolute values of the individual items, combined with students' attainment in the different PISA domains (for PISA 2003, see Turmo & Lie, 2007). Here, we have highlighted only some of the possibilities provided by the data. Yet, it can be said that the PISA data seem not to point to any great national concerns regarding the attitudes and beliefs of the Finnish students, if not for the low percentage of students showing a readiness to follow a career in advanced science

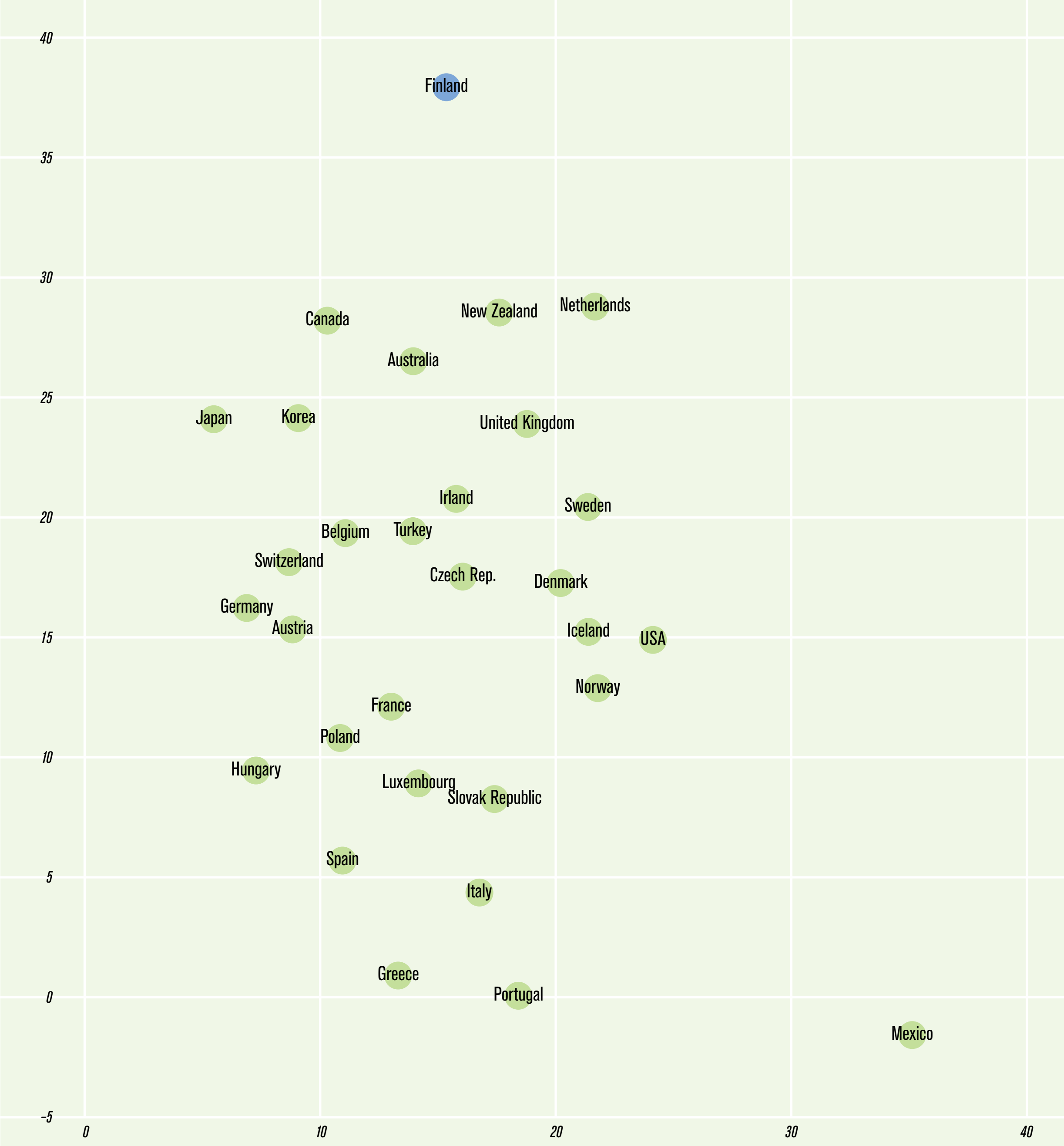
F 8.3 | A bi-dimensional symbolic map of 30 OECD countries based on the indices for students' science related attitudes (interest, support).



F 8.4 | A bi-dimensional symbolic map of 30 OECD countries based on the three indices for students' science competencies (explaining, identifying and using).



F 8.5 | A bi-dimensional symbolic map of 30 OECD countries based on the three indexes for students' science competencies (explaining, identifying and using) and on the two indexes of attitudes (interest and support)



– a concern shared by many other developed nations. Furthermore, looking at Finnish students' performance in PISA, their positive attitudes seem to be at work when needed, assisting in mobilising their mental competencies and skills in solving tasks, hopefully not only in PISA and at school, but also later in life. As the Finnish students' top-level performance in the literacy domains show – regardless of the Finnish mid-OECD level or lower means for most of the attitudinal factors – one result of PISA is the finding that in international comparisons, cognitive outcomes cannot be simply explained by students' attitudes. However, also the Finnish results and national analyses show that within a country, students' attitudes and beliefs have explanatory power, and accordingly, must be paid attention to in the educational discourse.

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The dilemma:
Why are Finnish
students so diligent?

Is there a connection
between concrete and
mental tools, between
pencil and thinking?

9
Claims, Arguments and Models

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The great educational experiment in Finnish education

Finnish peruskoulu, the comprehensive 9-year education for all with two layers – the primary school consisting of classes 1-6 with class school teachers, and the upper part, consisting of classes 7-9, with specialisation and subject teachers – was founded in 1968, and started in 1972/77. The new school was indeed comprehensive and radically changed the whole system of education. Also a concomitant large-scale teacher in-service training was comprehensive and obligatory. The new mandatory foundations for curricula were prepared in a committee, where all political parties and university experts of educational sciences participated. In the beginning, the steering system was centralised and governmental instruments through the National Board of Education were used with a firm purpose, in parliament, by government, in counties and local municipalities.

The major point to know is that the new system was indeed comprehensive. This was both a necessity – the reasons for the reform were serious problems of the lack of balance between the educational system's different components – and a chance encounter, a lucky constellation of political, economical and social conditions. In sum, the whole system was radically changed with great impetus also for secondary education, both gymnasium and vocational education. The consequences and outcomes of this reform are now measured, 40 years afterwards, with PISA. It is important to note that the whole structure of basic education changed, as described in Chapter 2, and it was not a case of partial reforms not touching the foundations.

The foundations for the Finnish PISA results were laid, in a system with equity goals and a strong steering system to take care of the goals and their even application, from the scarcely populated areas of northern Finland to the densely populated areas of southern Helsinki. Thus, in the beginning the educational institution was not an open, self-governed system. But, over a period of 20 years it evolved in that direction (Figure 1, Lyytinen, 2004).

The major point is that the present PISA results reflect an educational system, which was founded on a centralised and solid 'rock', but has, step by step, developed towards a more open and self-governed system. Educational change is often characterised by previous habits and ways of working still prevailing, while new methods and interpretations are only slowly introduced and find their place. The core layers of education seem to remain intact and change slowly, while talks change more easily, but also more superficially (Elmore, 1996).

In Table 9.d we compare the Finnish and global education ideas of governing the schooling using six trends (Hargreaves, Earl, Shawn & Manning, 2001; Sahlberg, 2004; 2007). Sahlberg (2004) presents the idea that Finland is best described using trends that

T 9.1 | The steering system of the Finnish comprehensive education and its major change in the 90s

Situation in 1970s and 1980s	*Situation in 1990s and 2000s*
Centralised control and decision-making	**Devolution of power**
• Centralised curricula	• Self-governance
• Long-term plans	• School-based curricula
• Budgeting based on expenditures	• Distinctive educational profit of institutes
• External evaluation: inspections	• Self-direction and regulation
	• Learning organisation as a model of functioning
	• Self-evaluation and own control
	• Performance-based funding

T 9.2 | Trend in global education movements (Sahlberg, 2004, with modifications)

Standardisation Standards for schools, teachers and students to improve the quality of outcomes.	**Flexibility and diversity** School-based curriculum development, networking through steering by information and support.
Emphasis on literacy and numeracy Basic knowledge and skills in reading, writing, mathematics and science (= prime targets of education reform).	**Emphasis on broad knowledge** Focus on broad learning; equal value to all aspects of an individual's growth in personality, moral, creativity, knowledge and skills.
Consequential accountability The school performance is closely tied to the "inspection" and ultimately rewarding or punishing of schools and teachers.	**Trust through professionalism** Culture of trust, i.e., valuing teachers' and headmasters' professionalism in judging what is best for students and in reporting on progress of their learning.

are listed in the right column and that these would be different from global trends, listed in the left column. A closer look at all trends reveals that in Finland they all occupy a role, but that there is one clear difference: we do not have the strong version of consequential accountability with national comprehensive testing, and that our standards are open to local flexibility and diversity. In Finland we have a strong emphasis on literacy and on having a command of the basics of numbers (the well-know 3Rs, reading, writing, and arithmetic) together with emphasis on broad general knowledge.

The Finnish system is a combination of both controlled and autonomous elements. It is both a governed and self-organised system, in which universal educational values are taken into account and respected, and which is capable of adapting to new social challenges within the Finnish framework. However, its power for adaptation to new types of pupils and social challenges, e.g. being posed by both an increase in immigrants and by changing family circumstances, remains to be seen. But, given the whole idea of the PISA framework, PISA outcomes should be anticipatory in relation to the future. If the framework is even partly predictive, then Finland will be able to cope well also in the future.

There are issues that are generally relevant for interpreting the outcomes of international comparisons, and this is true also for the case of PISA and Finland. The most relevant issues are listed and shortly commented on below. After that a more detailed explanation of the Finnish outcomes is given.

Differences in economy and social structure

Finland is a wealthy Nordic welfare country, which takes good care of its citizens. The people can trust the society to support them in cases of need, paying for this support through high taxes. A major form of this support is investments in education. Finnish students performed above the "expected" level in relation to GNP and per student expenditure in education (Figure 1.10, Chapter 1). This means that money as a part of GNP or as investments in education as such do not explain the Finnish outcomes, even if the general trend, that money matters, as expressed by the OECD, is as true as it seems to be. However, a regression trend cannot be a sufficient explanation for a case which shows the highest outcomes but has only a medium of expenditures and a fairly high GNP, but not the highest. It is to be hoped that the effects would be in both directions, and that one could expect the highest GNP in Finland in the future.

Differences in education systems

Finnish education is public and free-of-charge for all families. Also the management of education in Finland is a combination of centralised and decentralised management. To be public means that the schools are also in practice open to parents, and that if they would have the desire they can follow any lessons within the education system. Additionally, public means that the private sector of comprehensive education in Finland is very limited.

Generally, it seems that there are indeed several ways to organise education for teenagers. If the country is able to manage the between-student variation, then there are different systemic solutions which are related with excellent performance. The between-school component reflects this solution: good and even high results can be achieved also with relatively high between-school differences. This has not, however, been the Finnish way. According to our basic philosophy of equality, high between-school variation would be a moral dilemma in relation to ideas of general knowledge and universal value of enlightenment.

Comprehensive vs. parallel schooling

The Finnish system was comprehensive and common for all 15-year-old students, at the time of PISA assessment. The selection to secondary education takes place after the PISA testing, even if the preparations and decisions for the selection are performed during the spring when the PISA assessment takes place. The allocation of the pupils to different educational careers actually occurs after the summer vacation. This means that the effects of selection and tracking on within-school and between-school variation appear at least one year later than in most other PISA countries. The importance of the timing of the selection of pupils to different levels of the educational system for the PISA-results has not yet been considered. The Finnish studies on learning to learn competencies show that there are, in fact, great between-school differences in attainment and partly also in attitudes when the students are two years older and study in gymnasiums (secondary schools which prepares students for university) or vocational schools (Hautamäki et al, 2002). Also the age of starting the school is important, as it affects the timing of the selection/tracking to secondary education. Even with a 9-year comprehensive and general education, the varying starting age of six vs. seven results in different timing for PISA measurement with different estimates of between-school and, apparently, also of between-student variation.

Regional or urban / rural differences

If a country is able to cope with and manage this issue successfully, then the between-school variation will be under control, but also the within-school variation probably will be lower and the overall mean level of the country increases. But, generally, the regional issue is growing more and more important throughout all EU countries, and also in Finland, intertwined, as it is, with the local effects of globalisation, e.g., the ebb and flow of working places. From the perspective of the Finnish political system this issue is a central one, which is reflected in elections and in parliamentary discussions.

The outcomes, presented in Chapter 3 and Chapters 5-7, seem to indicate that the fundamental idea of comprehensive and general education for all, in cities and villages, for the poor and wealthy, for boys and girls has succeeded well. The results do not offer evidence that only the comprehensive system may result in high performance. The results also do not, however, show that the parallel and selective system with private schools would do better. Both the empirical evidence and the moral argument are unequivocally for comprehensive systems.

Curricular differences

The curricular system and goals for science, reading and math education in relation to the PISA framework have been described in Chapters 5-7. In this connection, it is important to remind that, generally speaking, the Finnish curricula are aligned rather well with the PISA framework.

Additionally, the school days are relatively short, especially in the lower grades in most Nordic countries, and relatively little time is spent doing homework after school. But, if and when homework is given, Finnish teachers check the assignments. When school intrudes into the free time of pupils and into family life, it is necessary to make sure that the tasks have been completed. Without that, the intrusion is not effective in introducing and cultivating the study habits, and learning to learn. Consistent expectations concerning efficient study habits and learning to learn competencies should pervade all the contexts of the child, and not be limited to the ramifications of school buildings.

Streaming / ability grouping inside schools

PISA samples are random samples of a maximum 35(30) students of the selected schools. In Finland, this way of sampling may hinder recognising that there are educationally important between-class differences within relatively similar schools, even with the lowest between-school difference in the PISA data. The Finnish studies on learning to learn competencies (Hautamäki et al., 2004) show that there are considerable between-class differences in attainment and attitudes within schools, especially in bigger schools in which classes are often formed on the basis of foreign language or other subject choices of students. Additionally, there are differences in grade repeating policies as a part of managing the variation between students. Repeating of a grade is rare during basic education (in Finland 2% of pupils) due to the principle of education for all. From this principle follows that schools should provide support to pupils and students with slow learning and with even very mild learning difficulties. Class or grade repetition is not among the common tools.

Differences in national evaluation practices

Countries with covering (encompassing) and obligatory assessments will undoubtedly train students' "test-taking skills". Supposing that the tests and arguments for their use are valid and accepted by pupils, this training should assist in solving PISA tasks. However, the case seems to be that the country with the least number of obligatory testing of PISA nations –Finland – seems to cope best with the PISA testing. Some countries seem, metaphorically, to kill the sense of testing, by repeated testing. Testing stops being an important, formative source of feedback for students and instead turns into a machinery grinding the interests of students. In Finland there is no obligatory and comprehensive testing during the 9-year comprehensive education. The obvious outcome of excessive testing may be that new testing situations do not motivate students to perform their best. This would mean that PISA outcomes in countries with a comprehensive national testing system might be underestimates, characterised by all kinds of methodological complexities.

Gender differences

The tradition of women's labour force participation, and education in Finland is more established than in other Western countries. Also mothers of small children are part of the labour force, most of them full-time. It is not surprising that Finnish women have been considered strong. Legally, they have equal rights to men in society. Thus, there are no strong fundamental pre-conceptions of gender differences in school achievement. However, there are empirical results indicating that there is a better goodness of fit between the requirements of the schools and the girls than the boys. However, the empirical fact is also a set of gender differences, in PISA science, PISA math and PISA reading.

The major differences in Finland are, once again, in reading. Despite the high level of performance of both Finnish girls and boys in PISA reading in PISA 2000, PISA 2003 and PISA 2006, the difference in performance between boys and girls was among the highest in all OECD countries. In math, there were no gender differences in PISA 2000 (the differences were less marked in other OECD countries, too, and in many countries boys outperformed girls). In the more extensive study on math in PISA 2003, Finnish boys slightly outperformed girls. This was also the outcome of PISA 2006. In science, the finding was that there were area-specific, but no gender differences in the overall level in PISA 2000. In 2003, girls slightly outperformed boys in science. The general trend continued with PISA 2006, where there were no gender differences.

The major gender difference is in reading. However, in Chapter 3 using the notions 'level' and 'balance', the results indicated that there are no major gender differences in level, which combines all three PISA areas in one index. But, there was a large difference in balance. This gender difference in balance is a universal result, as it seems to hold in all PISA countries. The interpretation of balance is based on the concept of a profile of problem solving strategies. The boys' profile is math, and to a small extent science dominated. The girls' profile is characterised by more verbal problem solving strategies. The gender difference issue is sometimes called the gender gap.

Australian Gary Marks (2008), in accounting for the gender gaps in reading and mathematics using PISA 2000 evidence, seems to have found a rule, which combines both level and balance. There is, according to him, strong association between gender gaps in reading and mathematics, which seems to imply that these gaps are both influenced by policy, i.e.,: "the extent that countries have successfully implemented policies to promote the educational outcomes of girls and young woman. In such countries the gender gap in mathematics is small or non-existent, but the gender gap in reading is relatively large "(p. 89). He continues: "the gender gap in reading tends to be larger in countries with a large public sector, although there are many exceptions", and, that analyses "provide some support for the hypothesis that girls perform relatively better in countries where there is greater equity in the work force or have a larger public sector, this is not true for the gender gap in mathematics" (p. 104). And finally the rule: "the two gender gaps [i.e., in reading and mathematics, our addition] are closely related. This means that in countries with a larger gap in reading favouring girls tend to show smaller gender gap in mathematics. Examples are Finland and New Zealand, both with very large gender gaps in reading and trivial gender gaps in mathematics. At the other extreme is Korea, with a large gender gap in mathematics and a much smaller gender gap in reading. …. These observations strongly suggest that the size of gender gaps in reading and mathematics reflect the implementation and success of policies which improve the performance of girls. Policies that promote girls' educational performance decrease the gender gap in mathematics but also increase the gender gap in reading. Correspondingly, countries that have not implemented such extensive policies to improve the educational outcomes of girls, or where the policies have been less successful, show larger gender gaps in mathematics and smaller gaps in reading." (p. 105).

We have shown in Chapter 3 that level in Finland is very high, the highest in the PISA study, but also that the Finnish mean value for balance is around zero. There is, indeed, a very large gender gap, positive, i.e., reading dominated the balance values of girls, and negative, i.e., boys had math dominated values. Given the empirical results and Marks' attempt to generalise, the gender issue turns out to be as complex as was expected. However, the fact that Finnish boys are less proficient readers than Finnish girls has been considered a high-priority question of national concern (Chapter 7; Linnakylä, Malin & Taube, 2006).

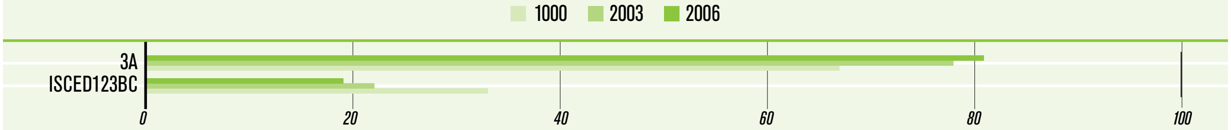
Possible explanations for the Finnish success in PISA

The relative homogeneity of the Finnish culture and Finnish population

Since the birth of schooling in Finland, during the last 150 years, the educational practices have been adapted to the needs of the Finnish and Swedish speaking population. Particularly in small village schools, in rural areas, parents have been educated by a teacher, who knew their parents, and the parents even went to a school where their grandparents were educated. The process of urbanisation took place later than in the other Nordic countries, or in countries in which the industrial revolution started. Finnish society has developed from a rural to a predominantly urban, knowledge-based society within the last half of the twentieth century. Finland differs from the other Western countries in the timing, speed and the intensity of this transition (Ingold, 1997). Finland, in the early days of the 1960s, when preparing for the implementation of comprehensive school education, was still a rural, agricultural country, characterised by a very homogenous culture. It has been proposed that the Finns still represent an industrious population with a homogenous culture which emphasises self-reliance, predictability and hard work more than fun or happiness (Crittenden & Claussen, 2000). As such, the homogeneity argument is not very easy to prove or even to interpret in educational terms and outcomes. The tricky issue is to show how the homogenous culture has influenced the consistently high level of performance in Finland?

The small differences in wealth and income between different social strata and the small size of the elite are one way to understand the present situation, where there are almost no private schools. The sizes of the elite and other leading groups have been so negligible that they simply could not support a large sector of selective private schools. Of course, private tutoring was often used to help educate upper-class children. But it was not so extensive that it would have been enough to support a whole net of private schools and lyceums. Also the role of the Lutheran church was to promote the education of all the people, including those living in sparsely populated areas, in villages and parishes. The aim of the Lutheran church was not to establish grammar schools with Latin and Greece as routes to a career in the priesthood. Also the establishment of Normal Schools for apprentice teachers and, later, Real Schools for educating other parts of the intelligentsia, created a system with state schools. These were, and still are, the top selective schools in Finland. However, they were, and still are, public and open to all, who could show their aptitudes in entrance examinations or on the basis of earlier school marks. Additionally, private organisations in villages and towns established their own local schools. However, these reflected the general goal of striving towards enlightenment and educational progress, and were not selective in the sense of social status. Of course, this is not the whole truth, as it was more difficult for the children of peasants and workers to go to school, as often they had to earn money for the household. In Finland a widely shared Lutheran work ethic and culture prevailed, and still prevails, in a secularised form. In an educational context this belief means that the success of an individual depends on his own work and persistence. By working hard a thrifty pupil could go to the local town, live in a boarding house and learn to survive in school, in an environment differing from that of his home. Thus, the homogenous culture in Finland implied that the formation of the Finnish speaking upper and middle class took place rather late. Education was the primary means of social mobility and advancement. The subsequent role of education as a vehicle of social mobility was established in the joint activities of villages and towns, using also public means. This prevented the formation of selective private schools. These are difficult to uproot, when new educational reforms are

F 9.1 | Changes in mothers' education from 2000 through 2006



pursued, as they provide surplus value for the upper social classes, which are over-represented in government and administration.

The four first years of schooling were, since the establishment of The School of People, common. After finishing The School of People, 15-25% continued on a track leading to a gymnasium and even to university. The rest started to work or chose other routes, not leading to a general education or to university. The need for a more educated workforce was evident after World War II. It took, however, decades before the new idea of the comprehensive school attained sufficient political support. Due to this need of more skilled workers, a considerable expansion of higher education in the 1960s and 1970s, in fact parents of the PISA-generation, also took place. Currently, we are experiencing the secondary effects of good schooling, and the children of the well educated parents of the 60s and 70s are, indeed, doing well.

The parents' educational level was low before the comprehensive school started, but has since risen. This increasing of the level of the education of parents can also be seen in PISA trends. The changes in percentage of mothers with 3A education (higher secondary education) is presented in Table x. The means for 3A level are higher in every assessment cycle.

A corollary to this movement to open the education system for all, is the teacher education (Westbury, Hansen, Kansanen, Björkvist, 2005). Earlier teacher seminars, as separate higher educational institutions, were abolished and a high quality university level teacher education was introduced in 1971. This has lead to a high proportion of teachers with adequate academic qualifications. In 1995, a few years before the present PISA 2006 students started their schooling, we had in Finland both seminar educated and university educated teachers. In 1995 seminar educated teachers made up 52% (7062) of all teachers in comprehensive school, in 2000 there was 43% (5900), and in 2005 there was only 30%. (4140). However, also the seminar teachers are and were experienced and effective teachers, respected by other teachers and by pupils. This movement towards an academic profession in teacher education has contributed to the continuous popularity of the teaching profession. In Finland around 10% of those wanting to study to become a teacher are accepted onto teacher training programmes. This means that we can select academically proficient students, by taking advantage of the selection process, which will result in finding those students with high motivation and good skills. The relative difficulty of the entrance examinations is a signal for future applicants that a career as a teacher is intellectually interesting and demanding.

One way to explain the Finnish results in PISA is via reading. The studies in reading difficulties have shown that the English results of dyslexia are not universal. English is a difficult language compared to almost any other language. The phonetic character of the Finnish language is often given as an explanation for the high standards achieved in PISA. Despite the apparent difficulty of the Finnish language for many foreigners, Finnish is easy to read as it is "read as it is written" with only a few exceptions. Also all foreign TV-programmes are subtitled without dubbing – an early incentive to start reading. Additionally, the role of libraries is important, as well as the general cultural habit of reading. Paralleling the dense network of libraries, there is a tradition of newspapers carried to one's home, and practically zero illiteracy among adults. Finland is a small bilingual country, in which two national languages, Finnish and Swedish are taught. Additionally, in Finland there is the need to learn a range of foreign languages (a minimum of two, but for many students aiming to be accepted into university even four languages besides mother tongue before grade 8).

But to use the Finnish language as an explanation is not totally convincing. The four most successful PISA countries use Chinese, Finnish, English/French and Korean (Canada, Finland, Hong Kong, Korea), which clearly disqualifies the explanation of Finnish being an easy language. From the Finnish perspective, it seems that the Chinese language is relatively difficult and so is Korean. Also the difficulty of English does not fit with the good results of Canada, New Zealand and Australia. To take as an example, scholars explain the good results of Hong Kong on the basis of the easiness of Chinese (source is somewhere!!). However, Chinese and perhaps also Korean may be a better explanation for the good results in mathematics in Chinese speaking countries (Aunio et al, 2004-5). The nature of the language system of the country is not a strong argument. To take it to an absurd extreme, it could be said that it would be sensible to make other countries change their language to Finnish or Chinese, in order to enhance their relative position in PISA rankings. In Chapter 7 on reading, a longer and more detailed account is given.

Chapters 5 and 6 are devoted to science and math. In this section, some of the arguments and explanations are summarised. The first point is the interconnectedness of the proficiency in reading and math / science due to the character of the assessment tasks, which rely on written instructions, to be read, and open answers to be written. There is a claim that PISA tasks are contextualised and refer to "real" problems, but this is, of course, not fully true. The tasks are paper-and-pencil tasks, conducted in the classrooms, and not in market squares, not in railway stations, not in demanding and potentially dangerous working places, i.e., the respondent's health, fame or money is not at stake. It is simply enough to read the instructions and follow them, but also using analytical reasoning is called for. In this kind of non-stressful situation, conducting the task demands the attention of the pupil.

A strong argument is presented in Chapter 5 in regard to the applied nature of the PISA tasks, with a good fit between the PISA tasks and the Finnish curriculum. There has been a trend towards increasing the emphasis on math and science instruction in the Finnish comprehensive school (LUMA-project, see Chapters 5 & 6). Evidence is lacking that the LUMA schools would do better than other schools in PISA or in national assessments, but the point is that LUMA and similar activities have stressed an approach, which suits well with the PISA 2006 framework.

In reading related PIRLS studies 15 years ago, Finland's position was very good. Already in earlier science related IEA studies, 1983, Finland was doing very well. In the case of PISA mathematical literacy, it really would have been interesting to see how well Finnish students would have performed in TIMSS 2003 or in the future TIMMS 2009. An international assessment like PISA seems to offer new and important insights into national educational systems as it allows for a point of reference and comparison otherwise missing. International comparisons might provide a vehicle for exploring country differences and similarities in terms of culture, curricula and school organisation. When new methodological innovations in scaling, sampling, multilevel and multidimensionality analysis are taken into account and aligned with (hoped for) future longitudinal designs, the educational studies and policy relevant recommendations can be achieved and backed with new models for educational innovations (see Goldstein, 2004).

In sum, we have presented a narrative which stresses that the PISA framework and National Finnish Core Curricula and the whole educational setting would show a goodness of fit. Due to a relative lack of common educational evaluations, Finnish students have not been tested to the point after which tests simply become boring, or might even be seen as being a burden, thus possibly lowering students' intellectual and moral commitment to perform well on them. The Finnish students have faced similar types of tasks, and they have fluent reading skills, whenever these might be called for. Also students with learning difficulties and slow acquisition rates have been a part of the normal education. They are also used to actively doing things and being persistent, and not giving up without first making a valid attempt to complete a task. In the final section of this chapter we follow this line of argument, in order to present a hypothesis of the possible mechanism which could be discerned as a reasonable explanation for the good results.

No Item Left, NIL – principle as a descriptive/an explanatory factor

No item left, NIL, refers to calculations, conducted on the basis of PISA file information regarding science, math and reading items. The data include values for missing or invalid responses which shows the percentage of pupils, who have received their respective booklet, opened it, tried to do something which resulted in no marking (all the markings can be classified as either right or wrong). The examiner knows that the item has been looked upon, something has been thought about and some marking has been done, but not enough for scoring. The missing or invalid responses-category refers to those pupils, who have taken the booklet, but left no mark on the item page, which could have been coded with the response codes. In general, this percentage gives an estimate of the habit of leaving items left or not responding to items. The lower the NIL score, the less often items have been left, i.e., not responded to. The reasons for not trying to respond to an item can be various: the pupil has mistaken a page, is afraid of making a mistake, driven by a fear of failure, or the pupil is just arrogant, and opposes the whole idea of being tested. The differences in NIL-

T 9.3 | No item left-, NIL-values for science, math and reading (country aggregates, N=56-57, USA has no value for reading, NIL%)

	N	Minimum	Maximum	Mean	Std. Deviation
NIL science	57	1,6	23,5	8,46	4,83
NIL reading	56	3,4	34,4	12,96	6,98
NIL mathematics	57	4,2	37,4	14,5	6,90

scores may be explained in terms of learning motivation. We believe these NIL scores may tell something relevant about the PISA framework. It can be assumed that persons with low NIL will express the same perseverance and dutifulness in real life, in working life, in which tasks are not always pleasing or negotiable, in the future knowledge society. This score has been used previously in Chapter 6 (Mathematical Literacy).

A new data file has been prepared to include the national PISA results in science, math and reading of various countries, and also the respective NILs. NIL science refers to science items, NIL math to math items and NIL read to reading items, and are based on the percentage of invalid responses or missing values as percentages. The data are country level aggregates, and, accordingly, there are 57 lines of data, one line for each country with values for national PISA science, PISA math and PISA reading, and for NIL science, NIL math and NIL reading. This arrangement means that we are not taking into account sample corrected standard errors, which should be kept in mind. However, the main idea is to show that this new source if information is at least interesting for interpreting the national results.

We present firstly some descriptives of NILs (Table 9.1), and then proceed to show the country level correlations between national PISA science, PISA math, PISA reading, NIL science, NIL math and NIL reading estimates.

The rank order correlations between science, math and reading are as high and positive as they are expected to be, all more than +0.90. The NIL-correlations to respective PISA scores are strong and negative, as they should be, if the NIL-principle is interesting and useful for explaining differences between different countries. The between-NIL correlations are all very high and positive, again, as one would expect given the model for a possible explanation. All together, this table of correlations is a strong argument for the validity of NIL-principle, and also a reason to continue the analysis. The aim is to understand Finnish national results better. At the same time, this table with its very high correlations provides a strong explanation for the PISA outcomes.

NIL and Finland among different countries

Using the data on national NIL and PISA literacy scores, the countries can be clustered, using K-means cluster analysis. Clustering with the three NILs and the three literacy scales (country level data aggregation) with 10 clusters shows types of countries with their NIL and literacy values (Table 9.b). If also the country level results of three PISA literacy scales are included, four (two + two) countries pop up as countries with a high level of performance and a high level of commitment for learning as reflected in low NIL percentages, namely Finland and Hong Kong, Canada and Korea.

Using the NIL approach, four countries with both a high PISA attainment and a very low NIL are identified: Canada, Finland, Hong Kong China and Korea.

We claim that Nil is a proxy for an estimate of achievement motivation and commitment to work which is particularly important, when the tasks –PISA or any other similar tasks requiring the mastery of thinking and the commitment to learning– are not highly appealing and instantly rewarding. Some tasks are of a kind that pupils may feel that they just have to be done. Pupils will not refuse the task, if they accept schooling as a context of learning and studying dutifully.

Finland is a country where the harsh conditions of nature have forced people to work, to accept, even stoically, the necessities governing life, but at the same time, to object to what is wrong, to change what can be changed, and to use arms, tools, spades, or pencils to do what is asked of them, to do what they are trained and able to do. The Finnish existential conditions of life are succinctly put by Finnish writer Väinö Linna (1959) in his novel. "Under the Polar Star":
"In the beginning, there were the swamp, the mattock - and Jussi."

And this Jussi-principle is the Finnish way of studying and learning: we accept the pencil, and with a prepared mind and with a stable hand we can open any booklet and get good scores. And this was what we did!

T 9.4 | Correlation of PISA scores and No Item Left. NILs for science. math and reading (country aggregates. N=56-57. USA has no value for reading/NILr)

	Science	*NILs*	*Read*	*NILr*	*Math*	*NILm*
Science	1	-.75	.97	-.81	.95	-.83
NIL science		1	-.80	.98	-.66	.88
Read			1	-.87	.93	-.85
NIL read				1	-.74	.89
Math					1	-.86
NIL math						

T 9.5 | PISA countries clustered using national PISA scores for science, math and reading, and NIL scores for science, math and reading (country levelaggregates, N=56, USA excluded, with values for variables in clustering, NILs in %, low value of NIL means that a very low number of items are leftuntouched)

Clusters	*Cluster1*	*Cluster2*	*Cluster3*	*Cluster4*	*Cluster5*	*Cluster6*	*Cluster7*	*Cluster8*	*Cluster9*	*Cluster10*
	Finland	Canada	Australia	Austria	Croatia	Chile	Bulgaria	Argentina	Kyrgyzstan	Azerbaijan
	HK-China	Korea	Belgium	Czech	Greece	Israel	Jordan	Brazil	Qatar	
			Taipei	Denmark	Italy	Turkey	Mexico	Colombia		
			Estonia	France	Latvia		Montenegro	Indonesia		
			Japan	Germany	Lithuania		Romania	Tunisia		
			Liechtenstein	Hungary	Luxembourg		Serbia			
			Macao-China	Iceland	Norway		Thailand			
			Netherlands	Ireland	Portugal		Uruguay			
			New Zealand	Poland	Russian					
			Switzerland	Slovenia	Slovak					
				Sweden	Spain					
				UK						
NILSci	3	4	5	7	8	11	12	11	20	23
NILMath	7	7	8	12	14	20	20	22	33	15
NILRead	5	6	8	10	12	17	18	18	31	34
Science	553	528	523	506	484	439	423	390	336	382
Math	548	537	526	502	478	426	412	375	314	476
Reading	541	542	504	495	469	443	404	385	298	353

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We can trust our children to do well also in the future, when they are applying their knowledge and skills to new and as yet unanticipated demands.

10
Conclusion

Jarkko Hautamäki, Sirkku Kupiainen and Airi Hautamäki

Toward and beyond PISA

The road leading to PISA has a history that starts with the studies conducted by the International Association for Evaluation of Educational Achievement, IEA. IEA was non-formally founded in 1958 by a group of social science scholars interested in education, Torsten Husén from Sweden and Martti Takala from Finland being among them. The aim was "to look at achievement against a wide background of school, home, student and societal factors in order to use the world as an educational laboratory so as to instruct policy makers at all levels about alternatives in educational organization and practice" (Gustafsson, 2007; which is the main source for this section).

This first phase of IEA lasted until 1990, and was led by university researchers. The goal was set high: to build a general model of education which would allow for causal inferences across the world. The methods used were the most sophisticated of the time, however, these were not enough for causal modelling due to cross-sectional design, too simple sampling procedures, and too demanding data collection. In 1990, a second phase started in the IEA studies with a stronger involvement of national educational policy institutions. Some of these were established while – and due to – the nations taking part in the first phase studies, such as Finland, where the Institute for Educational Research was established in 1968 in Jyväskylä. Gustafsson emphasises that there was a shift from the goal of explanation to that of description.

This shift was an important change. The new studies produced descriptions as their primary reports. The second phase was marked by new methods such as more careful random sampling of subjects, matrix-sampling for data collection (a large pool of items with individual students answering only a sub-sample of them in a manner allowing for the generalising of the results over the whole item set), and psychometric theory (item-response theory). Also, the participating countries' own research communities and/or administrations were expected – and given the opportunity – to produce their own extended interpretations and explanations of the data for local use.

Interpretations of such international research data are not easy to make in a comprehensive manner, due to the complexity of the data and a lack of good theoretical models for comparative education. However, the key national research institutes responsible for the interpretation of the data quickly began to build knowledge and expertise in educational research methods and statistical modelling. Still, there is the major issue of analysing and understanding the context of these studies and their intended goals. The question is: What is the role of the supranational institutions now responsible for such large scale international comparative educational studies as TIMMS, PIRLS and PISA?

What is their agenda – is it to promote output-driven modes of educational governance as Simola (2005) and Prais (2003) claim, or is it to replace national educational models with international models promoting market economy and globalisation? These are relevant questions, even if in most countries there might be more talk than radical new definitions of educational policy based on the results and ranking lists of PISA or TIMMS. However, there is one undeniable outcome of PISA – a new kind of interest in educational debates nationally and internationally. In this debate, also laymen are participating, even if the discussion is seldom based on first hand knowledge of the actual reports and manuals, leading to interpretations of diverse quality.

Gustafsson (2007) presents two major questions concerning these studies:

- Can we trust the descriptive results generated by PISA, TIMMS and PIRLS?
- What kind of conclusions do these studies support?

'Weather and climate' is one of the metaphors used by Gustafsson (2007) in this context. The weather affects our daily lives and we have to adapt to it. It may be an option for rich countries to manipulate the weather for specific events such as the opening ceremony of the Olympic Games, but generally we cannot do much about it. Gustafsson's point in his metaphor is that whereas in the short run we can predict the weather, it is unpredictable beyond a week ahead. Climate, on the other hand, is generalised weather, and can be described with indicators which are aggregated through weather measurements such as mean temperatures and rainfalls. While the weather is unpredictable and chaotic, climate is stable and predictable. Climate is a theoretical abstraction, providing for long-term predictions based on empirical models.

Large-scale educational surveys are concerned with climate, and they can be complemented with context-specific studies on the weather in classes, schools and individual countries. In the climate-level models we need data aggregation and indices. In them, it is necessary to control for or to get rid of specifics, in order to be able to see general patterns of educational systems. But this does not mean that primary level descriptions and local context-bound knowledge does not exist or is not relevant, valid or reliable. It all depends on the purpose of the study in question.

To conclude, we can trust PISA with regards general trends and cross-sectional descriptions of different educational systems. But, it has to be kept in mind that, firstly, this concerns only the kind of competences measured in PISA (OECD, 2007), and secondly, more detailed studies and analysis are needed for national reforms, based on national educational goals and the specific contextual features of the respective countries. No single supranational assessment can cover all relevant aspects of individual national education systems and aspirations. However, regularly repeated international assessments are useful and after the three cycles of PISA some trends can be seen and can be used for national discussions and planning.

The PISA Framework, tasks and data

In critical international discussion concerning education, three major lines of thought can be discerned. Firstly, concerns have been raised about the relevance of the successive OECD PISA frameworks (the latest in 2006) from the point of view of the national curricula of the participating countries (Prais, 2003). These concerns pertain, among other things, to the type of tasks and items used in the assessment, to how well they cover or coincide with nationally important topics in science education, mathematics education or mother tongue and literature education. Secondly, concerns have been raised pertaining to the definition of the target population, including the question of how representative or comparable samples can be sampled in practice in the different countries once the educational paths of their students have already taken such diverse directions. Prais (2003) is an early observer of this concern, and the comments made earlier in this book concerning the impact of the age children begin school on between-school variation at age 15 is related to this as well. Thirdly, doubts have been raised concerning the nature of OECD competence data from the point of view of measurement models (Goldstein, Bonnet & Rocher 2007).

Frameworks and tasks

Prais' first critical point can be summarised as pinpointing the fact that the explicit attempt of the OECD to define PISA in relation to the demands of the future knowledge society is a step away from local national educational goals, which makes national interpretations of the results difficult. Nationally sensitive interpretations have been performed earlier concerning TIMMS, using notions such as intended syllabus, implemented syllabus, and attained syllabus (Prais, 2003, 141), as well as with a direct matching of the diverse national math curricula and TIMMS. This is not so easily done with PISA, whose assessment model clearly has different goals. However, from the very beginning, the objective of PISA was explicitly not to replicate or extend TIMMS or other IEA studies, but instead was to complement these with a novel point of view on the assessment of educational outcomes

Prais' point is relevant even if it is difficult to see how any extensive comparative study could be done with tasks and items that were relevant from the point of view of the national curricula of all the countries participating in the studies, for all the three major domains, and allowing for trend data. Hence, as the goals of PISA do differ by design from the more curricular studies like TIMMS, the national education systems need new conceptual tools to profit from and to be able to use PISA – be it just as a mirror or for actual reforms in national educational planning. Accordingly, there is indeed a need and a reason to link the PISA framework to national curricula. This is what we have aimed at doing in this book for science, mathematics and mother tongue and literature education in the Finnish comprehensive school.

The general interpretation from the Finnish perspective is that the PISA 2006 Framework coincides well with the Finnish national core curriculum in all the three domains, even if with some reservations. The main reservations concern the coverage of the PISA tasks. It is no surprise that PISA does not cover all the targets and aims of the Finnish curriculum but, admittedly, the contents covered in PISA form a good part of Finnish curricular contents, especially in science and mathematics. The Finnish core curriculum and the PISA frameworks are aligned to a degree, which makes the results attained by the Finnish students in PISA useful for national discussions. However, especially with regards to mathematics, the items do not seem very demanding from the point of view of having a good mastery of a more advanced mathematical thinking. This is partly true also for the science and reading tasks. This suggests that there is still a need and a place for more thorough international curricular or academic comparisons, such as TIMMS and PIRLS, within specific subject areas. PISA clearly does not replace these studies. At the same time, there are clearly reasons to conduct systematic Finnish studies in the major subjects to complement international data with even more closely curriculum-bound national data.

Target population and sampling

The target group of PISA is 15-year-old students who are at school. This definition suits well the internal purposes of Finland, but poses practical difficulties for some other countries and complicates system-level comparisons. Critical problems follow from the choice of the target age group when comparing countries where students move through the education system in different ways (Goldstein, Bonnet, Rocher, 2007; Prais, 2003).

In Finland, the great majority of children start school in August of the year in which they reach the age of seven. A small number of children start school one year earlier or postpone their start by one year, both depending on a professional assessment of their cognitive and psycho-social development. There is almost no grade repetition (in PISA 2000, the share of Finnish students who had repeated a grade before age 15 was just 2 %), meaning that for almost the whole age cohort basic schooling takes 9 years. The dropout rate during comprehensive education is also very low. This means that in Finland, the PISA target population is easy to identify, to locate and to sample for assessment. Practically the whole age cohort born between 1 February and the 31 January of successive years are still in comprehensive school, either at grade 9 which is the last year of compulsory education or – those born in January – at grade 8.

But this is not the case with most of the countries participating in PISA, as Goldstein, Bonnet and Rocher show for England and France. In England, the demarcation used for school entrance is the beginning of the school-year, while in France it is the calendar-year as it is in Finland. However, as the French children begin school the year they turn six, not seven, the "norm student" has already advanced to upper secondary school by the age of 15. But, as grade repeating is a common practice in French schools, the French PISA sample covers four grade levels, with two different programmes at two of these levels (Monnier & al., 2007). There are also differences in the bases and in the beginning age of tracking among the countries where tracking is done before the age of 15 (also in Finland students are tracked to vocational and general education, but only after compulsory education). All in all, differences in the length of the educational experience of students in the different countries can be more than one year even if all of them are 15-year-olds. Goldstein, Bonnet and Rocher have developed methods which can take these differences in age and length of schooling into account, and they show that the differences are relevant. Prais concludes that sampling problems in England for the PISA 2000 data collection were such that the estimated means for England became too high. This – or the contrary – may be the case for other countries as well, also in PISA 2006. However, there is no reason to think that this would be the case in Finland.

In Finland, the definition for the PISA target population is, indeed, easy to implement and maximally suitable for studies concerning comprehensive education. This also means that it is easy to show and to assure that the Finnish students participating in PISA really are representative of the targeted age group in Finland and sampled strictly through agreed definitions. However, as indicated earlier, this target definition implies that we have to be careful when comparing between-school variation among the countries. The wish to compare education systems' efficiency and equity, and to model world education, using between-school and within-school variations is well grounded, but needs an in-depth understanding of the different national education systems.

Some concern regarding students with special needs has been raised in national and international discussions regarding PISA. There have been rumours that the Finnish sample differs from those of other countries, as a significant part of students have been left out of the final sample, and that this was done to raise the mean results. However, we can assure you that the Finnish sample contains all students attending schools, which follow the national curriculum, strictly according to the sampling principles of the OECD / ACER. This means that also special schools were included in the primary phase of sampling, as were most students with special needs in the final phase of student sampling, independent of whether they studied in special education classes or were integrated into the mainstream classrooms (see Appendix 3).

PISA scores and their secondary analyses

PISA results in the different literacies are presented in PISA scores, based on the standardised mean of the country-level results of the 30 OECD countries (500, SD 100). The major domain, which in PISA 2006 was Science, is further analysed and described using a variety of more detailed dimensions. The argument for one score for each domain is based on the use of item response theory, IRT. This family of theories has proven useful for large-scale studies where a theoretically grounded simplicity of presentation (and interpretation) of results is needed. At the same time, the use of IRT is based on certain assumptions which are under constant discussion in the international literature.

One of the basic assumptions of IRT is, in fact, not fully true or fulfilled in PISA. In IRT, it is assumed that responses are conditionally independent. In PISA, however, quite a few items involve responses to the same syllabus (text or figure), which may present a violation of the type where "the (conditional) probability of a correct response to one item may depend on the outcome with respect to an earlier item" (Goldstein & al., 2007, p. 255). The point which Goldstein, Bonnet and Rocher (2007) want to make is that one can get more information if the unidimensionality assumption is not (fully) followed. i.e., one could get a richer picture of the data with a less restricted assumption, accepting more than one latent factor. This might be useful in more detailed comparisons between countries, using the original PISA data, not the standardised scores. Goldstein & al. show in the article one way of performing this kind of an analysis, using the French and English data. There are indeed items which "behave" differently in these two countries. The open-ended items and multiple-choice items, for example, seem to be solved differently (the ratio of the percentages of correct answers in them are different) in England and France (Goldstein, 2004; see also Olson, 2005).

The Goldstein & al. argument seems valid. However, the validity of the argument does not implicate that results based on the standardised PISA scores or even on the condensed scores for level and balance presented in Chapter 3 are not valid. Both views of the data are useful and serve their purpose. But there is indeed a need for more detailed secondary analyses for both national and comparative studies. Data are available in abundance; only time and money are needed.

The bottom line

It seems evident that with PISA, the OECD has succeeded in making its permanent footprint in the educational research and policy of the 21st century. PISA can be seen to have gained – at least for the first decade of this century – the status of a general climate station whose reports are read all over the world, in three-year cycles. Put together, the reports with their concomitant data constitute a rich source for ever more detailed educational research. The data are partially open and ready for secondary analyses, and already this allows for an almost endless flow of new comparative studies to enrich and support the earlier IEA studies.

Comparative studies are critical for national self-understanding. It has been somewhat of a surprise to find that the prevailing national understanding of one's own education system in fact has not been comprehensive enough for in-depth comparative purposes. Reflecting this, may be the most important outcome of the PISA studies, has been the aroused interest and possibility to better know the education systems of other countries, and to better see and understand our own education system and the societal reasons and peculiarities behind the Finnish educational reforms of the past fifty years.

Firstly, the general level of the outcome of the Finnish comprehensive education has been found to be very high three times in a row, in 2000, in 2003 and in 2006. Taking all the three literacy domains together, in 2006, Finland is without any reservations in first place. This is a great achievement, even if PISA does not cover some of the subject domains of Finnish comprehensive education. For any national purposes, science, mathematics, and mother language and literature are the core subjects. Finnish students have again been shown to do very well in all these key domains. Besides this, the trend is stable, if not increasing. Furthermore, in 2006, Finnish students were not only the very best in the lowest 5-percentile subgroup in all domains but also the best in the 95-percentile group in PISA science, and the third best in PISA mathematics (after Korea and Switzerland) and PISA reading (after Korea and New Zealand). However, with the high professional standards and dedication of Finnish teachers, together with carefully planned interventions to foster thinking skills, the attainment of Finnish students could be even better.

Secondly, the equity of the Finnish attainment is exceptional. The between-school variation is the smallest among the participating countries, with also the total student variation being low. Also other factors contributing to general equity are mostly very well balanced. The differences between the various parts of the country are small, and the same goes for rural-urban differences. Public schooling is at least as good as the tiny sector of private schooling, with all the best schools in the Finnish PISA sample being public. All this is important from the societal and moral points of view, given the heated debates of the 1960s in Finland. There seem to be only two major concerns in the field of equity. The first is gender difference. There are no inherent reasons why boys should or could not be interested in reading and literature, or girls to like mathematical thinking more than they do today. The second is related to the impact of the social and economic status of home on learning and studying. Even if differences in student attainment related to family background are smaller in Finland than in many other countries, the results indicate there is reason to follow the situation more closely even here. Some positive effects from parents having attained education themselves are to be expected and can hardly be prevented, but narrowing the educational gap related to students' home background to a minimum should be a key target in the future. Failing this might lead to increased differences in social and academic capital, and to aggravated social inequality. So far, Finland seems to have fared this fairly well.

In Finland, families can safely choose any local school for their children. They are welcomed there by well-educated teachers, who have at their disposal locally adapted curricula based on the national core curriculum, and high quality textbooks and other teaching materials. The buildings are in good repair, warm in winter and a free healthy meal is served to all during the school day. Students go to school where they meet their friends, and learn to pursue at least some study in the major school subjects with or without deep interest, still doing their best when the task and situation call for intellectual mental work, perseverance and commitment to learning. This is the third facet of PISA for Finland. We can trust our children to do well also in the future, when they are applying their knowledge and skills to new and yet unanticipated demands.

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OSCAR WILDE

Appendices

Basic education curriculum system in Finland

Irmeli Halinen

The ethos of the system

The educational administration in Finland is flexible and supportive. The ethos of it is based on clearly defined, common national goals and objectives. These are given in the educational legislation and in the national core curriculum. In place of control, the focus is on supporting and developing the work of municipal education authorities, schools and teachers. During basic education, there are neither school inspections nor national tests of learning outcomes on the basis of which schools could be placed in an order of superiority. There are no ranking lists of comprehensive (basic education) schools. Instead of comparison and competition between schools, the role of self-evaluation and cooperation is emphasised. This self-evaluation of municipalities and schools is supported by national, sample-based evaluations of student achievement and of students' health and welfare, and by thematic evaluations.

At the national and municipal level, the information gathered from these evaluations is used for the development of education and in the training of teachers. Mutual trust, cooperation and interaction are the important prerequisites for the development of Finnish education.

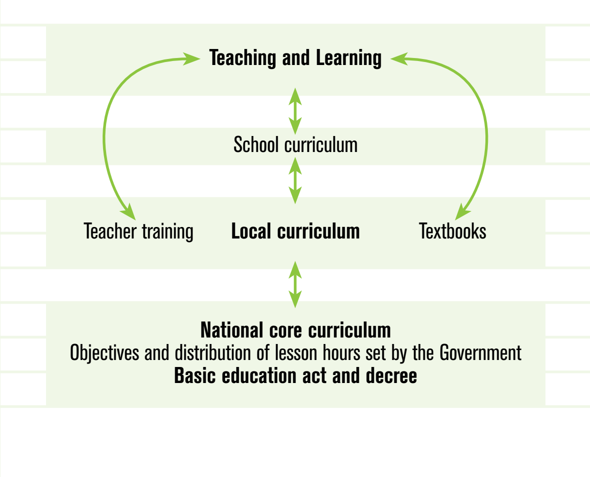
The elements of the steering system

The Finnish Parliament renders decisions on educational legislation and the general principles of education policy. The Government, the Ministry of Education, and the Finnish National Board of Education are in charge of the implementation of this policy at the central administration level. The municipalities are responsible for providing education. Municipalities and schools are granted a great deal of autonomy in matters of how to organise education and how to implement the core curriculum. The Government participates in school expenditures by discharging the so-called statutory government transfer to the education provider.

Preschool and basic education are governed by the Basic Education Act (628/1998) and Basic Education Decree (852/1998) and the Government Decree on the General National Objectives and Distribution of Lesson Hours in Basic Education (1435/2001). These regulations stipulate the common educational goals, the principles according to which education must be provided, and matters such as the subjects taught to all students, and the distribution of teaching hours between these subjects.

The National Core Curriculum is the pedagogical basis for the work of the education providers. They are responsible for designing the local curriculum, which can be tailored either to involve the entire municipality or each school, or a combination of the two.

F 1 | Overview of the education system in Finland



Basic education act and decree (by the parliament)

- general goals and objectives for education, core subjects, general principles for providing education

Government's Decree

- more detailed general objectives of education, allocation of teaching hours between the core subjects i.e. the minimum number of weekly lessons in each subject.

National Core Curriculum (by the National Board of Education)

- basic principles in organizing teaching and learning and other activities of schools, central goals and contents in the core subjects, obligatory cross-curricular themes, principles of student assessment, description of good performance and final-assessment criteria

Municipal/school curriculum

- implementation of the national guidelines, allocation of hours, goals and contents of subjects in different grades, organising instruction and other activities of the school

The national norms directing municipal educational arrangements and instruction create common lines, and build a solid foundation upon which municipalities and schools can plan their work. The most important element of the system in meeting the goals set for education, and in meeting the various needs of students, is the every-day teaching and learning process, the interaction between the learners and the teachers. The central goal of the entire steering system is to support this process in order to promote successful learning and the healthy growth and development of all students.

Teachers' initial (pre-service) and in-service education offered mainly by universities, as well as textbooks and other study materials produced mainly by private publishers, support the implementation of the core curriculum guidelines. Together these three elements, curriculum, teacher education and study materials, form a strong and coherent basis for teachers' work.

The history of the core curriculum in short

During the 1970s Finland moved from a parallel education system based on student selection to a comprehensive system where basic education is the same for all. In 1970 the first national curriculum for basic education was created. This curriculum was detailed and the steering system centralised. The national curriculum has been reformed three times since 1970. In 1985 Finland implemented its first national core curriculum, and the responsibilities of the municipalities and the role of the municipal curriculum were emphasised. In 1994 even more power was delegated to the municipalities and schools. School-based curriculum became important, and teachers participated actively in the development of both the school and municipal curriculum.

Teachers were also used as experts when the national core curriculum was drawn up in 1994. In 2004 the cooperation between national authorities, municipalities and schools was extensive. The core curriculum was outlined, with the Finnish National Board of Education in charge, in an intensive interaction process involving more than 200 municipalities and 500 schools, with teacher training personnel, publishers of learning materials and different representatives of society. The interactive nature of the steering mechanism was strengthened, and the role of the curriculum became central in the development of the whole education system.

The national core curriculum and the local curricula are considered as constantly developing, living documents. They are regarded more as a process rather than a completed product. The implementation of the objectives defined in the current national core curriculum is supported by several national and local development projects. Participating in the national projects is optional for municipalities and schools. The projects are based on networking that offers the opportunity to receive guidance from national experts and, above all, to share experiences and learn from the practises of other teachers and schools.

The National Core Curriculum

The National Core Curriculum for Basic Education 2004 defines the common guidelines along which all municipalities and schools arrange their work. It deals extensively with the whole area of school's operations. It is inclusive in the sense that it covers education for all students, even for the most severely impaired children. The main goals and working guidelines are the same for all students, and municipal authorities, school principals and teachers are responsible for implementing them so as to support the learning and well-being of every student. The core curriculum also obliges municipalities and schools to cooperate with parents and with municipal social and health authorities, especially in matters of student development and welfare. It obliges municipalities and schools to evaluate and continuously develop their own work.

The core curriculum defines the value basis for education, the learning conception and criteria for choosing teaching methods, and the guidelines for developing the learning environment and schools' working culture. It defines the central contents of instruction and the policies of organising instruction, the counselling of pupils, student welfare and other forms of support. It gives also the main principles for student assessment and defines the level of what good performance is. The description of good performance includes the definition of how pupils should master the knowledge and skills set for objectives in each subject and the skills of working and learning in order for them to achieve the verbal assessment "good" or the corresponding grade of 8 (on the scale of 4–10). These descriptions work as a tool for teachers with the help of which they can compare their own assessment to the national standard and, therefore, enhance equal treatment of students in the assessment process.

The premise for providing education is the conception of the student as an active learner. Supporting the individual learning process is important and essential as is the importance of the communal learning process and interaction. The aims of learning are values, knowledge and skills and the ability to use the knowledge and skills and to reflect on one's actions in relation to values. Learning to learn and learning good working habits are considered more and more important. The core curriculum also emphasises the importance of a friendly and supportive atmosphere, and the development of an open, encouraging operational culture that is based on interaction and participation.

The core curricula for preschool, basic education, upper secondary education and for adult education are to have a common policy and pedagogical base. Together they create the foundations for the path of lifelong learning.

Municipal and school curriculum

The municipalities are obligated to draw up a municipal curriculum which is based on the National Core Curriculum and at the same time takes into consideration local distinctions, requirements and opportunities, and especially the needs of children and families of that area. In most cases, the municipal authorities delegate much power to schools and every school has a school-specific curriculum. The school curriculum is a central pedagogical document on the basis of which schools also draw up their yearly working plan, every teachers' working plan, and also individual study plans for students when needed.

Teachers and other school staff are deeply involved in the process of planning the school curriculum. When teachers discuss together issues relating to the curriculum, they have to think about all the basic things influencing their teaching and students' learning. Teachers decide on how to organise support for those with learning difficulties, how to organise multicultural education and special needs education, and student guidance and counselling, and how to take care of students' well-being. They plan cooperation between home and school, and draw up the knowledge strategy for their school, which defines how information and communications technology and virtual teaching are utilised in instruction, what kind of equipment is needed and how the ICT know-how of teachers is developed. They also draw up a plan regarding how they attend to the safety of the learning environment, how they follow pupils' absences and how they protect pupils from bullying, violence and harassment.

In the curriculum planning process teachers learn how to view the operations of their school as a whole and also how to commit to taking responsibility for the whole and not just for their own class or subject. Thus their expertise is developed. In addition to the teaching personnel, pupils and their parents and the rest of the school personnel are becoming increasingly involved in the process. Hence, also their needs and opinions influence the practices of the school.

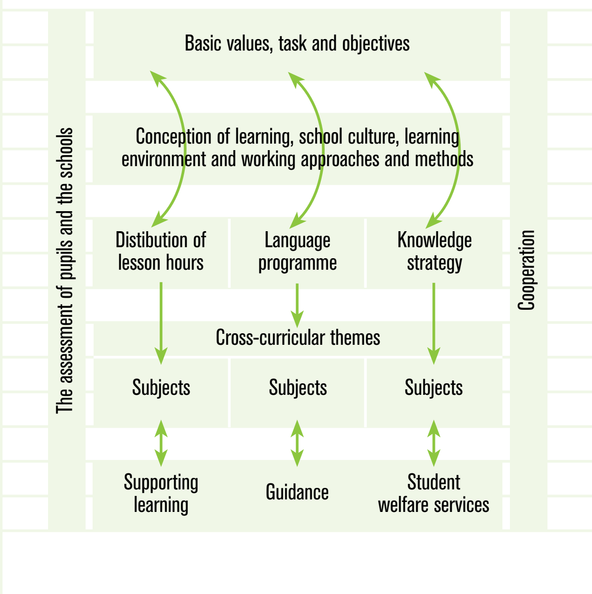
Moreover, operators outside the school are involved in the outlining work of education, especially social and health care authorities and other operators working for the benefit of children and young people. It is important that schools are not left alone, as the challenges to securing the learning and well-being of pupils are continuously growing.

Subjects and cross-curricular themes

The national core curriculum defines the role and the task, and the objectives and contents for all subjects and for the seven cross-curricular themes. The subjects in basic education are mother tongue and literature, the second national language (Finnish or Swedish), foreign languages, mathematics, environmental and natural studies, biology and geography, physics and chemistry, health education, religion or ethics, history, social studies, music, visual arts, crafts, physical education, home economics and educational and vocational guidance. In addition, pupils are offered school-specific optional subjects from which pupils may choose. The total amount of lesson hours is defined in the national decree, but how the lesson hours are divided between different grades is decided locally. In addition, it is a municipality- or school-specific decision as to what foreign languages are taught in each school. The national core curriculum makes it possible for pupils to study three foreign languages during basic education if the education provider offers them.

The cross-curricular themes reflect the central phenomena of society. They are 1) growth as a person, 2) cultural identity and internationalism, 3) media skills and communication, 4) participatory citizenship and entrepreneurship, 5) responsibility for the environment, well-being and a sustainable future, 6) safety and traffic and 7) technology and the individual. These themes are implemented in the subjects and in the different activities of the school like festivities, excursions and camp schools, school meals, club activities etc. and thus connected with the working culture of schools. The aim is to strengthen the extensive abilities of pupils and their ability to function in society. The implementation of the cross-curricular themes requires good cooperation between all the teachers and the school's other personnel as well, and also cooperation with partners outside of school.

F 2 | The structure of a school curriculum



F 3 | Distribution of lesson hours in basic education

Subject	1	2	3	4	5	6	7	8	9	Total
Mother tongue and literature	14			14			14			42
A-language				8				8		16
B-language								6		6
Mathematics	6			12			14			32
Environment studies	Environment and nature									
Biology anf geography		9			3			7		
Physics and chemistry		2	7							31
Health education								3		
Religion/ethics			6				5			11
History and social studies					3			7		10
Music	Arts and practical subjects			4-				3-		
Art		20		4-		30	4-			56
Craft, technical work, textile work				4-			7-			
Physical education				8-			10-			
Home education							3			3
Student counseling								2		2
Elective subjects								(13)		13
Minimum number of hours	19	19	23	23	24	24	30	30	30	222
Optional A-language					(6)			(6)		(12)

1 Lesson hour = 37 hours

Teacher education in Finland

Ritva Jakku-Sihvonen

Introduction

In Finland, teacher education for future teachers in kindergarten, comprehensive and upper-secondary schools is carried out in 12 departments, at 8 universities. The main principles for teacher education were implemented in the 1970s, when the Teacher Education Committee (Committee report 1975) defined the main aims for research-based teacher education as follows:

1. Initial education of teachers must give a common and broad qualification to all teachers and this common background can then be flexibly complemented by in in-service education.
2. Pedagogical studies should be developed in such a way that teachers are prepared to be educators in the broad sense of this concept and can attend to their pupils' socio-emotional growth. Teachers should have a pedagogical, optimistic attitude to their work that is grounded in the latest research. Theoretical and practical studies as well as subject academic matter and pedagogical studies should be integrated.
3. Teacher education should consist of societal and educational policy studies.

During the last 30 years Finnish teacher education has been developed in many ways. Developing it has been based on evaluations, scientific findings and the new demands of social, cultural and technological development. There have been both national and international evaluation projects to find weaknesses, strengths and innovations for research-based teacher education.

As a member of the European Union Finnish teacher educators must also take into account the common European principles for teacher competences and qualifications launched by the European Council and the European Commission. According to the European teacher education report, teachers should be able to work with a variety of types of knowledge, technology and information. Teachers should also be able to access, analyse, validate, reflect on and transmit knowledge. Furthermore, teachers' pedagogic skills should allow them to build and manage learning environments and retain the intellectual freedom to make choices over the delivery of education, and to match a wide range of teaching and learning strategies to the needs of learners (The Joint Report by the European Council and the European Commission on progress towards Education and Training 2010).

The teacher education programmes are designed and implemented by educational departments in the autonomous universities. Although the programmes vary by universities, they are based on a common structure developed as a part of voluntary cooperation between universities in 2003-2006. This structural updating of the teacher education programmes was motivated by the European degree reform known as the Bologna process. A project "National-Level Coordination of Degree Programme Development in Teacher Education and in Sciences of Education" (http://www.helsinki.fi/vokke/english/index.htm) was established by the Finnish Ministry of Education. The coordination project produced publications; and in one of them the demands for the teacher profession were described:

"One of the most important roles of teachers is to open pathways to cultural richness and understanding. Teachers have to be familiar with the most recent knowledge and research about their subject matters. They also have to know how subject matters can be transformed in relevant ways to benefit different learners and how it can help learners create foundations on which they can build their lifelong learning. This means that teachers need the latest research results and knowledge in pedagogy. They should have a thorough understanding of human growth and development and they need knowledge of the methods and strategies that can be used to teach different learners. In addition, teachers have to be familiar with the curricula and learning environments of educational institutions. They also have to know about learning in non-formal educational settings, such as in open learning and labour market contexts. Teachers should have the latest knowledge of educational technology and they need to be able to apply ICT in their work." (Niemi & Jakku-Sihvonen 2006, p. 41).

Class teacher education is one of the most popular study options available to students at Finnish universities. Subject teacher training has not been as attractive, and more than likely there the will be a lack of teachers in many subjects in the near future.

Research-based teacher education

Research-based teacher education means education that is based on academic research and which qualifies teachers to use scientific findings in their work and to work as a partner in a research group. Niemi (2008, p. 67) has described the aims of the high-level teacher education:

1. Teachers need a profound knowledge of the most recent advances in research in the subjects they teach. In addition, they need to be familiar with the latest research on how something can be taught and learnt.
2. Teacher education in itself should also be an object of study and research.
3. The aim is that teachers internalise a research oriented attitude towards their work.

In Finland teachers have to complete a master's degree (300ECTS; one ECTS equals 27 hours work). In terms of the new Bologna process, this degree is equivalent to the second cycle degree in the European higher education area. As a part of the master's degree the production of a master's thesis is obligatory. The degree for kindergarten teachers is a Bachelor of Education (180 ECTS).

Evaluations have assured Finnish teacher educators and administrators that research methods and the completion of a master's thesis play an essential role in teacher education. The evaluation of the quality of all educational programmes carried out at Helsinki University 2001–2002 was very positive for class teacher education. The international evaluation panel was convinced that efforts to integrate theory and practice were on a sound basis. A positive indication was good working relationships with training and field schools, where students perform their supervised practise. These relationships were seen as crucial to the high quality of practice training (Lahtinen 2003, p. 53).

Both class teachers and subject teachers have to perform pedagogical studies for teachers (60 ECTS). For subject teachers this 60 ECTS component is a minor, and for class teachers it is included as a part of their major, which consists of a minimum of 140 ECTS studies in education. Pedagogical studies for teachers includes the basics of teaching methods and evaluation, support of different kinds of learners, latest research results and research methods of teaching and learning, co-operation with different partners and supervised teaching practise (minimum 20 ECTS).

Class teacher education

Class teachers, have education (meaning the Science of Education or Education as a discipline) as their major, and this degree requires completion of a master's thesis.

As a whole, the class teachers degree (300 ECTS) consists of:
1. At least 25 ECTS common academic studies (e.g., languages, communication studies, ICT, generic skills),
2. 60 ECTS subject matter studies for comprehensive school teachers,
3. about 75 ECTS optional academic studies in different disciplines
4. about 140 ECTS studies in education including 60 ECTS in pedagogical studies for teachers.

Studies in education for class teachers (140 ECTS) consists of pedagogical studies for teachers, theoretical studies in education, optional studies in education and research methods of teaching and learning, including a master's thesis. The topics of the master's thesis are usually school-related. (Jakku-Sihvonen 2007a, pp. 218-221 and Niemi and Jakku-Sihvonen 2006, p.38-39) As education is the major for class teachers, the studies of the different sub-disciplines in education mean there is some variation between the curricula in education at different departments. Traditionally the sub-disciplines of education are didactics, history of education, philosophy of education, educational psychology, sociology of education and comparative education. In the curricula for class teacher education, the number of obligatory studies in didactics varies from 4 to 25 ECTS and in educational psychology from 5 to 21 ECTS. This reflects the way departments of teacher education are oriented in research and teaching: There are 10 departments oriented more toward didactics and two departments oriented more toward educational psychology. There is also some variation concerning the optional studies and studies focused on research readiness in education. Still, all departments have followed well the national recommendations of the main components of the educational studies accepted by the national coordination project (Jakku-Sihvonen 2007a, pp. 220, 225).

At the focus of the reform motivated by the Bologna process were opportunities for personal study plans, meaning in practice opportunities for optional studies, and such academic studies which prepare students for working life. In teacher education, the supervised teaching practice has a very important function. For instance at the University of Helsinki, the class teacher education includes 20 ECTS supervised practical studies and even during this practice period students may choose optional studies. In the major subject practicum, during the 4th and 5th study year, a student teacher can choose one of the following orientations: 1) Classroom teaching practicum in classes 1-6 of comprehensive school, 2) basic teaching practicum with classroom teaching and subject-teaching in classes 1-9, 3) wide-ranging practicum with classroom teaching and, for example, special education, immigrant education, practice abroad or high-school or adult education, and 4) research practicum which combines thesis preparation and teaching practice by, for example, enabling a student teacher to collect the material for his/her thesis during teaching practice (Conzalez &Wagenaar 2003, p. 24, The Finnish Bill on Degrees 2004, Section 7, Jyrhämä 2006, pp. 59-60).

Class teachers work at comprehensive schools with pupils from grades 1- 6. If a teacher's master's degree includes 60 ECTS in a discipline taught at Finnish schools, s/he is qualified to work also as a subject teacher.

Subject teacher education

Subject teachers complete a major and 1-2 minors in their academic teaching subjects. For instance, a teacher in history may have history as a major, and social sciences as one minor and teachers' pedagogical studies as another minor.

As a whole, a subject teacher's master's degree (300 ECTS) consists of:

1. At least 25 ECTS common academic studies (e.g., languages, communication studies, ICT, generic studies),
2. about 140 ECTS subject matter studies in the major subject, including the master's thesis,
3. about 75 ECTS optional academic studies in some other discipline and
4. about 60 ECTS in pedagogical studies for teachers.

For subject teachers, pedagogical studies for teachers may be completed either concurrently with their academic studies as part of their major or as a one-year block at the end of their studies. If someone has a master's degree with two minors but without pedagogical studies for teachers, it is possible to perform the 60 ECTS pedagogical studies for teachers afterwards. The master's thesis is usually completed in the academic major teaching subject, or in some cases in subject didactics.

To conclude

Teachers are key actors in advancing the knowledge-based society and promoting competences needed in preparing new generations for future challenges. Jokinen and Välijärvi (2006, p. 99) have argued that the induction phase of new teachers moving to working life must be made in cooperation between teachers, schools, education providers, trade unions and teacher education departments. The initial professional stage is a well defined stage of a continuum of professional development which starts with teacher education and continues throughout the teaching career.

The rapid growth of new information, the local and global changes in living and learning environments as well as our multicultural and complex society, place demands on teacher competencies. After initial teacher education, continuing education centers at universities have an important task in supporting teachers to develop themselves as professionals. Courses and programmes are organised to offer new knowledge and skills in the spirit of lifelong learning. The Finnish Ministry of Education supports teachers' in-service training although a municipality as an employer of the teacher is generally responsible for in-service training of the school staff.

As the master's degree qualifies class teachers and subject teachers to continue their academic studies to the doctorate level, some Finnish teachers take advantage of this opportunity. Some of them may also turn out to be potential teacher educators and researchers.

In April 2008 a European meeting for developing teacher education made the following conclusions, which are in line with the Finnish idea of developing knowledge-based teacher education policy:

"There needs to be a 'common language' so that researchers, politicians, policy makers and school staff understand the need for a change, agree on the direction to go, and use common concepts to communicate about the change… Knowledge, experience and research need to be better networked." (http://ec.europa.eu/education/policies/2010/doc/teacherreport_en.pdf).

To implement and develop research-based and society-relevant teacher education, a close co-operation between policymakers, evaluators, researchers and school staff is needed. To achieve successful cooperation in education, there is a need for researchers, evaluators and teacher educators who are not only critical, creative and analytical but also willing to help make education more human and supportive. Finally, there is also the need for policymakers, administrators, head-masters, teacher educators and teachers who are willing and able to listen to researchers and understand the value of new scientific findings (Jakku-Sihvonen 2007b, p.75).

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PISA 2006 sampling and estimation

Tommi Karjalainen and Seppo Laaksonen

General

The PISA survey focuses on cross-country comparisons although it is also useful for national purposes. Comparisons require high standards for sampling and statistical analysis. Hence, the whole survey process has been strictly coodinated and controlled. In sampling, this means first determining the same target population for each country, and consequently for the study population. The target population is based on the age of students in schools, that is, it excludes 15 year-old persons not attending school. In addition to this, there are also some other exclusions, too. In order to attain good estimates the following principles have been used (see OECD, 2007):

(i) The sampling design is equal in each country, and follows stratified two-stage cluster sampling. Stratification varies to some extent between countries, but usually strata are regions or school types. This choice has no influence on estimates. In Finland, 12 strata are applied, constructed from 6 regions and the rural vs urban nature of the municipalities in these regions. Three strata are rather small, that is, both rural and urban strata of Ahvenanmaa and the rural stratum of Southern Finland. These should consequently be used carefully.

The first stage of sampling is a school cluster that is selected by probability proportional to size sampling, PPS where the size is the PISA eligible population of each school. The second stage consists of selecting students of selected schools. These are chosen at random if there are more than 35 PISA eligible students in the sampled school. All sampling procedures were strictly controlled by the PISA central team in Australia.

(ii) The minimum requirements for sample size are given for school samples and for student samples. In Finland, these were fulfilled (see below). Some countries exceeded the minimum limit, mainly due to national intentions to obtain more accurate regional estimates. The Finnish sample sizes for schools and students are slightly above the minimum. It should be noted that the 2003 sample size was larger than the 2006 sample (5796 vs 4714 students) due to oversampling Swedish speaking schools. Hence, the 2003 estimates are more accurate than those in 2006.

(iii) There were minimum requirements for school nonresponse and student nonresponse. These are explained in Section 2 in detail.

(iv) The whole data collection procedure was complex. There was even sampling used for selecting task items for each sampled student. This reduced the test burden of students, but consequently, a certain number (usually two-thirds) of the item level variables were missing. This was compensated by like imputation, made by the PISA central team. This kind of imputation of missing values is naturally uncertain to some extent. In order to show this uncertainty, the PISA team have produced five different plausible values for each student in all tested literacies. Hence, no missing values are left in the combined literacy scores, but missing values are present in individual item level data files. Moreover, when there are missing values in survey questions, these categories are coded accordingly.

The estimates from the public PISA micro files can be produced correctly, if a user includes in the statistical procedure the sampling weights (student sampling weights in student analysis, and school weights in school analysis, respectively), stratification and clustering due to sampling by schools. In addition, it is necessary to include the same sampling design elements for estimating variances and confidence intervals. Since there are five plausible imputed values for literacy variables, the final point estimate is obtained as the average of these five estimates. The corresponding variance estimate consists of the two components, (a) the average of five single sampling estimates and (b) the uncertainty due to the variation in five plausible estimates. The central PISA team has calculated the correct estimates for basic results and hence there are no estimation problems at these levels of results. We have in this report performed several other estimations ourselves. These are based on valid methods as well.

Details

In order to ensure the comparability of the results across countries, PISA has devoted great attention to assessing comparable target populations. Because of the differences between countries' education systems, the school grades are not directly internationally comparable. This is why the PISA sample is based on the age of the students. PISA covers students who are aged between 15 years 3 months and 16 years 2 months at the time of the assessment and who have completed at least 6 years of formal schooling. The sampled students are valid students regardless of the type of institution in which they are enrolled, whether they are in full-time or part-time education, whether they attend academic or vocational programmes, and whether they attend public or private schools or foreign schools within the country. Accordingly, PISA's target populations are divided between different education systems, tracks or streams, differently in different countries. However, in Finland, and also in the other Nordic countries, all the students in the target population go to comprehensive school. (OECD 2007a, 22-23)

Most PISA samples were designed as two-stage stratified cluster samples (countries which applied different sampling designs are documented in the PISA 2006 Technical Report, OECD, 2007). The first stage was managed by the PISA central team at the Australian Council for Educational Research, ACER, and it consisted of sampling individual schools, in which 15-year-old students could be enrolled. Schools were sampled systematically with probabilities proportional to size, the measure of size being a function of the estimated number of eligible (15-year-old) students enrolled. For all sampled schools, replacement schools were simultaneously identified, to be enrolled in case a sampled school chose not to participate in PISA 2006.

A minimum response rate of 85 % was required for the schools initially selected. Where the initial response rate of schools was between 65 % and 85 %, however, an acceptable response rate could still be achieved through the replacement schools. This procedure brought with it a risk of increased response bias. Participating countries were, therefore, encouraged to persuade as many of the schools in the original sample as possible to participate. (OECD 2007a, 354)

Sampling schools

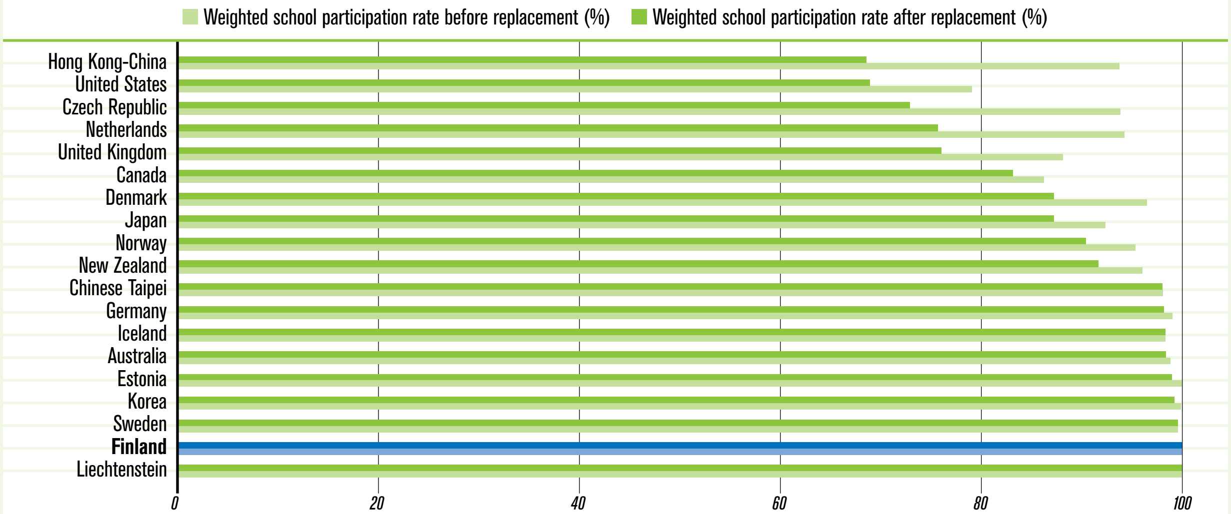
In Finland there were 155 sampled schools (the minimum for Finland was 150 schools) and all 155 schools from the initial sample participated in the study, with no replacements being needed. Among the top performing countries Finland, Estonia and Liechtenstein achieved the weighted school participation rate of 100 % in the initial sample (OECD average 92 %), while in Hong Kong-China (68.6 %) and in The Netherlands (75.7 %) the rate in the initial sample was much lower. Most of the countries were able to raise the participation rate with the replacement schools. Only in the United States was the rate below 80 % even after the replacement (OECD 2007a, 355 and Figure 1).

Sampling students

The second stage of the selection process sampled students within sampled schools. Once schools were selected, a list of each sampled school's 15-year-old students was prepared. From this list, 35 students were then selected with equal probability (all 15-year-old students were selected if fewer than 35 were enrolled). The sampling of students was made in National Centres by using KeyQuest software, which was designed to manage PISA data. Data quality standards in PISA required minimum participation rates also for students. These standards were established to minimise the potential for response biases. In the case of countries meeting these standards, it was likely that any bias resulting from non-response would be negligible, i.e. typically smaller than the sampling error (OECD 2007a, 354).

PISA 2006 required a minimum participation rate of 80 % of students within participating schools. This minimum participation rate had to be met

F 1 | School participation rates before and after replacements in top fifteen countries in science performance, the Nordic countries and in the U.S. (OECD 2007a, 355)



at the national level, not necessarily by each participating school. Although, schools with a student participation rate between 25 % and 50 % were not regarded as participating schools, but data from these schools were included in the database and contributed to the various estimations. Data from schools with a student participation rate of less than 25 % were excluded from the database. Follow-up sessions were required in those schools in which too few students had participated in the original assessment sessions. Student participation rates were calculated over all original schools, and also over all schools whether these were in the original sample or replacement schools, and from the participation of students in both the original assessment and any follow-up sessions (OECD 2007a, 354).

The sampling design and size for each country was designed to maximise sampling efficiency for student-level estimates. In OECD countries, sample sizes ranged from 3789 students in Iceland to over 30000 students in Mexico. The sample size in Finland was 4714 students, which covered 93 % of the national desired population (OECD average 89 %). The coverage was also high in Sweden (97 %), Norway (97 %) and Iceland (96 %). In Denmark the coverage was 85 %. The coverage of the 15-year-old population in top performing countries was highest in Hong Kong-China (97 %) and lowest in Liechtenstein and New Zealand (84 %). The coverage in Finland was 93 %, which is above the average in the top performing countries.

Exclusions at various levels

Stringent technical standards were established for the definition of national target populations and for permissible exclusions from this definition (www.pisa.oecd.org). It was also required that the overall exclusion rate within a country should be below 5 %, to ensure that under reasonable assumptions any distortions in national mean scores would remain within plus or minus 5 score points, i.e. typically within the order of magnitude of two standard errors of sampling. Exclusion could take place at the school level or within schools. In PISA, there are several reasons why a school or a student could be excluded. Exclusions at school level might result from removing a small, remote geographical region due to inaccessibility or size, or because of organisational or operational factors (OECD 2007a, 23).

The OECD has set clear restrictions on the level of exclusions of various types.

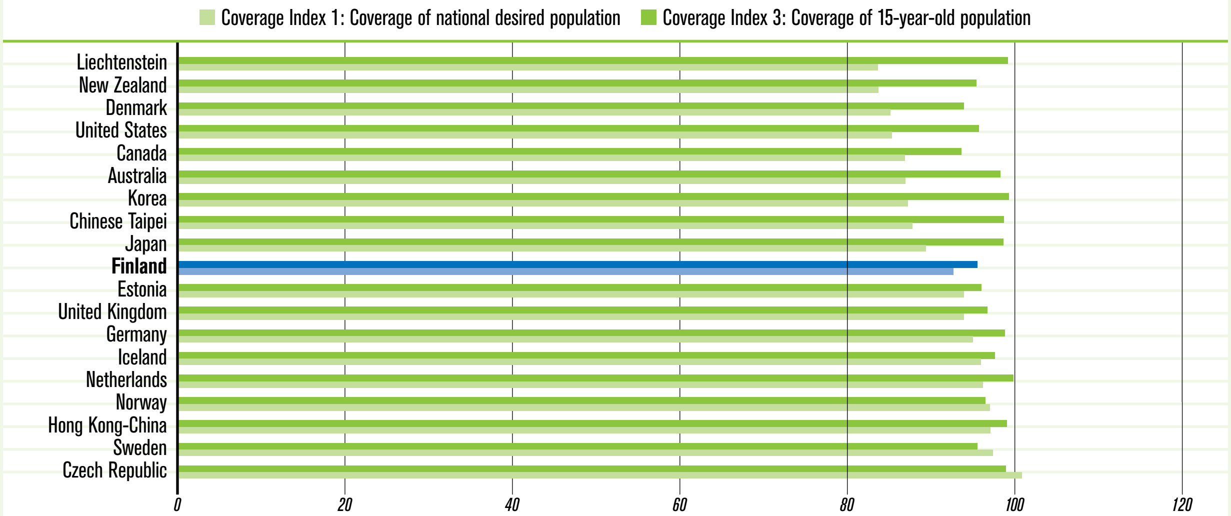
For schools the rules were as follows:

(i) School-level exclusions for inaccessibility, feasibility or other reasons were required not to exceed 0.5 % of the total number of students in the PISA target population. Schools on the school sampling frame that had only one or two eligible students were not allowed to be excluded from the frame. However, if it was clear that the percentage of students in these schools would not cause a breach of the 0.5 % allowable limit, then such schools could be excluded, if at that time, they still only had one or two PISA eligible students.

(ii) School-level exclusions for students with intellectual or functional disabilities, or students with limited proficiency in the language of the PISA test, were required not to exceed 2 % of students.

(iii) Within-school exclusions for students with intellectual or functional disabilities or students with limited language proficiency were required not to exceed 2.5 % of students (OECD 2007a, 23).

F 2 | Coverage indexes of national desired population and 15-year-old population in top fifteen countries in science performance, the Nordic countries and in the U.S (OECD, 2007a, 350)



Within schools students who could be excluded were:
(i) Intellectually disabled students, defined as students who are considered in the professional opinion of the school principal, or by other qualified staff members, to be intellectually disabled, or who have been tested psychologically as such. This category includes students who are emotionally or mentally unable to follow even the general instructions of the test. Students were not to be excluded solely because of poor academic performance or normal discipline problems.
(ii) Students with functional disabilities, defined as students who are permanently physically disabled in such a way that they cannot perform in the PISA testing situation. Students with functional disabilities, who could perform, were to be included in the testing.
(iii) Students with limited proficiency in the language of the PISA test, defined as students who had received less than one year of instruction in the language(s) of the test (OECD 2007a, 23-24).

In the top performing countries and in the Nordic countries, the school-level exclusions were below 2 % with few exeptions. In Estonia the school level exclusion rate was 2,9 % and in Denmark 2,8 %. In Finland, the rate was 1,9 %. The average within-schools student exclusion in OECD countries was 1.6 %. In all of the Nordic countries the exclusion rate was higher than the OECD average. In Denmark the rate was 3.3 %, in Norway 2.9 %, in Sweden 2.7 %, in Finland 2.6 % and in Iceland 2.0 %.

The overall exclusion is a combination from the two previously mentioned exclusions. The overall exclusion rate remains below 2 % in 32 participating countries, below 4 % in 51 participating countries and below 6 % in all countries, except Canada (6.4 %) and Denmark (6.1 %). Also other Nordic countries had a greater overall exclusion rate than the OECD awerage (2. 7 %). In Finland the overall exclusion rate was 4.5 % in Sweden 4.5 % and in Norway 3.5 %. (OECD 2007a, 348)

T 1 | Exclusion rates and coverage indexes of national desired population and 15-year-old population in top fifteen countries in science performance, the Nordic countries and in the U.S. (OECD, 2007a, 350)

OECD	*School-level exclusion rate (%)*	*Within-school exclusion rate (%)*	*Overall exclusion rate (%)*	*Coverage Index 1: Coverage of national desired population*	*Coverage Index 3: Coverage of 15-year-old population*
Australia	0,54	1,23	1,76	0,98	0,87
Canada	1,21	5,20	6,35	0,94	0,87
Czech Republic	0,90	0,16	1,06	0,99	1,01
Denmark	2,84	3,32	6,07	0,94	0,85
Finland	1,90	2,62	4,47	0,96	0,93
Germany	0,57	0,66	1,22	0,99	0,95
Iceland	0,33	2,04	2,37	0,98	0,96
Japan	1,36	0,00	1,36	0,99	0,89
Korea	0,55	0,11	0,66	0,99	0,87
Netherlands	0,03	0,12	0,15	1,00	0,96
New Zealand	0,76	3,84	4,58	0,95	0,84
Norway	0,67	2,86	3,51	0,96	0,97
Sweden	1,83	2,67	4,46	0,96	0,97
United Kingdom	1,68	1,62	3,27	0,97	0,94
United States	0,47	3,83	4,28	0,96	0,85
PARTNERS					
Chinese Taipei	0,93	0,31	1,24	0,99	0,88
Estonia	2,90	1,10	3,97	0,96	0,94
Hong Kong-China	0,90	0,03	0,93	0,99	0,97
Liechtenstein	0,00	0,84	0,84	0,99	0,84

Estimations in this Finnish PISA report with examples

This report includes results based on the official estimates prepared by the ACER team on the one hand, and the estimates calculated by the Finnish team on the other. The methodology is equal in both estimates so that the sampling design has been taken into account. Furthermore, we have checked the impact of the 'imputation' uncertainty. As far as the latter point is concerned we have used the five plausible (imputed) values as they are available in official public micro files and calculated our own estimates from these. Naturally, our point estimates are the averages of the five plausible values. This section presents some empirical examples on our data handling.

We have calculated our point estimates using sampling weights, that is, the student weights for student data and the school weights for school data, respectively. The weighted and unweighted estimates do not differ substantially from each other in most countries due to the design close to self-weighting. This concerns Finland, Sweden and the United States, among others. Italy is an exception, in that their unweighted estimates for science, reading and mathematics are more than 10 scores lower than the weighted ones. This thus means that the 'good' schools are oversampled in Italy (but using student weights this bias has been taken into account). The Italian overall sample size, 21773 students, is much higher than the required minimum, whereas the size in Finland, Sweden and the United States is just above the minimum.

The calculation of point estimates with the uncertainty estimates are needed, since the major part of analysis is based on comparisons between various domains such as countries, genders, regions, types of schools and parents' backgrounds. For most PISA estimates this can be done using tools that estimate the standard errors correctly (e.g. SPSS complex samples, SAS survey procedures). In addition, in the case of plausible scores for science, reading and mathematics, this uncertainty has to be summed up like as imputation variance. The whole variance estimate is thus the estimate of the sampling variance plus the imputation variance. Consequently, the square root of this variance corresponds to the standard error.

The different components of the variance estimates can be compared using the ratios. The so-called sampling design effect, DEFF, is the ratio between true sampling variance and the respective simple random sampling (srs) variance. If simple random sampling was successfully applied, the DEFF would be equal to one. In PISA, it is expected that DEFF's are always higher than one, in particular due to school clusters used in sampling. We calculated two types of examples in this appendix. Table 2 is for four countries and Table 3 for four Finnish strata (2 counties/rural-urban).

The standard errors are not very high, and due to the big sample size in Italy, Italian estimates are much smaller than in the other three countries. Furthermore, the increase in standard errors and variances due to clustering is substantial in all countries but especially in Italy and in the United States.

DEFF's are expected to be rather similar in small domains but the uncertainty estimates naturally will increase as well. Hence, it is necessary to be careful in estimating small domains. An illustrative example is shown in Table 3 where we could not publish the standard errors for the rural Southern Finland at all, since the true estimates were damaged due to there being only two schools in the sample. The same problem was met both in rural Ahvenanmaa and in urban Ahvenanmaa. It was possible to fairly accurately estimate the other regions with rural vs urban divisions. There were, naturally, some other small-domain problems met, but we did not publish our results at such a level.

The imputation variance due to the five plausible values for science, reading and mathematics, similarly adds the uncertainty and much more so in small domains. This also suggests that it is better not to use rural estimates for Southern Finland, for instance. Fortunately, this uncertainty is not dramatic in most larger-domain estimates. A simple indicator for its effect is to calculate the share of the imputation variance from the real design vari-

T 2 | Uncertainty figures for the four selected countries

	Standard error under this design	*Finland*	*Sweden*	*USA*	*Italy*
Science	srs design	1.2	1.4	1.4	0.6
	real design	2.0	2.5	4.9	2.3
	DEFF	2.8	3.2	12.8	13.4
Reading	srs design	1.1	1.4	1.3	0.7
	real design	2.2	2.8	4.4	2.6
	DEFF	3.9	4.0	12.3	14.3
Mathematics	srs design	1.1	1.3	1.1	0.6
	real design	2.1	2.5	4.5	2.6
	DEFF	3.4	3.7	15.3	16.8

T 3 | Uncertainty figures for the four Finnish regions

	Standard error under this design	*Southern Finland rural*	*Southern Finland urban*	*Mid Finland rural*	*Mid Finland urban*
Science	srs design	10.9	2.5	5.2	3.9
	real design	–	4.3	7.7	7.2
	DEFF	–	2.9	2.2	3.4
Reading	srs design	11.3	2.3	4.9	3.8
	real design	–	4.3	8.7	7.8
	DEFF	–	3.6	3.2	4.3
Mathematics	srs design	10.1	2.3	5.2	3.8
	real design	–	4.5	7.0	6.9
	DEFF	–	3.7	1.8	3.4

ance. This indicator was below 5 % in most country estimates as well as in the three Finnish regions (Table 3). The two exceptions were found for four countries in Table 2: 17 % for mathematics in Finland and 15 % for reading in Sweden. It is understandable that these are found in mathematics and reading since the measurement of plausible values is in these topics more uncertain, but it is still difficult to see any real reason for these two values. In scores, they are fortunately rather small.

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PISA06

APPENDIX 3 | PISA SAMPLING AND ESTIMATION


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“Without data,
you are just
another person
with an opinion.”

Andreas Schleicher
Head, Indicators and Analysis Division
OECD Directorate for Education

Opetusministeriö

Undervisningsministeriet

Ministry of Education

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PISA 2006 Finland: Analyses, reflections and explanations provides an introduction to the Finnish educational system in the light of OECD's Programme for International Student Assessment, PISA.

The foundations for the Finnish comprehensive school system were laid with great expectations. PISA is used as an international tool for testing the underpinnings. This deepens the understanding of one's own system, which is a condition for exchanging ideas and experiences in schooling.

The book is useful for those who want to understand how Finland has solved the problem of the reform of schooling at a time when it is evermore important. Finnish education is a part of the Finnish national innovation system, which is tuned to face the demands of the future knowledge society.