4 INFRASTRUCTURE

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This chapter describes the hardware and software infrastructure that was available in schools at the end of 1998. Indicators are presented with regard to student:computer ratio, the quality of the available equipment, availability of peripherals, access to the Internet, availability of software, problems and priorities with regard to hardware and software, as well as expenditures from school budgets. The chapter also presents results of the first analyses, which address questions relating to relationships between different indicators.

Introduction

On the basis of the IEA Computers in Education Studies (CompEd), which were conducted in 1989 and 1992, the following conclusions were drawn with regard to the hardware and software infrastructure in schools (Pelgrum, Janssen Reinen & Plomp, 1993):

In 1989 the USA was the only country, among all those participating in the study, where in all schools at the elementary and secondary level computers were available for instructional use. Since then an increasing number of schools in the other countries also acquired access to computers, but a substantial number of elementary schools in Japan (about 64%) and the Netherlands (17%), lower secondary schools in Bulgaria (17%) and Japan (29%), and upper secondary schools in India (85%) did not yet possess computers for instructional use in 1992.

In almost all countries the number of computers in schools increased considerably in three years time, but (except for Austria, Japan, and Slovenia) most equipment still consisted of quite old-fashioned 8-bit machines. While most computer coordinators perceived the shortage of hardware less as a problem than in 1989, a majority of students (except for Japanese secondary and Dutch lower secondary schools) complains about computers not being available when they wanted to use them, although this problem does not occur very often.

Access to external networks was quite rare, except in the USA, Austrian upper secondary schools and Dutch lower secondary schools and regular use of networks occurred seldom (except for about 15% of the schools in the USA).

In some countries many students have access to computers at home. In Austria, Germany, the Netherlands, and the USA computers were available in roughly half or more of the homes.

> The availability of instructional tool software increased between 1989 and 1992, except in Greece, India, the Netherlands and Japanese upper secondary schools. Shortage of software was still seen as an important problem, although only slightly less than in 1989. In all countries a majority of students complained that programs were difficult to handle. (pp117-118)

Before SITES and since CompEd, no international, large-scale, comparative statistical surveys had been conducted of the ICT-infrastructure in education. A few questions relating to ICT were included in the IEA Third International Mathematics and Science Study (Beaton, Mullis, Martin, Gonzalez, Kelly & Smith, 1996), which was conducted in 1995 in approximately 45 countries. However, the only information collected about infrastructure was the number of computers in schools. This chapter, drawing as it does on data from SITES-Module 1, provides some of this missing detail by describing the ICT-infrastructure existing in the SITES schools at the end of 1998.

Hardware

Student:computer ratios

A general basic indicator of hardware availability in schools is the number of PCs (or work-stations) that are available to students and/or teachers of the target grades[1] for teaching and/or learning purposes. In the technical questionnaire, respondents were asked to specify the total number of computers available to students in the target grades. Although it is possible to calculate the mean or median of this variable, doing so would be meaningless unless the size of the schools was taken into account.

One indicator of the extent to which students can access hardware in a school is the student:computer ratio. This ratio indicates how many students on the average have to share one computer and can be determined by dividing the total number of students in the school by the total number of computers available. A ratio of 30, for example, indicates that for every 30 students there is one computer available. Furthermore, if these 30 students spend about 30 hours in lesson time per week in their school, then each student, on average, could use a computer for one hour per week.

Obviously, there are different ways of calculating the ratio, perhaps by taking into account the non-using schools in a country, or counting all the computers in the whole school or in a particular range of grades, or determining the number of students that use the available equipment. Each of these measures has limitations. For example, calculating the student:computer ratio on the basis of the number of students in the grade range divided by the number of computers available for these students can result in a downwards biased (that is, in this case, a too favorable) estimate because students other than those from the target grades may be using the computers. Alternatively, if the ratio is calculated on the basis of the number of students in the whole school divided by the number of computers in the whole school, the estimate might be inaccurate for the students in the target grade range. The assumption here is that these students have access to the computers when, in fact, they may not; the computers may be available only to students from other grade levels. Such a

[1] SITES Module-1 was conceived as producer of baseline information for SITES Module-3, in which samples of students at a particular grade level (the so-called target grade) will participate. In order to provide school-context information that is relevant for this group, Module-1 focused as much as possible on students at the target grade (see Chapter 1 for further explanations).

situation can occur if, for example, lower and upper secondary schools share the same building and facilities but the computers are available only to upper secondary students. (This happens in schools where computer use is restricted to computer science courses such as programming.)

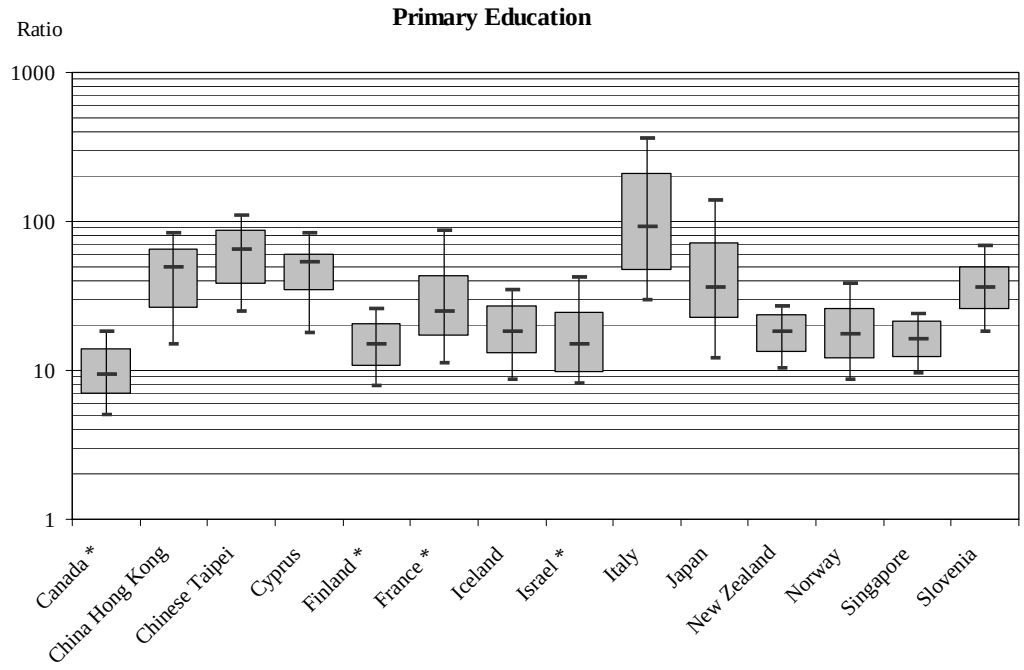
In order to capture these different situations, the technical questionnaire included a whole series of questions about available computer equipment for the grade range, the entire school, numbers of students using computers, and so on (see Appendix B, technical questionnaire, questions 15-24). After extensive analyses of the results it was concluded that the student:computer ratio could best be based on:

$$\text{Student:computer ratio} = \frac{\text{total number of students per school}}{\text{total number of computers available for student use in the whole school}}$$

The reasons for using this indicator were as follows:

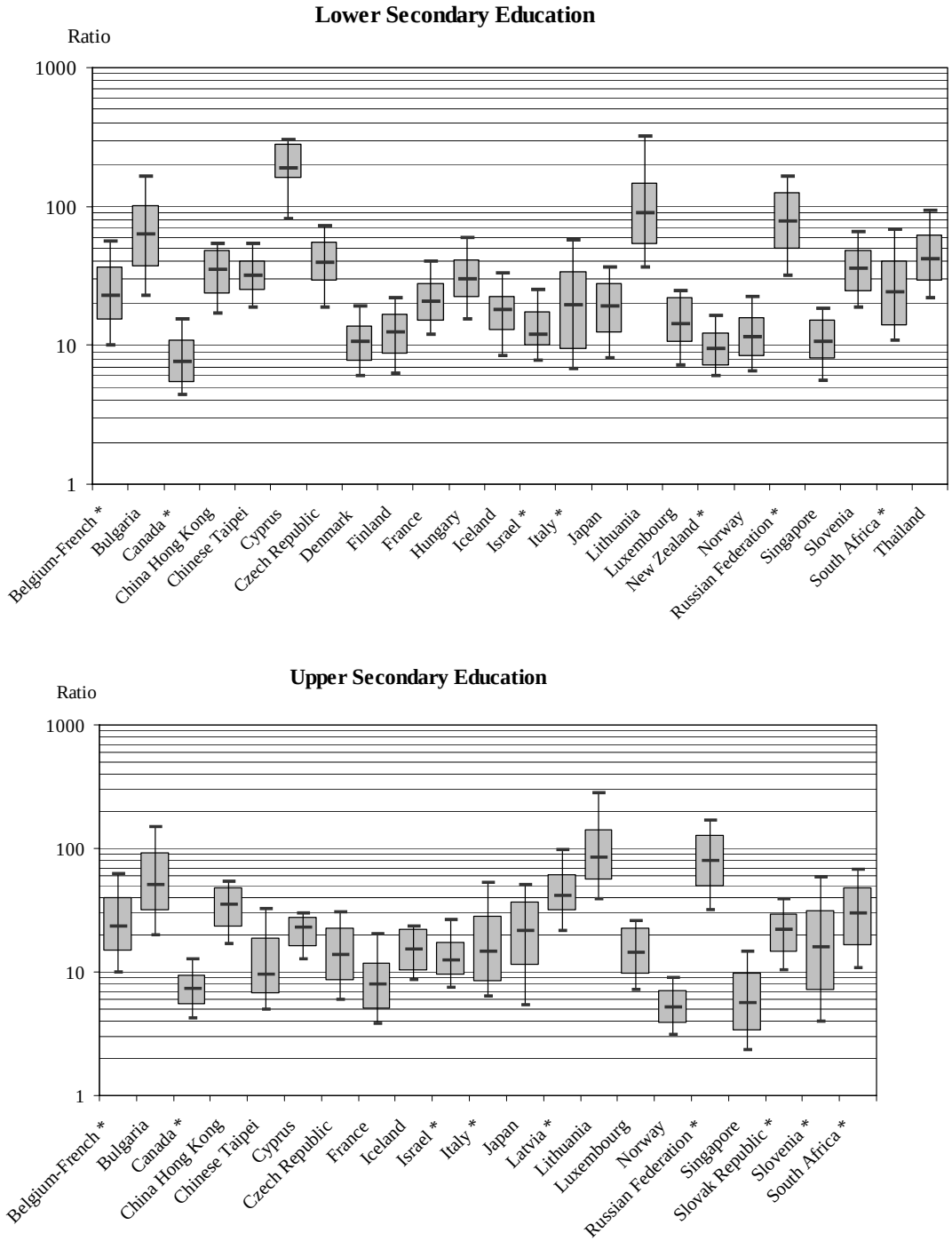
- In many schools, the number of computers listed for the grade range appeared to be roughly the same as the number of computers for the whole school.
- The grade range definitions varied quite a lot between countries.

Appendix G (Tables G.1.1, G.1.2, and G.1.3) presents several of the alternative estimates of student:computer ratios, including an index that takes into account the non-using schools. (Table 1.2 in Chapter 1 provides an overview of the percentages of computer-using schools per country and educational level.)



Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). Boxes range from 25% lowest to 75% highest value; the horizontal line in the boxes represents the median; tiles show values for 10% and 90% of the cases. Because of the huge differences between countries, these box plots are presented on a logarithmic scale, the gridlines should be read as 1,2,3,…, 10, 20, 30, …,100, 200, 300, …

Figure 4.1 Box plots of student:computer ratios in computer-using schools-primary, lower secondary, and upper secondary education. (continue on next page)



Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). Boxes range from 25% lowest to 75% highest value; the horizontal line in the boxes represents the median; tiles show values for 10% and 90% of the cases. Because of the huge differences between countries, these box plots are presented on a logarithmic scale, the gridlines should be read as 1,2,3,…, 10, 20, 30, …,100, 200, 300, …

Figure 4.1 (continued from previous page) Box plots of student:computer ratios in computer-using schools-primary, lower secondary, and upper secondary education.

Figure 4.1 contains the box plots for the student:computer ratios (calculated on the basis of the above definition) in computer-using schools for each country and educational level.

The overall impression gained from Figure 4.1 is that the student:computer ratios differed quite substantially across countries, but also within countries (for example, at one extreme, 25% of the primary schools in Italy have a ratio of roughly 50 or less, while at the other extreme, 25% have ratios of 200 or more).

For *primary education*, the median student:computer ratios differed quite substantially between countries. Relatively low ratios were observed in, for instance, Canada, Finland, Iceland, Israel, New Zealand, Norway, and Singapore. Less favorable ratios (30 or more) were observed in China Hong Kong, Chinese Taipei, Cyprus, Italy, Japan, and Slovenia.

The student:computer ratios at *lower secondary schools* also differed substantially between countries: the medians varied, for instance from below 10 (in Canada and New Zealand) to higher than 50 in Bulgaria, Cyprus, Lithuania, and the Russian Federation.
At the *upper secondary level*, the student:computer ratios tended to be more favorable than at the lower secondary and elementary levels. Low median (and, hence, most favorable) ratios of less than 10 were observed in Canada, Chinese Taipei, France, Norway, and Singapore.

Comparison of student:computer ratios between 1995 and 1998
In the Third International Mathematics and Science Study (TIMSS) a few questions were posed about the number of computers that were available in schools (see Beaton et al, 1996).

The TIMSS data regarding computers were based on the following questions that were included in the TIMSS school questionnaire.

Write in a number for each. Write 0(zero) if there are none
15. In your school, how many computers are….

A. available for use by teachers or students _____
B. used by teachers for administrative
purposes (e.g. grade reports, attendance, etc.) _____
C. used by teachers during instructional time _____
D. used by students for educational purposes _____
E. used by office staff for school record keeping _____

17. The students in your school:
Write in the answer for each of the following. Write 0 (zero) if there are none.

	boys	girls
a) What is the total school enrollment (number of students) ?	_____	_____
b) …		

For calculating the student:computer ratio in a country on the TIMSS data the following procedure was used.
First of all it had to be decided which variable (15A or 15D) should be used.
It appears that not all countries treated this question in a similar way, because in at least one country the sum of questions 15B to 15D was lower than the number under 15A, whereas in other countries the values on 15D were about the same or even higher than the values on 15A. The OECD-network C members decided to use 15A, so this includes use of computers by teachers.

One should also keep in mind that in TIMMS the participating schools included those that did not use computers for instructional purposes at all at that time (and so answered 0 on 15A to 15D), whereas the SITES data came from computer-using schools.

For the TIMSS respondents both the total number of students and the total number of computers (from 15A) were computed. After this summation, the ratio was computed. Given that the TIMSS respondents are considered to be representative of their respective countries, this same ratio was used as an estimate for the student:computer ratio for the whole country.
An issue that arose before summation was that of how to weight the data. Eventually it was decided to weight the data by student weights, although the use of school weights would have resulted in ratios that deviated no more than 10% from the presented estimates.

The SITES data were taken from the following questions:

15. How many computers are available for use by students in the *entire* school?

TOTAL number of computers ☐

16. What is the total number of students in the *entire* school?

TOTAL number of students ☐

A further source of information was an estimate by each NRC of the 'percentage of students in ICT-using schools' for each stratum distinguished in the sampling of schools.

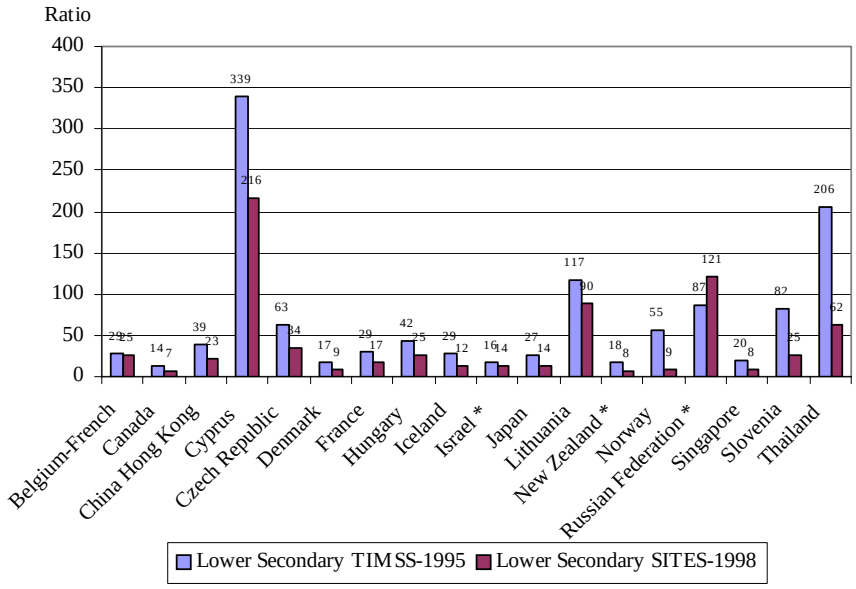
The calculation of the student:computer ratio on the SITES data was made as described below.

As with TIMSS, totals of students and computers were computed over all respondents. However, in order to compensate for the fact that non-using schools were not included, the subtotals of students per stratum were multiplied by 100/(percentage of students in ICT-using schools), before the totals per country were computed.

From the above it seems that, although the questions in TIMSS and SITES were not strictly comparable, one can be reasonably confident that the trend statistics offer a fair estimate of the amount of change that took place between Spring 1995 and Autumn 1998.

Figure 4.2 reveals that considerable improvements occurred in all countries except the Russian Federation across the intervening three-and-a-half years.

Figure 4.2 also reveals that one of the most noteworthy declines (and, hence, improvements) occurred at the lower secondary level for Norway (from 55 in Spring 1995 to 9 in Autumn 1998). The extent of improvement seemed, at first, quite implausible. However, comparisons of the current estimates with the results from a national survey on ICT in Norway conducted in 1997 validated the current estimates.



Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). Estimates are for all schools, that is, including non-computer using schools.

Figure 4.2 Comparison of student:computer ratios in 1995 and 1998 for lower secondary education[2] (includes all schools: computer-using as well as non-using).

Tables G.1.1.1-G.1.1.3 in the appendices further indicate that ratios based on the grade range were, in some countries, much more favorable (and maybe downwards biased, that is, giving a too favorable impression) than the ratios for the whole school. This finding tends to occur when schools do not differentiate between computer equipment for the whole school and for the grade range. However, in some countries it appeared that the grade range ratios were less favorable, suggesting that in these countries there may be a tendency to reserve this equipment for students other than those in the grade range. This scenario may well explain another statistic shown in Tables G.1.1.1-G.1.1.3, namely the percentage of students in the entire school using the equipment available for the entire school. In some countries, the percentage was below 50%.

As shown in Figure 4.3 the student:computer ratios generally have improved over the years. Those schools that had recently begun to introduce computers typically had a ratio of 60 to 70 students per computer at the elementary and lower secondary levels (and 30 at the upper secondary levels), while (across the educational levels) schools that had started 11 or more years ago had ratios of 20

[2] A comparison of data for the United States with results from TIMSS (1995) and a national survey that was conducted in Spring 1998 (Anderson & Ronnkvist, 1999) revealed a decline for lower secondary schools from 15 to 7 (roughly comparable to the developments in Canada). Comparisons of the SITES results with data collected recently in national ICT surveys in the The Netherlands, the United Kingdom and the United States provided the following additional information. A survey that was conducted in the United Kingdom (Department for Education and Employment/DFEE, 1998) in Spring 1998 revealed an average number of students per computer of 18 in primary education and 9 in secondary education. In the United States (Anderson & Ronnkvist, 1999), these numbers were respectively 8 for primary education and 7 for lower as well as for upper secondary education (comparable to Canada), while in The Netherlands, the numbers were respectively 23 and 20 (ten Brummelhuis, 1998, 1999).

and lower.

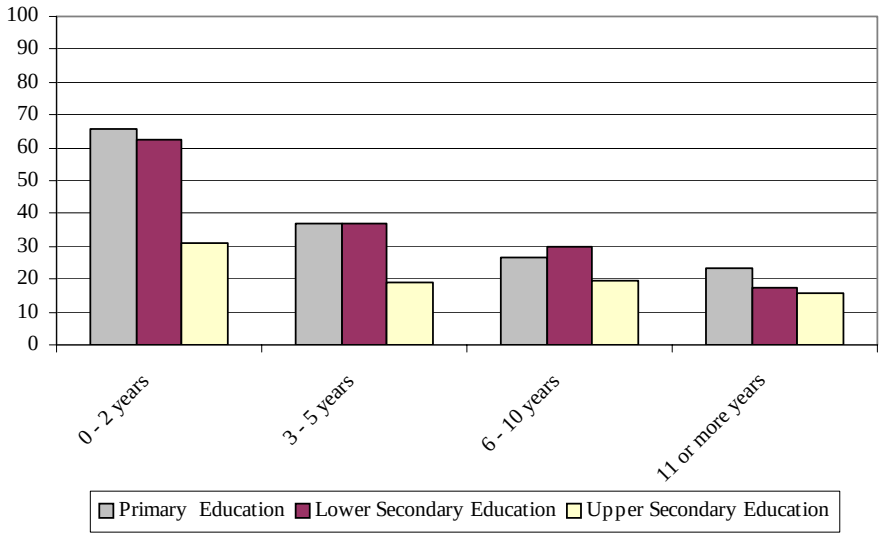


Figure 4.3 Breakdown for computer-using schools in primary, lower secondary and upper secondary education of student:computer ratios by number of years schools had used ICT.

A question that was of interest (especially in terms of it providing a benchmark for judging future developments) to the researchers who participated in SITES concerned the use of laptop-computers. In the technical questionnaire one item asked for an estimate of the percentage of students from the entire school that brought their own laptop to the school. The percentage proved to be nearly zero in all countries, although schools in two countries (two lower secondary schools in Japan and one in Norway) noted that more than 50% of their students had their own laptops. As a general conclusion, then, laptop use among students was negligible in 1998.

Hardware Functionality

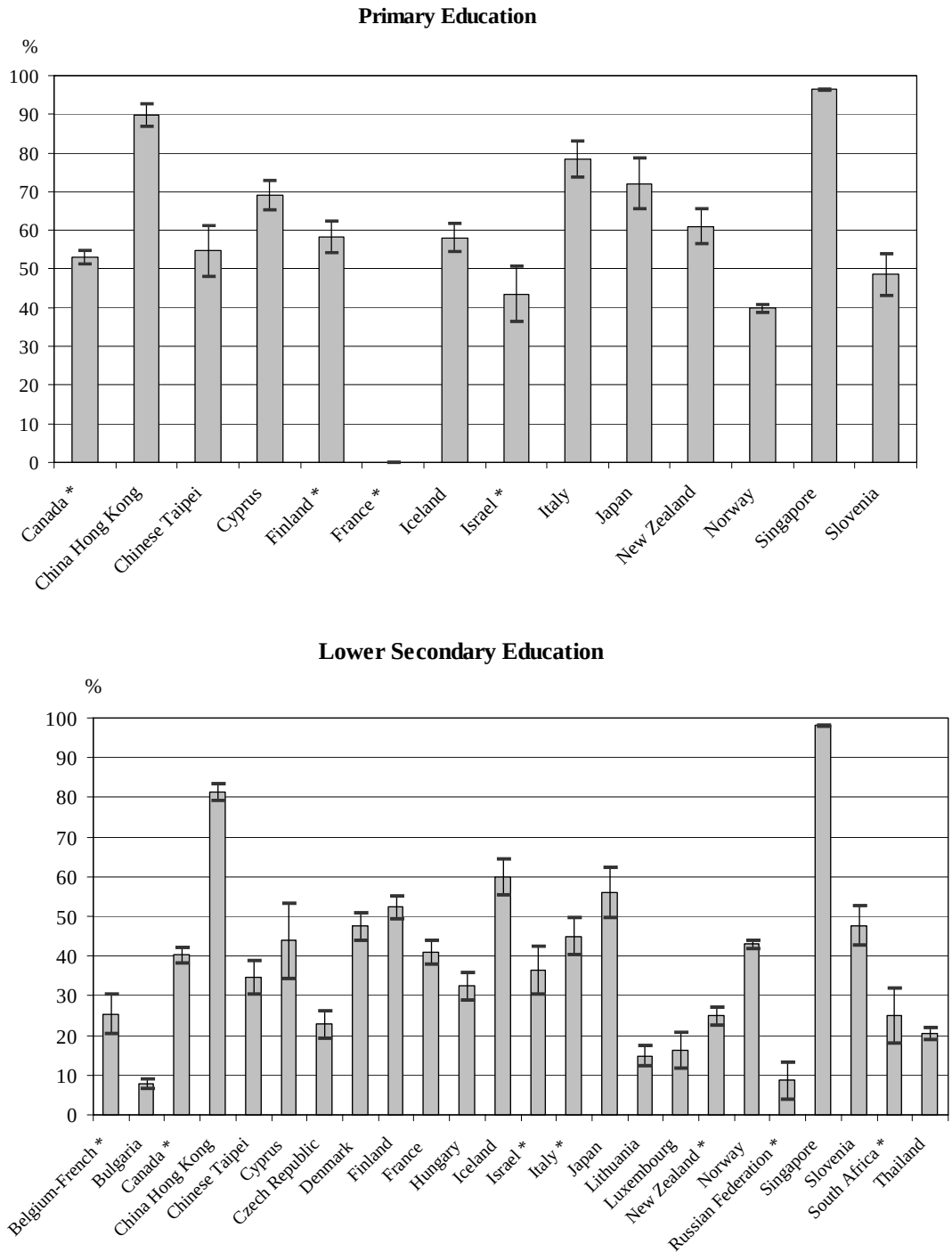
The student:computer ratio, although of interest to policy-makers (given that policy targets in many countries refer to planned ratios), is a rather crude indicator of the available ICT-infrastructure. More illuminating for the purpose of interpreting the ICT-related curriculum indicators discussed in Chapter 3 are indicators of the quality and (potential) functionality of the available equipment.

One potential indicator of hardware functionality is the percentage of computers in schools that are suited for multimedia applications. The respondents who filled out the technical questionnaire were asked:

26. With respect to the total number of computers from question 20 (that is the number of computers available for the grade range): How many are multimedia computers (equipped with a CD-ROM and a sound card)?

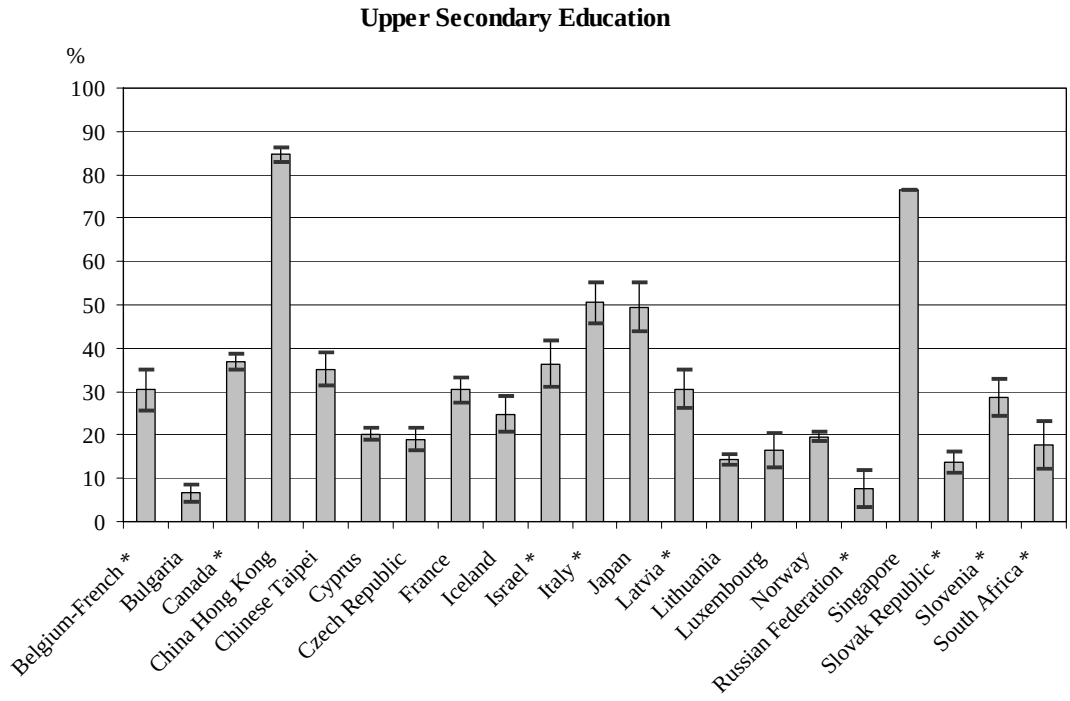
Number of multimedia computers ☐

The average percentage of equipment suited for multimedia purposes is shown in Figure 4.4. Here, it is evident that for the targeted grade range in *primary education*, more than 70%, on average, of the available computers in China Hong Kong, Cyprus, Italy, Japan, and Singapore were suited for multimedia applications. In other countries, for example, Israel, Norway, and Slovenia, these types of computers were less available.



Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). Top of bar displays 95% confidence interval. Missing boxes: data not available.

Figure 4.4 Bars and 95% confidence interval of average percentages of multimedia computers for the grade range in computer-using schools-primary, lower, and upper secondary education. (continue on next page)



Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). Top of bar displays 95% confidence interval. Missing boxes: data not available.

Figure 4.4[3] (continued from previous page) Bars and 95% confidence interval of average percentages of multimedia computers for the grade range in computer-using schools-primary, lower, and upper secondary education.

For the targeted grade range at the *lower secondary level*, the average percentage of multimedia computers was very high (greater than 70%) in China Hong Kong and Singapore and very low (less than 30%) in Bulgaria, the Czech Republic, Lithuania, Luxembourg, New Zealand, the Russian Federation, South Africa, and Thailand.

For the defined grade range at the *upper secondary level*, high percentages of multimedia computers were observed in China Hong Kong and Singapore, while low percentages were evident in Bulgaria, Cyprus, the Czech Republic, Iceland, Lithuania, Luxembourg, Norway, the Slovak Republic, Slovenia, and South Africa.

It is interesting to note from Figure 4.4 that, in many countries, the targeted grade range in primary education tended to have a relatively higher percentage of multimedia computers than in upper secondary education, even though, as indicated in Figure 4.1, the student:computer ratios in upper secondary schools tended to be much more favorable. A potential explanation for this phenomenon

[3] In addition to the SITES countries, results from a national survey conducted in the United States during the spring of 1998 revealed for primary, lower secondary, and upper secondary education percentages of multimedia computers of respectively 48, 49 and 49 (Anderson & Ronnkvist, 1999). The percentage of computers suited for multimedia applications in The Netherlands was 30% in primary education (ten Brummelhuis, 1998) and 20% in lower secondary education (ten Brummelhuis, 1999).

is that upper secondary schools began to introduce computers earlier than did primary schools and, hence, had more old-fashioned equipment available. Moreover, multimedia computers might be considered pedagogically more appropriate or appealing (given their diverse multi-sensory functions) for younger children than for older students.

A further indication (see Tables 4.1.1-4.1.3) of the potential functionality of the hardware infrastructure is possible by calculating the percentage of computers (available for the grade range) equipped with one of the following types of processor:

- Equivalent to Pentium, Mac 603 and higher, SUN, Alpha, etc.;
- 386/486 SX/DX, Macintosh SE, Mac II up to 68030, Atari ST, Amiga, etc.;
- 16-bits computers, such as AT/XT 80286;
- 8-bits computers, Apple II/IIe, Apple II clones, C64 and other old 8-bit.

Table 4.1.1

Average percentages (and standard errors) of computers equipped with different processor types and different operating systems at the grade range-primary education

Country	% INTEL Pent.+Mac 103+higher	% 386/486SX/DX,Mac up to 68030	% 16-BIT Compat. AT/XT80286	% 8-BIT Compatible,APPLE2/2E	% Wind.95/98,WinNT,MacOS7,5+	% Wind.3.0/3.1,OS/2,Mac-OS <7.5	% MS DOS(3.1-7.0)without Wind.	% Other Operating Systems
Canada *	52 (1.3)	36 (1.2)	6 (0.6)	5 (0.6)	58 (1.0)	36 (1.1)	9 (0.7)	11 (0.9)
China Hong Kong	91 (2.3)	6 (1.9)	2 (1.2)	1 (0.8)	95 (1.0)	13 (2.5)	1 (0.5)	1 (0.7)
Chinese Taipei	72 (3.0)	26 (2.8)	3 (1.2)	0 (0.0)	73 (3.2)	19 (2.8)	10 (2.0)	0 (0.0)
Cyprus	48 (5.5)	45 (5.2)	7 (4.6)	~	55 (4.1)	57 (3.4)	2 (1.2)	15 (8.9)
Finland *	53 (2.2)	39 (2.1)	6 (1.0)	2 (0.7)	56 (2.3)	40 (2.4)	2 (0.6)	1 (0.6)
France *	~	~	~	~	~	~	~	~
Iceland	67 (1.8)	31 (1.7)	1 (0.2)	1 (0.4)	69 (1.5)	27 (1.5)	0 (0.1)	13 (1.7)
Israel *	51 (8.5)	38 (8.2)	8 (4.5)	4 (3.4)	49 (4.2)	59 (4.2)	15 (4.3)	12 (5.8)
Italy	73 (2.8)	20 (2.4)	4 (1.2)	3 (1.0)	77 (2.7)	20 (2.5)	5 (1.3)	1 (0.8)
Japan	44 (4.1)	27 (3.7)	20 (3.4)	9 (2.5)	49 (3.7)	26 (3.3)	25 (3.5)	10 (2.5)
New Zealand	50 (2.8)	40 (2.8)	5 (1.2)	5 (1.0)	58 (2.5)	24 (2.2)	3 (0.8)	14 (2.3)
Norway	39 (1.0)	55 (1.0)	4 (0.4)	2 (0.3)	52 (0.6)	46 (0.6)	6 (0.4)	3 (0.4)
Singapore	93 (0.0)	7 (0.0)	0 (0.0)	0 (0.0)	96 (0.0)	3 (0.0)	1 (0.0)	0 (0.0)
Slovenia	64 (2.7)	35 (2.7)	2 (0.7)	0 (0.1)	82 (2.4)	16 (2.3)	0 (0.2)	1 (0.7)

Notes: Percentages per school calculated as: (total number of particular type divided by total number of computers available at the grade range)*100. Standard error (se): value ± 2*se provides 95% confidence interval for the population. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). ~: data not collected.

Table 4.1.2

Average percentages (and standard errors) of computers equipped with different processor types and different operating systems at the grade range-lower secondary education

Country	% INTEL Pent.+Mac 103+higher	% 386/486SX/DX,Mac up to 68030	% 16-BIT Compat. AT/XT80286	% 8-BIT Compatible,APPLE2/2E	% Wind.95/98,WinNT,MacOS7,5+	% Wind.3.0/3.1,OS/2,Mac-OS <7.5	% MS DOS(3.1-7.0)without Wind.	% Other Operating Systems
Belgium-French *	35 (3.0)	50 (3.2)	9 (1.8)	6 (1.8)	40 (3.2)	40 (3.2)	19 (2.6)	1 (0.7)
Bulgaria	12 (1.0)	27 (1.3)	30 (1.3)	31 (1.6)	15 (1.1)	23 (1.2)	34 (1.4)	31 (1.6)
Canada *	48 (1.4)	40 (1.2)	10 (0.8)	1 (0.3)	55 (1.2)	38 (1.1)	17 (1.0)	8 (1.1)
China Hong Kong	84 (1.3)	16 (1.3)	0 (0.2)	0 (0.0)	81 (1.1)	18 (1.2)	5 (1.0)	1 (0.4)
Chinese Taipei	63 (1.9)	35 (1.9)	2 (0.6)	0 (0.3)	73 (1.9)	19 (1.7)	7 (1.0)	2 (0.9)
Cyprus	51 (8.5)	49 (8.5)	0 (0.0)	~	57 (6.1)	65 (6.3)	0 (0.0)	0 (0.0)
Czech Republic	32 (3.3)	59 (3.5)	6 (1.7)	4 (1.4)	47 (2.9)	55 (3.0)	16 (2.5)	6 (1.7)
Denmark	45 (2.8)	51 (2.9)	3 (0.7)	1 (0.5)	53 (2.1)	53 (2.1)	6 (1.4)	0 (0.3)
Finland	57 (1.3)	36 (1.3)	5 (0.6)	2 (0.5)	55 (1.7)	40 (1.6)	5 (0.7)	0 (0.0)
France	45 (1.6)	46 (1.6)	6 (0.8)	3 (0.6)	47 (1.6)	43 (1.6)	10 (1.1)	0 (0.2)
Hungary	48 (2.0)	43 (2.0)	7 (1.0)	2 (0.6)	46 (2.3)	46 (2.5)	17 (2.0)	4 (1.1)
Iceland	71 (1.8)	27 (1.8)	1 (0.2)	1 (0.3)	76 (1.6)	19 (1.4)	1 (0.2)	8 (1.6)
Israel *	42 (5.5)	48 (5.5)	7 (3.0)	2 (1.8)	44 (3.7)	56 (3.9)	14 (3.2)	7 (2.7)
Italy *	52 (2.6)	32 (2.4)	12 (2.0)	4 (1.2)	57 (2.5)	27 (2.3)	17 (2.1)	0 (0.3)
Japan	43 (3.4)	33 (3.4)	22 (2.9)	2 (1.2)	42 (3.2)	8 (1.9)	47 (3.3)	13 (2.6)
Lithuania	32 (2.3)	43 (2.3)	15 (1.6)	10 (1.5)	44 (2.3)	33 (2.2)	15 (1.6)	8 (1.4)
Luxembourg	75 (3.3)	24 (3.2)	1 (0.7)	0 (0.0)	69 (3.9)	31 (3.7)	1 (0.5)	0 (0.0)
New Zealand *	53 (1.6)	43 (1.5)	3 (0.4)	1 (0.2)	57 (1.6)	35 (1.7)	2 (0.4)	5 (0.9)
Norway	48 (1.2)	48 (1.2)	2 (0.3)	2 (0.3)	60 (0.6)	39 (0.7)	3 (0.3)	1 (0.2)
Russian Federation *	15 (3.1)	18 (3.6)	10 (2.8)	57 (4.8)	17 (3.4)	11 (2.8)	20 (3.8)	38 (4.6)
Singapore	96 (0.1)	4 (0.1)	0 (0.0)	0 (0.0)	95 (0.0)	18 (0.4)	0 (0.0)	1 (0.1)
Slovenia	61 (2.5)	37 (2.5)	1 (0.3)	0 (0.3)	79 (2.3)	21 (2.3)	0 (0.2)	2 (0.9)
South Africa *	40 (4.4)	43 (4.6)	13 (3.2)	4 (2.0)	49 (4.8)	21 (4.1)	30 (4.4)	0 (0.3)
Thailand	52 (1.6)	43 (1.6)	4 (0.7)	2 (0.5)	54 (1.6)	20 (1.3)	22 (1.4)	0 (0.2)

Notes: Percentages per school calculated as: (total number of particular type divided by total number of computers available at the grade range)*100. Standard error (se): value ± 2*se provides 95% confidence interval for the population. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). ~: data not collected.

Table 4.1.3

Average percentages (and standard errors) of computers equipped with different processor types and different operating systems at the grade range-upper secondary education

Country	% INTEL Pent.+Mac 103+higher	% 386/486SX/DX,Mac up to 68030	% 16-BIT Compat. AT/XT80286	% 8-BIT Compatible,APPLE2/2E	% Wind.95/98,WinNT,MacOS7,5+	% Wind.3.0/3.1,OS/2,Mac-OS <7.5	% MS DOS(3.1-7.0)without Wind.	% Other Operating Systems
Belgium-French *	46 (2.6)	47 (2.6)	6 (1.1)	1 (0.4)	53 (2.9)	40 (2.8)	7 (1.3)	0 (0.1)
Bulgaria	10 (1.4)	24 (1.8)	32 (1.9)	33 (2.4)	16 (1.7)	20 (1.7)	38 (2.2)	30 (2.3)
Canada *	49 (1.2)	42 (1.1)	8 (0.6)	2 (0.3)	55 (1.1)	42 (1.1)	10 (0.7)	3 (0.6)
China Hong Kong	87 (1.0)	13 (1.0)	0 (0.1)	0 (0.0)	86 (0.8)	15 (1.0)	4 (0.8)	1 (0.4)
Chinese Taipei	72 (1.5)	26 (1.4)	2 (0.3)	0 (0.0)	79 (1.4)	5 (0.7)	14 (1.3)	0 (0.2)
Cyprus	41 (3.0)	51 (3.4)	7 (2.1)	~	32 (1.3)	62 (1.5)	8 (1.9)	20 (5.9)
Czech Republic	41 (2.7)	56 (2.7)	3 (0.8)	0 (0.0)	55 (2.3)	47 (2.5)	12 (1.8)	1 (0.8)
France	53 (1.6)	43 (1.5)	4 (0.6)	0 (0.2)	53 (1.7)	43 (1.7)	4 (0.6)	0 (0.1)
Iceland	86 (1.6)	12 (1.4)	1 (0.5)	0 (0.2)	81 (1.4)	13 (1.1)	1 (0.5)	2 (0.4)
Israel *	51 (4.6)	46 (4.6)	3 (1.2)	1 (0.4)	53 (3.0)	40 (3.2)	13 (2.8)	5 (2.3)
Italy *	58 (2.4)	33 (2.3)	8 (1.3)	1 (0.4)	65 (2.1)	25 (1.9)	11 (1.7)	2 (0.8)
Japan	47 (3.5)	35 (3.4)	17 (2.8)	1 (0.8)	50 (3.0)	20 (2.6)	38 (3.2)	7 (2.1)
Latvia *	47 (7.3)	34 (6.3)	8 (3.4)	11 (3.5)	66 (2.7)	42 (3.5)	16 (3.5)	15 (5.3)
Lithuania	27 (0.8)	45 (0.9)	13 (0.6)	14 (0.7)	41 (0.9)	33 (0.9)	15 (0.6)	12 (0.7)
Luxembourg	73 (2.8)	24 (2.8)	3 (0.9)	0 (0.0)	71 (3.4)	28 (3.2)	1 (0.4)	0 (0.0)
Norway	57 (1.1)	42 (1.1)	1 (0.2)	0 (0.0)	61 (0.9)	39 (1.0)	2 (0.3)	0 (0.2)
Russian Federation *	15 (3.0)	19 (3.7)	11 (2.7)	55 (4.7)	17 (3.3)	11 (2.8)	20 (3.8)	38 (4.6)
Singapore	83 (1.4)	17 (1.4)	0 (0.1)	0 (0.0)	92 (0.0)	7 (0.8)	0 (0.0)	1 (0.2)
Slovak Republic *	12 (5.9)	27 (10.3)	23 (5.4)	38 (10.1)	40 (1.9)	49 (2.5)	44 (2.5)	39 (16.2)
Slovenia *	58 (2.3)	40 (2.3)	2 (0.5)	0 (0.0)	82 (1.9)	16 (1.9)	1 (0.4)	0 (0.1)
South Africa *	39 (4.2)	47 (4.3)	12 (2.8)	3 (1.5)	45 (4.4)	34 (4.3)	25 (4.1)	5 (2.5)

Notes: Percentages per school calculated as: (total number of particular type divided by total number of computers available at the grade range)*100. Standard error (se): value ± 2*se provides 95% confidence interval for the population. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). ~: data not collected.

The average percentage of computers equipped with one of the following operating systems/user interfaces (see Tables 4.1.1-4.1.3) also helps shed light on hardware quality/functionality in the schools:

- Windows 95/98, Win NT, or MacOs 7.5 and higher;
- Windows 3.0/3.1 or OS/2 or MacOs lower than 7.5;
- MS DOS (from 3.1 to 7.0) *without* Windows /no graphical system;
- Other systems.

The percentage of computers for each of the above-mentioned categories was calculated for each school, and these percentages were then averaged across schools in each country. The results, as

presented in Tables 4.1.1-4.1.3[4], reveal that at the targeted grade range in *primary education* in China Hong Kong, Chinese Taipei, Italy, and Singapore, the average percentage of computers equipped with high-speed processors and Windows 95/98, Windows NT or MacOs 7.5 or higher exceeded 70%. In Israel and Japan, the average percentage was around 50% or lower.

At the targeted grade range in *lower secondary education*, China Hong Kong, Iceland, Luxembourg, and Singapore seemed to be the most advanced countries in terms of availability of computers with high-speed processors and recent operating systems. Eight-bits computers were (as was expected) no longer common, although relatively substantial percentages were still observed in Bulgaria, Lithuania, and the Russian Federation.

In *upper secondary education*, a high percentage of computers equipped with high-speed processors and recent operating systems was observed at the targeted grade range in China Hong Kong, Chinese Taipei, Iceland, Luxembourg, and Singapore. Low availability of high-speed processors was observed in Bulgaria, Lithuania, the Russian Federation, and the Slovak Republic.

Connections to Internal Networks

Another important means of evaluating the ICT infrastructure in schools is the extent to which the available equipment is connected to an internal network. The respondents who filled out the technical questionnaire were given the following question:

> How many of the total number of computers from question 20 are in a local network?[5]
>
> Number of computers in local network ☐

Figure 4.5 contains the average percentage of computers connected to a local network at the targeted grade range in each country. Note that the wording of the question may have led respondents to interpret the term ‘local network’ in a broader sense than the term ‘local area network’.

At the targeted grade range in *primary education* (see Figure 4.5) in Canada, Chinese Taipei, Iceland, Israel, and Slovenia, most of the computers seemed to be connected to an internal network. This was barely (that is, less than roughly 20%) the case in China Hong Kong, Cyprus, and Singapore.

At the targeted grade range in *lower secondary education*, there were a few countries where nearly all computers were connected to an internal school network (Canada, Finland, Iceland, Israel, New Zealand, and Slovenia). Countries where this was the case to a much lower extent were, for instance, Bulgaria, Cyprus, France, and Singapore.

At the targeted grade range in *upper secondary education* in Canada, Chinese Taipei, the Czech Republic, Iceland, Latvia, Norway, and Slovenia, most computers were connected to an internal network. This was much less the case in, for instance, Bulgaria, Cyprus, and France.

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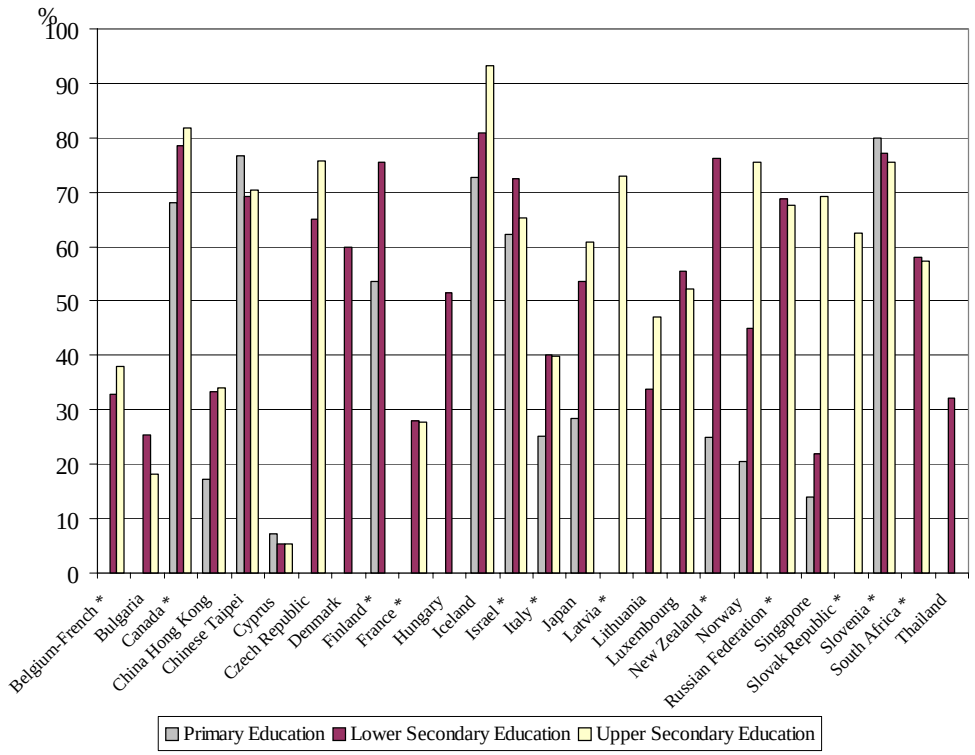
[4] In the United States in 1998 the percentages of computers equipped with Pentiums and PowerMacs were 35, 43, and 43 respectively for primary, lower secondary, and upper secondary schools (Anderson & Ronnkvist, 1999).

[5] Note that question 20 referred to the total number of computers available for use in the targeted grade range.



Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). Missing bars: data not collected.

Figure 4.5[6] Bar graph of average percentages of computers accessible at the grade range connected to a local network-primary, lower, and upper secondary education.

It was expected that the substantial number of schools that began introducing computers in the 1980s would suffer from outdated or malfunctioning equipment. An indication of the extent to which this was the case can be obtained from the SITES respondents' answers to the following question:

Does your school have any computers (in addition to the computers listed in questions 15 and 18)[7], which are not currently in use by teachers and/or students for teaching and/or learning purposes?

If none, write 'none' or '0' and proceed to question 26.

Number of computers not in use: ☐

[6] In addition to the SITES countries, it appeared that in The Netherlands nearly half of the computers (48%) were connected to an internal school network in primary education (ten Brummelhuis, 1998), and 73% were connected in lower secondary education (ten Brummelhuis, 1999).

[7] The computers listed in questions 15 and 18 referred respectively to (i) the total number of computers available for students in the entire school, and (ii) the total number of computers in the entire school that were available for administration and for teachers only.

Why are they not in use?

– Please tick all that apply.

o Computers are outdated
o They are not compatible with other computers
o They are broken
o Teachers/students do not know how to use them
o Other reason

The results are given in Table 4.2.1, which shows that a high percentage of primary schools did not have computers in use because they were broken. (This was especially true of Iceland.) Across countries, the average number of broken computers in schools ranged from 0.5 to 4.

Table 4.2.1
Percentages of students whose schools had computers that were not in use-primary education. For this sub-group: average number of computers (standard errors in parentheses) not in use and percentages of schools that checked reasons for computers not being in use

Country	% schools having comp. not in use	Number of computers not in use	Reason 1: Computers are outdated	Reason 2: Not compat. oth. comp.	Reason 3: They are broken	Reason 4: Don't know how to use
Canada *	51	3.9 (0.2)	73	27	53	10
China Hong Kong	32	1.3 (0.3)	71	11	35	5
Chinese Taipei	11	0.6 (0.2)	40	11	27	13
Cyprus	19	0.5 (0.3)	67	13	64	0
Finland *	49	1.7 (0.2)	75	16	55	8
France *	~	~	~	~	~	~
Iceland	78	4.1 (0.4)	77	34	33	2
Israel *	32	3.2 (0.7)	70	3	38	3
Italy	35	1.4 (0.2)	75	18	31	9
Japan	~	~	~	~	~	~
New Zealand	49	1.9 (0.3)	71	22	61	9
Norway	~	~	~	~	~	~
Singapore	48	4.1 (0.5)	75	18	24	0
Slovenia	41	1.5 (0.2)	86	14	18	4

Notes: Standard error (se): value ± 2*se provides 95% confidence interval for the population. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). See Appendix D for rules of thumb for estimating the standard error for percentages. ~: data not collected.

Tables 4.2.2 and 4.2.3 show that in a good number of countries a substantial percentage of *lower and upper secondary schools* possessed equipment that was not in use for instructional purposes. The absolute number of computers not in use at these levels ranged from 1 to 18. The most common reason for computers not being in use was, as expected, that they were out of date or broken. It is interesting to observe (from a comparison of the statistics from different educational levels) that, Overall, schools at the *upper secondary level* were more inclined to report the existence of computers not being in use than were schools at the primary level.

Table 4.2.2

Percentages of students whose schools had computers that were not in use-lower secondary education. For this sub-group: average number of computers (standard errors in parentheses) not in use and percentages of schools that checked reasons for computers not being in use

Country	% schools having comp. not in use	Number of computers not in use	Reason 1: Computers are outdated	Reason 2: Not compat. oth. comp.	Reason 3: They are broken	Reason 4: Don't know how to use
Belgium-French *	36	3.1 (0.4)	73	16	42	2
Bulgaria	60	5.4 (0.3)	71	24	67	4
Canada *	61	11.0 (0.5)	85	25	52	5
China Hong Kong	50	6.8 (0.3)	87	19	61	1
Chinese Taipei	23	3.9 (0.6)	72	3	63	7
Cyprus	50	1.1 (0.1)	92	37	26	24
Czech Republic	26	1.0 (0.2)	73	16	42	4
Denmark	57	3.7 (0.4)	65	13	57	2
Finland	73	5.6 (0.3)	84	22	47	4
France	~	~	~	~	~	~
Hungary	42	2.1 (0.2)	32	8	24	1
Iceland	81	5.4 (0.4)	80	30	34	3
Israel *	27	2.3 (0.5)	71	16	29	3
Italy *	37	4.7 (0.8)	85	12	42	3
Japan	~	~	~	~	~	~
Lithuania	32	1.7 (0.2)	66	36	65	9
Luxembourg	~	~	~	~	~	~
New Zealand *	68	6.9 (0.4)	76	18	59	6
Norway	~	~	~	~	~	~
Russian Federation *	41	2.7 (0.5)	18	6	33	0
Singapore	55	18.3 (0.1)	81	7	45	0
Slovenia	43	1.5 (0.2)	85	14	18	3
South Africa *	56	4.3 (0.7)	62	20	56	8
Thailand	39	3.1 (0.2)	57	8	67	1

Notes: Standard error (se): value ± 2*se provides 95% confidence interval for the population. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). See Appendix D for rules of thumb for estimating the standard error for percentages. ~: data not collected.

Table 4.2.3

Percentages of students whose schools had computers that were not in use-upper secondary education. For this sub-group: average number of computers (standard errors in parentheses) not in use and percentages of schools that checked reasons for computers not being in use

Country	% schools having comp. not in use	Number of computers not in use	Reason 1: Computers are outdated	Reason 2: Not compat. oth. comp.	Reason 3: They are broken	Reason 4: Don't know how to use
Belgium-French *	33	2.7 (0.4)	72	15	47	0
Bulgaria	61	5.6 (0.5)	70	17	67	7
Canada *	58	12.5 (0.6)	84	19	59	2
China Hong Kong	50	6.8 (0.3)	87	19	61	1
Chinese Taipei	24	9.0 (1.8)	43	12	22	8
Cyprus	63	7.9 (0.7)	94	8	44	5
Czech Republic	29	1.3 (0.2)	73	15	35	3
France	~	~	~	~	~	~
Iceland	54	8.9 (1.8)	100	48	32	0
Israel *	38	4.1 (0.7)	56	5	28	3
Italy *	53	7.1 (0.8)	81	10	43	3
Japan	~	~	~	~	~	~
Latvia *	80	5.4 (0.6)	38	21	27	2
Lithuania	38	2.0 (0.1)	68	37	63	7
Luxembourg	~	~	~	~	~	~
Norway	~	~	~	~	~	~
Russian Federation *	40	2.6 (0.5)	18	6	33	0
Singapore	22	4.8 (0.0)	89	35	34	0
Slovak Republic *	100	5.8 (0.6)	45	11	21	0
Slovenia *	39	2.1 (0.3)	90	10	33	0
South Africa *	35	2.3 (0.5)	69	22	57	7

Notes: Standard error (se): value ± 2*se provides 95% confidence interval for the population. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). See Appendix D for rules of thumb for estimating the standard error for percentages. ~: data not collected.

Peripherals

The additional computer-related equipment (peripherals) available in schools for educational use is another useful indicator of hardware accessibility and functionality. The SITES researchers considered the following list to contain the most up-to-date types of peripherals:

- Laser printer
- CD-ROM drive
- Devices for disabled students
- Devices for digital image processing

- Color printer
- CD-writer
- Graphic tablet
- Video-projector
- Scanner
- LCD panel

Appendix G (Tables G.2.1-G.2.3[8]) contains the percentages of students at schools where it was reported that a particular type of equipment was available for educational use at the targeted grade range. The following findings were drawn from the data presented in these tables.

First, certain equipment was present at the targeted grade range for almost all students in *primary schools* in some countries but hardly at all in other countries. For example:

- A laser printer (at least one) was present for use by three-quarters or more of the students at the targeted grade range in Canada, Finland, and Iceland, but in less than a quarter of the schools in Chinese Taipei, Cyprus, France, and Italy.
- A LCD-panel was rarely available to students except for those in schools in Singapore and Slovenia.

Second, the overall index in Table G.2.1 regarding the average percentage of peripherals possessed by schools in primary education indicated that, especially in Singapore, the availability of peripherals for educational use at the targeted grade range was relatively high, whereas it was quite low in Chinese Taipei.

Table G.2.2 reveals that, in many countries, some peripherals (for example, a laser printer, CD-ROM drive, color printer and scanner) were available for almost all students at the targeted grade range in *lower secondary education*, while in other countries quite substantial variation regarding availability was evident. The overall index of availability of peripherals was relatively high in, for instance, Luxembourg and Singapore, but very low in other countries (less than 20% in Bulgaria, Cyprus, Lithuania, the Russian Federation, and Thailand).

At the targeted grade range in *upper secondary education*, on average more than 50% of the listed peripherals were available in Canada, China Hong Kong, Italy, Luxembourg, Norway, Singapore, and Slovenia. Low percentages of availability were observed in Bulgaria, Lithuania, and the Russian Federation.

Figure 4.6 presents a condensed overview of the availability of peripherals for each educational level, averaged across countries. A comparison of the data for the different educational levels shown in this figure reveals that at the targeted grade range, primary schools had fewer types of peripherals than did secondary schools (except for devices for disabled students, devices for digital image processing, color printers and CD-ROM drives).

[8] Some of the peripherals that were listed in the questionnaires for the ICT-monitor in The Netherlands (ten Brummelhuis, 1998, 1999) were the same as in SITES. Specifically, they were CD-ROM (69% of primary and 89% of lower secondary schools had one or more of these), color printer (45% primary, 65% lower secondary), CD-writer (2% primary, 13% lower secondary), video-projector/ LCD panel (1% primary, 35% lower secondary) and scanner (19% primary, 75% lower secondary).

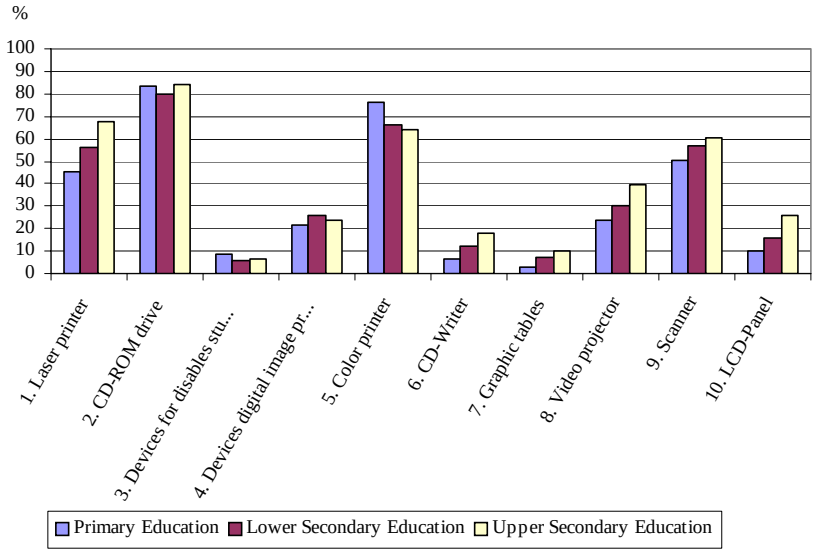


Figure 4.6 Percentages of students whose schools possessed particular peripherals for use in the grade range-primary, lower, and upper secondary education.

Access to Communication Facilities

The Internet and WWW are probably the most visible ICT innovations of the past 10 years. The ability of citizens and schools to access the Internet is rapidly increasing. Many governments have formulated explicit plans to equip schools with access to the Internet before or shortly after the year 2000. Although, as Chapter 2 shows, quite a number of the countries participating in SITES Module-1 had adopted such policies in 1998, many had not. The SITES researchers therefore asked a number of questions in order to determine if schools had *access* to the Internet for instructional purposes. This question was different from the one reported in Chapter 3, which dealt with the use of e-mail/WWW for instructional purposes at the targeted grade range.

Figure 4.7[9] shows the percentages of students attending schools that indicated they had access to the Internet for instructional purposes. It should be noted, however, that the actual percentages of schools that had access to the Internet but used it for purposes other than instruction are likely to be higher.

As a general trend, upper secondary schools had the highest access to the Internet by the end of 1998. Overall, the percentages were lower at the lower secondary level and still lower at the primary level. Access-percentages of over 80% were observed in Canada, China Hong Kong, Chinese Taipei, Denmark, Finland, Iceland, Lithuania, New Zealand, Norway, Singapore, and Slovenia. Low percentages existed especially in Bulgaria, Cyprus, and Thailand.

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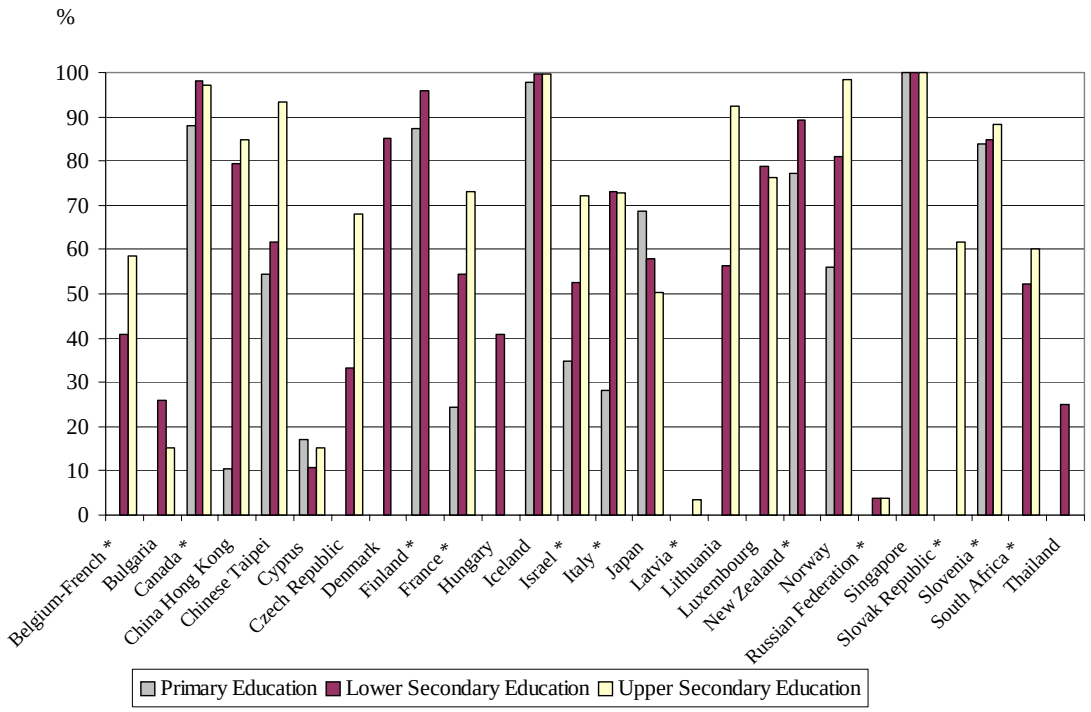
[9] Anderson and Ronnkvist (1999) report percentages of schools with access to the Internet of 87%, 94% and 98% respectively for primary, lower secondary and upper secondary education in the United States. In the United Kingdom, these percentages were 17% and 83% for respectively primary and secondary education (DFEE, 1998). In The Netherlands (according to ten Brummelhuis, 1998, 1999), the percentage at the primary level (23%) was lower than the percentage at the lower secondary level (72%).



Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). Missing bars: data not collected. See Appendix D for rules of thumb for estimating the standard error for percentages.

Figure 4.7 Percentages of students whose schools had access to the Internet for instructional purposes-primary, lower, and upper secondary education.

Those respondents who reported that the school had access to the Internet for instructional purposes were asked a number of additional questions, namely:

- Whether the school had plans to acquire access to the Internet;
- The number of computers that could simultaneously access e-mail;
- The number of computers that could simultaneously access the WWW;
- Whether the school had its own home page and, if yes, what content was available at the school's home page.

The responses to these questions are summarized in Appendix G[10], Tables G.3.1-G.3.3 and G.4.1-G.4.3. From Tables G.3.1-G.3.3 it appears that, in many countries, schools that did not yet have access reported that they planned to acquire it in 1999 or 2000.

Table G.3.1 indicates that, on average, a relatively large percentage of the available computers in the *primary schools* of Chinese Taipei, Finland, Iceland, and Slovenia could simultaneously access the Internet. This situation was seen to a much lesser extent in the other countries.
At the *lower secondary level* (Table G.3.2), roughly the same picture emerged: the average percentages of computers with simultaneous access to the Internet were relatively high in Canada, Chinese Taipei, Finland, Iceland, and Slovenia. Very low figures were observed in Bulgaria,

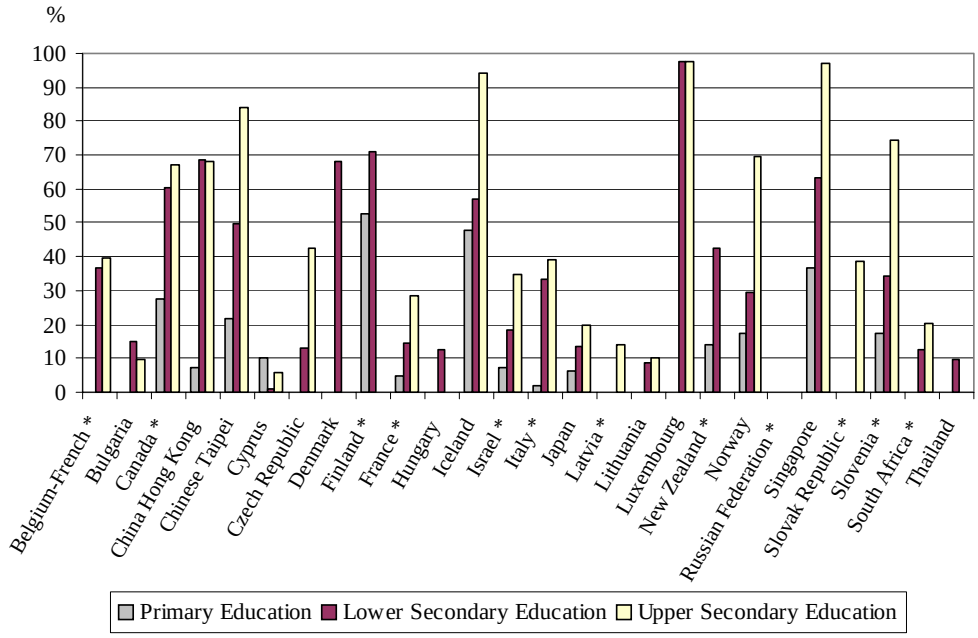
[10] For the United States, Anderson and Ronnkvist (1999) reported the following average percentages for computers with simultaneous Web access: primary education, 21; lower secondary education, 33; and upper secondary education, 37.

France, Italy, Japan, Lithuania, and the Russian Federation.[11]

In *upper secondary schools* (Table G.3.3) in Canada, Chinese Taipei, Iceland, Norway, Singapore, and Slovenia, the percentages of computers with simultaneous access to the Internet was relatively high. These percentages were low in Bulgaria, Cyprus, France, Italy, and the Russian Federation.

In many countries, schools that did not have access reported that they planned to acquire access to the Internet before the year 2001. However, substantial percentages of schools in Bulgaria, China Hong Kong, Cyprus, the Czech Republic, Japan, Latvia, the Russian Federation, and Thailand indicated that they did not have even these plans.

As can be inferred from Figure 4.8 the percentage of students at schools with a home page (that is, the percentage that used e-mail/WWW for instructional purposes at the grade range and that had a home page) was relatively high in a few countries but small in many others. At the *primary level*, a relatively large group of schools had home pages in Finland and Iceland. This was also the case for a majority (more than 50%) of schools at the *lower secondary level* in Canada, China Hong Kong, Chinese Taipei, Denmark, Finland, Iceland, Luxembourg, and Singapore. However home pages were rarely evident in the lower secondary schools of Bulgaria, Cyprus, France, Hungary, Israel, Japan, Lithuania, South Africa, and Thailand. At the *upper secondary level*, the percentage of schools with home pages was high in China Hong Kong, Chinese Taipei, Iceland, Luxembourg, Norway, Singapore, and Slovenia.



Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2). Missing bars: data not collected.

Figure 4.8 Percentages of students whose schools had its own home page (that is: use of e-mail/WWW for instructional purposes at the grade range AND having an own home page)-primary, lower, and upper secondary education.

[11] The percentages are based on those schools that had access to the Internet/WWW for instructional purposes.

With regard to the content of the schools' home pages, the questionnaire respondents were asked if these contained the following types of information and features:

General information
- General information about the school
- Special information for parents (e.g. parent meetings, parent/teacher conferences)
- Information about changes in the time schedule

Information for teachers
- Information on staff development activities
- Lesson plans
- Curriculum guidelines and frameworks
- Clickable links to resources for teachers

Information for students
- Results of student projects (essays, artwork, videos)
- Tests
- Assignments
- Clickable links to resources for students
- Curriculum materials
- Announcements about events
- Other

Given that the percentages of schools that possessed home pages was relatively low in a good number of countries, attempts to compare the available content of home pages across countries should be treated with caution. Summary information about the various types of content is shown in the bar graphs in Figure 4.9 (these statistics are based on the pooled data set, achieved by giving each country the same weight). As Figure 4.9 indicates, general information about the school was, overall, the most frequently available content of the home pages. The frequencies were much lower for the other types of content.

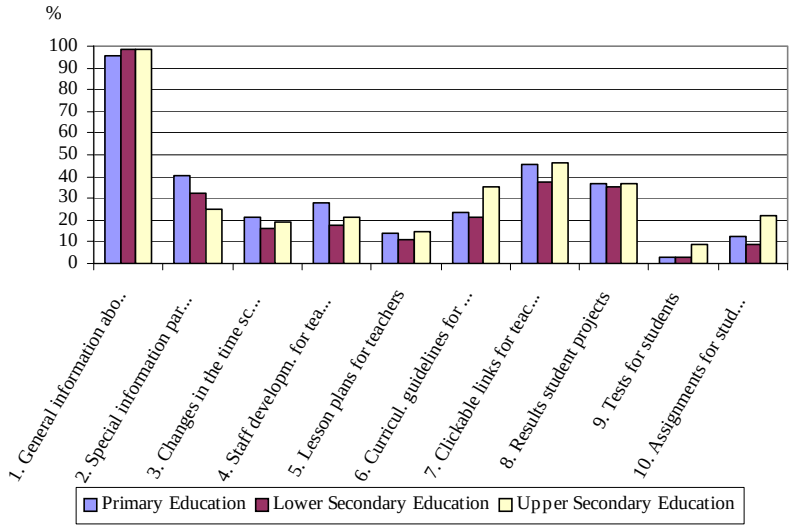


Figure 4.9 Percentages of students at schools that had included particular information on their home page, averaged across countries. Percentages based on the subgroup that used e-mail/WWW for instructional purposes at the grade range AND had an own home page-primary, lower, and upper secondary education.

A further inspection of the data (see Tables G.4.1-G.4.3) led to several other interesting observations. For example, at the lower secondary level:

- Clickable links for students were available at many home pages in Chinese Taipei.
- Many Finnish school-Web sites contained curriculum guidelines for teachers.
- Placing the results of students' projects on the Web was quite popular in Luxembourg.

Perceived Obstacles Regarding Hardware Infrastructure

In the sections above, a variety of indicators provided a bird's-eye view of the hardware infrastructure available in schools at the primary, lower secondary, and upper secondary levels at the end of 1998. The comparative data from across countries should help interested audiences make some decisions about which measures to take to improve this infrastructure in their schools. However, an additional piece of information may help inform debates on future policy initiatives. This is the perception that educational practitioners have of needs and priorities regarding the hardware infrastructure in the schools.

Tables G.7.1-G.7.3 and G.8.1-G.8.3 show the percentages of respondents (school principals and computer coordinators) who indicated that particular hardware problems were *major obstacles* for realizing the computer-related goals of the school for students at the targeted grade range. In order to interpret the relative magnitude of the percentages for the hardware-related items, these should be compared with the percentages for the other items in the list, which included problems relating to software, instruction, and the Internet/WWW.

Respondents identified the following hardware obstacles:

School principals (Tables G.7.1-G.7.3)
1. Insufficient number of computers

Technical respondents (Tables G.8.1-G.8.3)
1. Insufficient number of computers
2. Insufficient peripherals (printers, scanners, transviewers)
3. Outdated or lack of school network or LAN
11. Insufficient computers with simultaneous access to the Internet/WWW
12. Slow or unreliable network performance
13. Too complicated to connect to the network

An 'insufficient number of computers' was seen as a major obstacle by a majority of respondents in most countries. Relatively low percentages were observed in primary education in Singapore, in lower secondary education in Italy, and at the upper secondary level in Chinese Taipei, France, Italy, Luxembourg, Singapore, and Japan. Other problems that were frequently mentioned (although a good measure of variation existed between countries) were 'not enough simultaneous access to the Internet/WWW', 'lack of technical assistance', and 'outdated school networks'.

Software

The second main area of ICT-infrastructure in schools dealt with software. The two main categories of software distinguished for SITES-Module-1 were (i) general purpose software and (ii) school

subject-specific software. The importance of this distinction was documented by Pelgrum and Schipper (1993), who showed that the integration of computers in the school curriculum was associated with the availability of subject-specific educational tool software. In other words, the more educational tool software available, the more computer use was integrated into the learning of subjects. However, the extent to which general-purpose programs was available was shown to be associated with an emphasis on an informatics type of curriculum.

In order to determine which types of software were available in schools, the technical questionnaire respondents were asked the following question:

In your school, which of the following types of software are available for teaching and learning (in grades *-*) on at least one computer?

– Tick all that are available.

1. Word-processing, desktop publishing
2. Spreadsheet
3. Database
4. Graphics: presentation, no professional drawing
5. CAD (computer-aided design), CAM (computer-aided manufacturing)
6. Statistical/mathematical programs
7. Programming languages
8. Accounting, book-keeping, financial software
9. Drill and practice programs
10. Tutorial programs (for self-learning)
11. Simulations (e.g. real world simulations)
12. Educational games
13. Recreational games/other games
14. For exams/tests/constructing tests/administrating tests
15. Internet browser
16. Email software
17. Encyclopedia on CD-ROM
18. Video/audio/authorware
19. Music composition
20. Presentation software (e.g. PowerPoint)
21. Software supporting microcomputer-based laboratories.

Tables G.5.1-G.5.3[12] present summative data drawn from the answers to this question. From an inspection of these tables, it appears that most primary, lower, and upper secondary schools possessed software for word-processing at the grade range. Spreadsheet software was also quite commonly available, except in the primary schools of Chinese Taipei and the lower secondary schools of Cyprus, Lithuania, and the Russian Federation. For the other types of software, a much

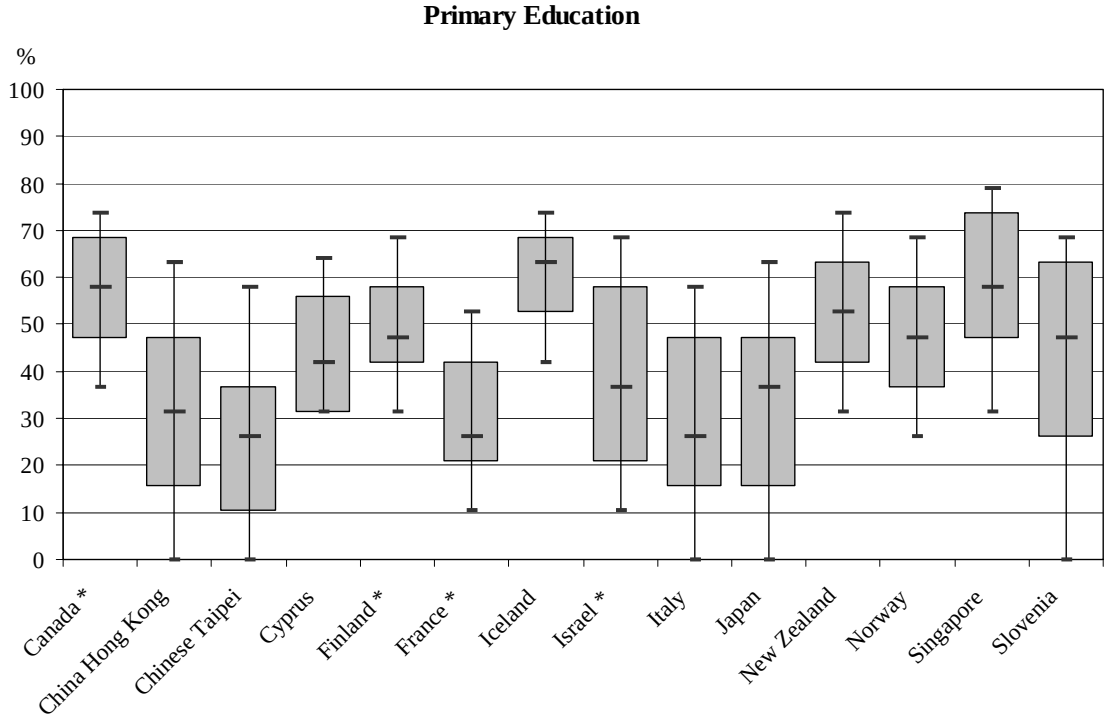
[12] The results regarding the availability of types of software for the lower secondary schools in The Netherlands (ten Brummelhuis, 1999) were comparable to the results for the other countries. The percentage for the availability of word-processing/desktop publishing, spreadsheet, and database software was nearly 100%. The percentages for the other types of software varied from relatively high (graphics, 91%) to low (music composition, 18%; multimedia, video/audio authorware, 5%).

greater variation across countries was observed. Software for simulations, for video/audio/authorware, for testing students, and for microcomputer-based laboratories were not yet commonly available in most schools.

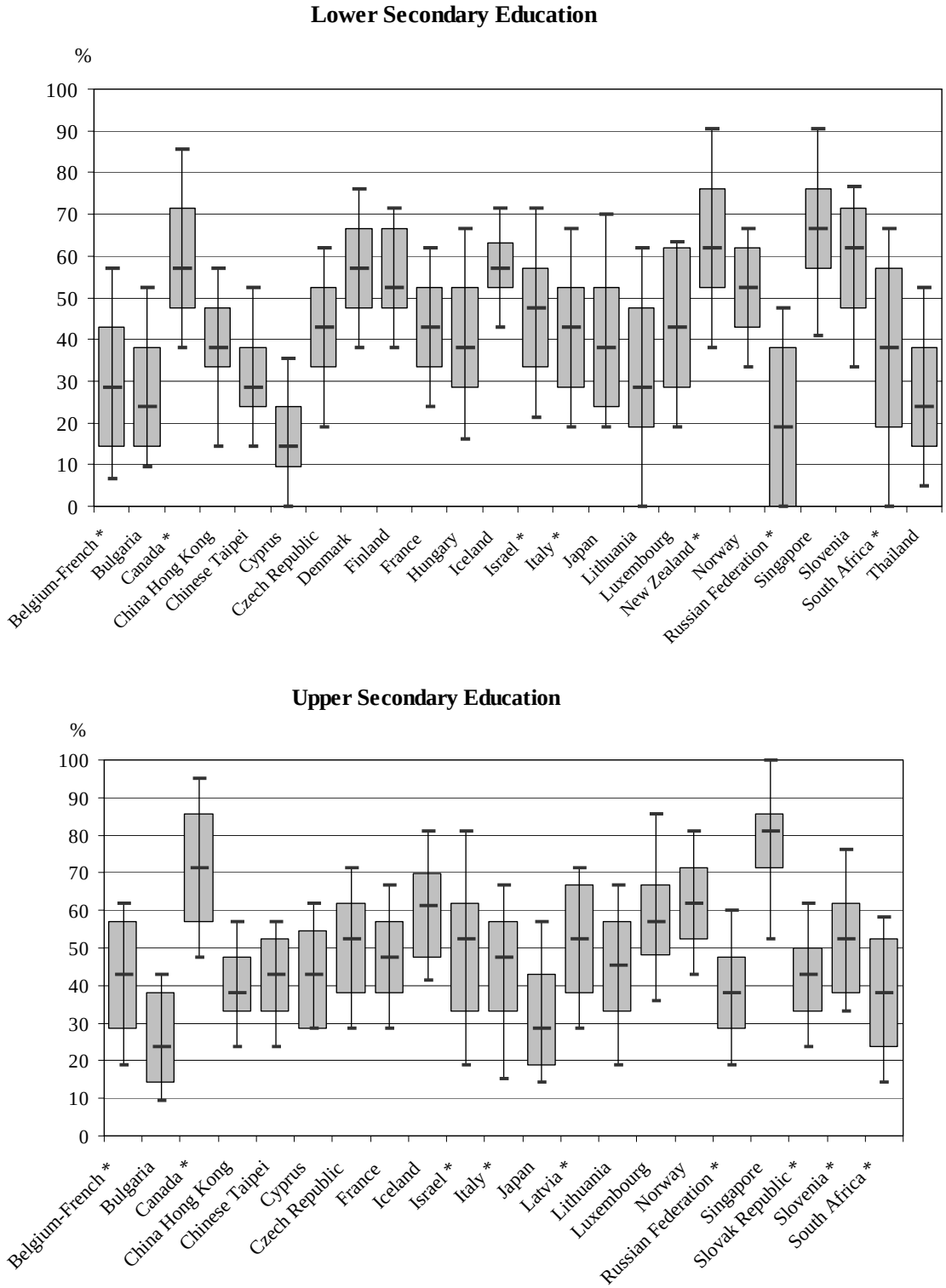
Figure 4.10 offers a more condensed presentation of the data relating to software availability. The figure shows that the median percentage of available types of software (for use in the grade range) was, for *primary education*, low in Chinese Taipei, France, and Italy, but relatively high in Canada, Iceland, New Zealand, and Singapore.

The average availability (in the grade range) of types of software was relatively high at *lower secondary schools*[13] in Canada, Denmark, Finland, Iceland, New Zealand, Norway, Singapore, and Slovenia. The availability was low in Belgium-French, Bulgaria, Chinese-Taipei, Cyprus, Lithuania, The Russian Federation, and Thailand.

At the *upper secondary level*, a relatively high average percentage of types of software appeared in Canada, Iceland, Norway, and Singapore. This index was relatively low in Bulgaria and Japan.



[13] With regard to the availability of software in the lower secondary schools, the item 'software supporting microcomputer-based laboratories' was not included in the questionnaire for the ICT-monitor in The Netherlands (ten Brummelhuis, 1998). When this same item was removed from the analysis for other countries, it became evident that the availability of the remaining types of software was high in The Netherlands compared to that of the other countries (median = 60). Only Singapore (70) and New Zealand (65) had higher median scores.



Notes: Availability per school was calculated as: (number of types available/21)*100; Items 5 and 8 (see text) were excluded for primary education. Boxes range from 25% lowest to 75% highest value; the horizontal line in the boxes represents the median; tiles show values for 10% and 90% of the cases. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2).

Figure 4.10 Box plots of availability of types of software for use at the grade range-primary, lower, and upper secondary education. Average percentage available from a list of 21 types.

The software types in the previous list were mainly general purpose. In order to understand the extent to which schools possessed software specifically dedicated to school subjects, the following question was included in the technical questionnaire:

For which of the following subjects (or subject areas) is educational software available in your school for use in grades *-*?

Exclude programming languages or office programs (like word processing and spreadsheet programs) as educational software.

– *Tick all subjects (or subject areas) for which software is available (including software for multidisciplinary approaches).*

1. Mathematics
2. Physics
3. Chemistry
4. Biology/life science
5. Earth science
6. Language/mother tongue
7. Foreign language(s)
8. Creative arts (music, visual arts)
9. History
10. Civics
11. Economics
12. Geography
13. Vocational subjects
14. Computer education/informatics
15. Multidisciplinary projects or activities

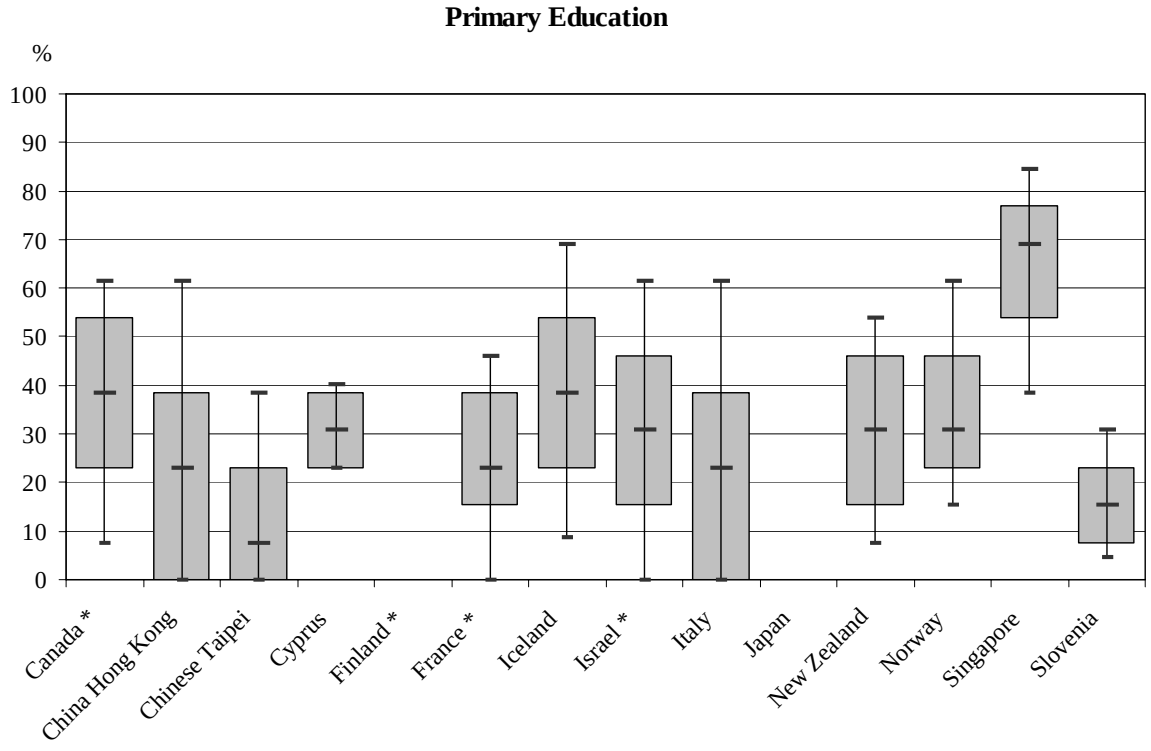
The CompEd study of 1992 revealed a low availability of school-subject specific software in the participating schools. One would expect that, after so many years of ICT developments, most schools would have possessed at least one piece of software for most subject areas by the end of 1998. Tables G.6.1-G.6.2 show that this was clearly not yet the case in all countries. For example, the availability of software for mathematics for use in the grade range in *lower secondary education* was *very* low in Bulgaria, Chinese Taipei, and Cyprus. However, software for mathematics was available at a relatively high percentage of lower secondary schools in the Czech Republic, Denmark, Iceland, Italy, Norway, and Singapore. For the other school subjects, the figures showed that an even greater number of countries had little such software available for use in the grade range.

Although, in general, mathematics (among all the school subjects) had the highest availability of software, there were some noteworthy exceptions to this trend. In *lower secondary schools*[14] in Belgium-French, the most common subject for which software was available, for use in the grade

[14] In the Netherlands ICT-monitor (ten Brummelhuis, 1998), the following subjects were mentioned in the questionnaire for primary schools (the percentages in brackets are for grade 7): mathematics (82%), biology/life science (24%), language/mother tongue (84%), foreign language (11%), creative arts (20%), history (9%), and geography (85%).

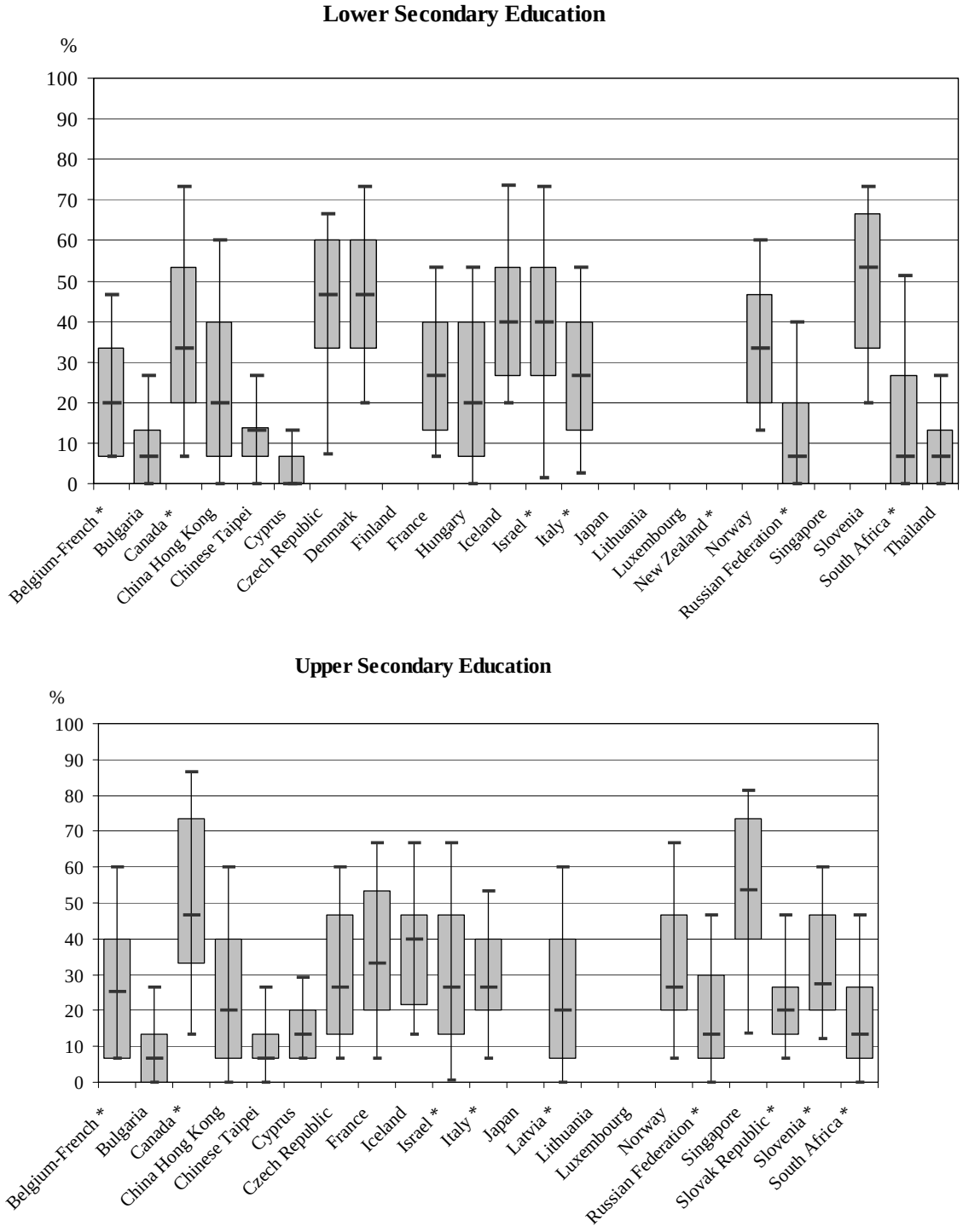
range, was mother tongue. In Bulgaria, China Hong Kong, Chinese Taipei, Hungary, Lithuania, the Russian Federation, and Thailand the most frequently mentioned subject was computer education/informatics. In Finland, it was foreign language(s).

Figure 4.11 contains the box plots of the subject-software coverage indicator. From this index it appeared that in *primary education* the availability of subject-specific software for use in the grade range was relatively high in Singapore. The subject coverage was very high in *lower secondary education* in Slovenia but was considerably lower in other countries. In *upper secondary education*, the median of the subject-software coverage was below 40 in all countries except Singapore. The lowest medians appeared in Bulgaria and Chinese Taipei.



Notes: Software coverage per school was calculated as: (number of subjects for which software was available/15)*100. Boxes range from 25% lowest to 75% highest value; the horizontal line in the boxes represents the median; tiles show values for 10% and 90% of the cases. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2.) Missing boxes: countries did not use complete international list.

Figure 4.11 Box plots of software coverage of school subjects for use at the grade range-primary, lower, and upper secondary education. Average across schools of percentage available from a list of 13 school subjects (primary education) and 15 (lower and upper secondary education). (continue on next page)



Notes: Software coverage per school was calculated as: (number of subjects for which software was available/15)*100. Boxes range from 25% lowest to 75% highest value; the horizontal line in the boxes represents the median; tiles show values for 10% and 90% of the cases. *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2.) Missing boxes: countries did not use complete international list.

Figure 4.11 (continued from previous page) Box plots of software coverage of school subjects for use at the grade range-primary, lower, and upper secondary education. Average across schools of percentage available from a list of 13 school subjects (primary education) and 15 (lower and upper secondary education).

Perceived Obstacles with Regard to Software

Tables G.7.1-G.7.3 and G.8.1-G.8.3 present the percentages of respondents (school principals and/or computer coordinators) who said that particular software problems (respondents could choose items from the following list) were preventing realization of the schools' computer-related goals for students in the targeted grade range.

Principal questionnaire (Tables G.7.1-G.7.3)
2. Not enough copies of software for instructional purposes
3. Not enough types (variety) of software

Technical questionnaire (Tables G.8.1-G.8.3)
4. Not enough copies of software for instructional purposes
5. Software too complicated for teachers and/or students to use
6. Software not specific enough and/or not adaptable for use in subjects
7. Lack of information about software or its quality prior to purchasing
8. Most of the software is not in the language of instruction
9. Cultural incompatibility of imported instructional software
10. Curricular incompatibility of imported instructional software

The tables show that the most frequently mentioned obstacle from the above list in almost every country, at all educational levels, was 'not enough copies of software for instructional purposes'. However, in Israel and Singapore, the obstacle most mentioned by respondents from the *primary and secondary school levels* was 'software not specific enough and/or not adaptable for use in subjects'.

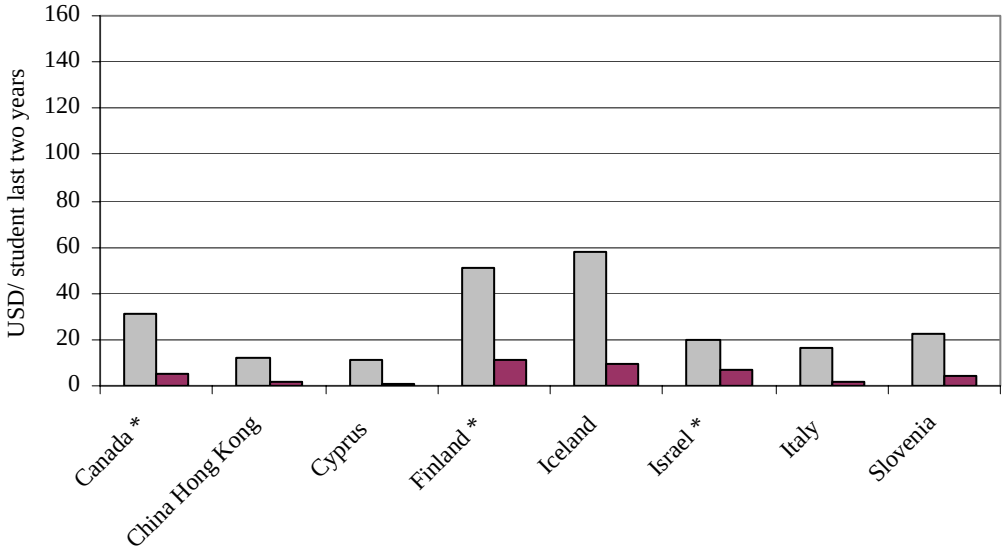
Schools' Investments in Hardware and Software

An interesting, albeit difficult to investigate, question is this: How much should schools spend from their own budgets on different ICT items (hardware, software, staff development, maintenance, and staff salaries) for the targeted grade range? This information was collected (in national currencies) in 14 countries.[15] It makes little sense to present the raw figures here because these figures are meaningful only if they are presented alongside contextual information, such as the size of the school. Figure 4.12 contains the average amount of money (in US$ per student) that schools at the primary, lower secondary and upper secondary educational levels had spent, from their own budgets, over the *previous two years*, on hardware and software[16]. It is interesting to note that the amounts spent on software were only a fraction of the sums spent on hardware. As may be expected, the differences between countries were very high. For example, in primary education the expenditure per student in Finland was approximately $US50 while in Italy it was $US15.

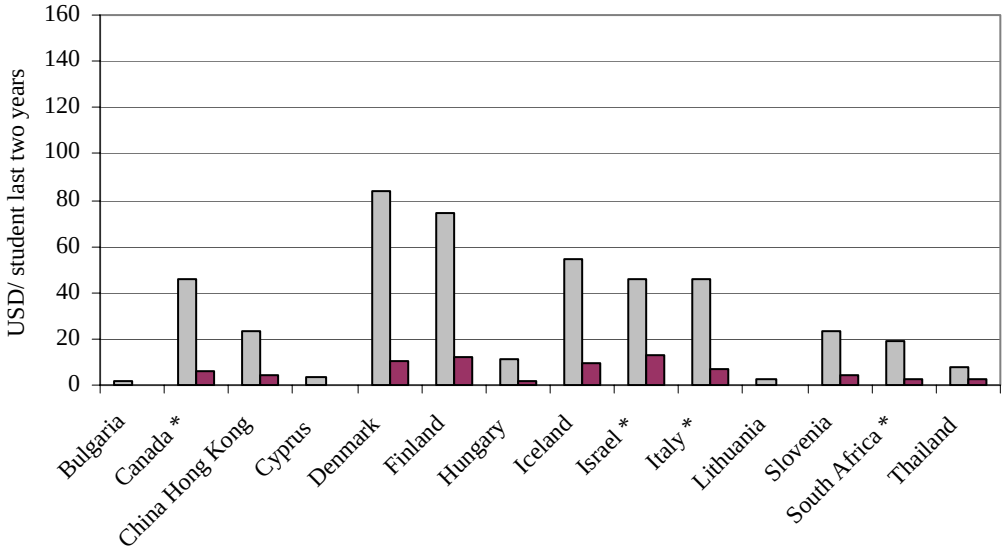
[15] The SITES researchers from these countries considered that collecting this data from school principals would be feasible. This was not the case in the other countries in the study.

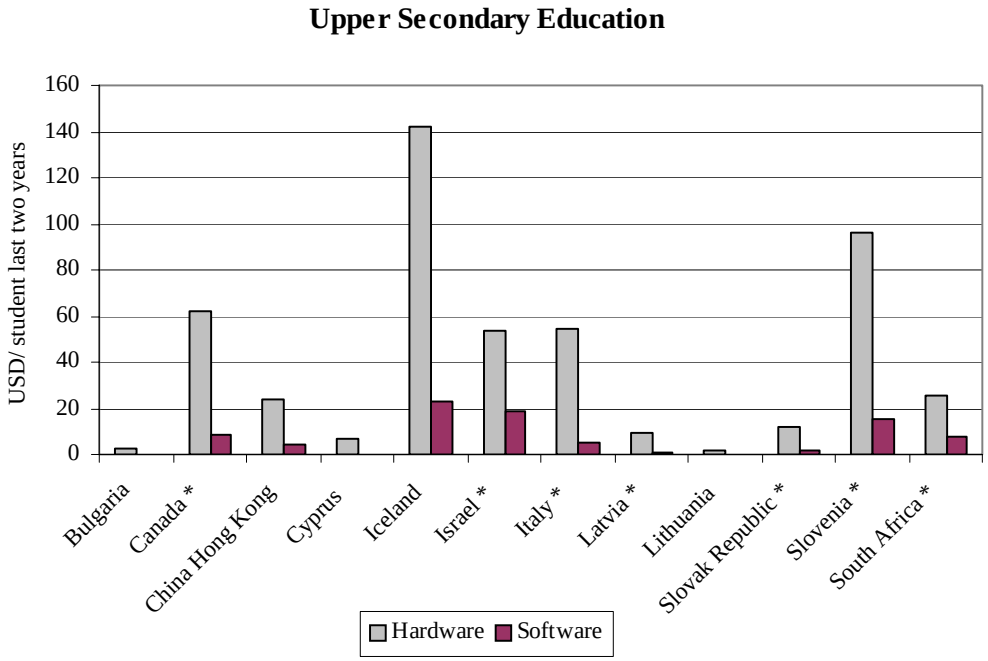
[16] The actual question to principals was in terms of expenditures for the grade range. However, there were indications that the answers were given for the whole school. Therefore, the expenditure per student was calculated on the basis of all students in the school.

Primary Education



Lower Secondary Education





Notes: *: country did not satisfy all sampling criteria (see Chapter 1, Table 1.2).

Figure 4.12 Average expenditures in the last two school years (in US$ per student) for hardware and software items-primary, lower, and upper secondary education.

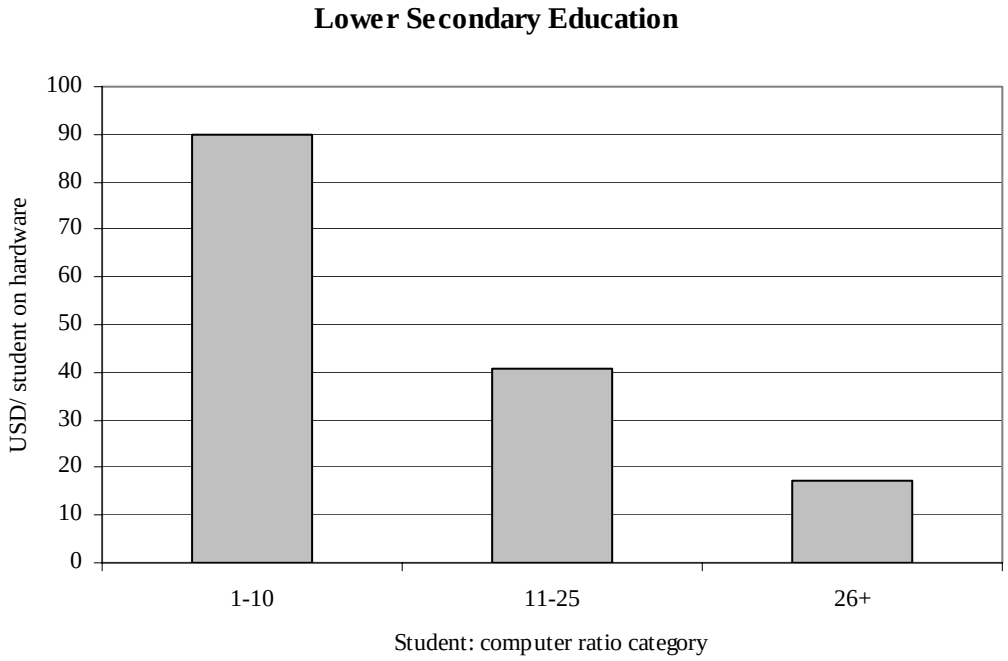


Figure 4.13 Average expenditures on hardware by level of student:computer ratio for lower secondary education (across countries).

To determine if there was a demonstrable relationship between schools' investments in hardware and their student:computer ratios, the latter was categorized into three levels (between 0-10, 11-25, and 26). Breakdowns of the hardware expenditures by these three groups showed clear relationships within countries. The overall trend (across countries) is evident in Figure 4.13, which shows that schools with favorable student:computer ratios tended to spend much more from their own budgets on hardware acquisition than did the other schools.

In the United Kingdom, for the financial year 1997-1998, an average expenditure was reported of £9 per student in primary education and £30 in secondary education (DFEE, 1998). The money was spent on 'computers, robots, software, and other materials' and 'peripheral equipment, upgrades, and replacements'.

Summary and Reflections

This chapter contained a description of a large number of indicators regarding the hardware and software infrastructure in schools. The trend data (that is, a comparison of current student:computer ratios with 1995 data) show that over the four year period most countries developed rapidly in terms of equipping their schools with computer hardware and software. The overall picture that emerges from this chapter is that huge differences exist between schools in different countries regarding access to ICT equipment and facilities such as the Internet/WWW. It seems plausible to argue that such differences stem mainly from the fact that some governments tend to stimulate the creation of ICT-infrastructure in schools to a much greater extent than others do. However, it may also be the case that differences in the extent to which schools undertake private initiatives contribute to these disparities (refer Figure 4.13).

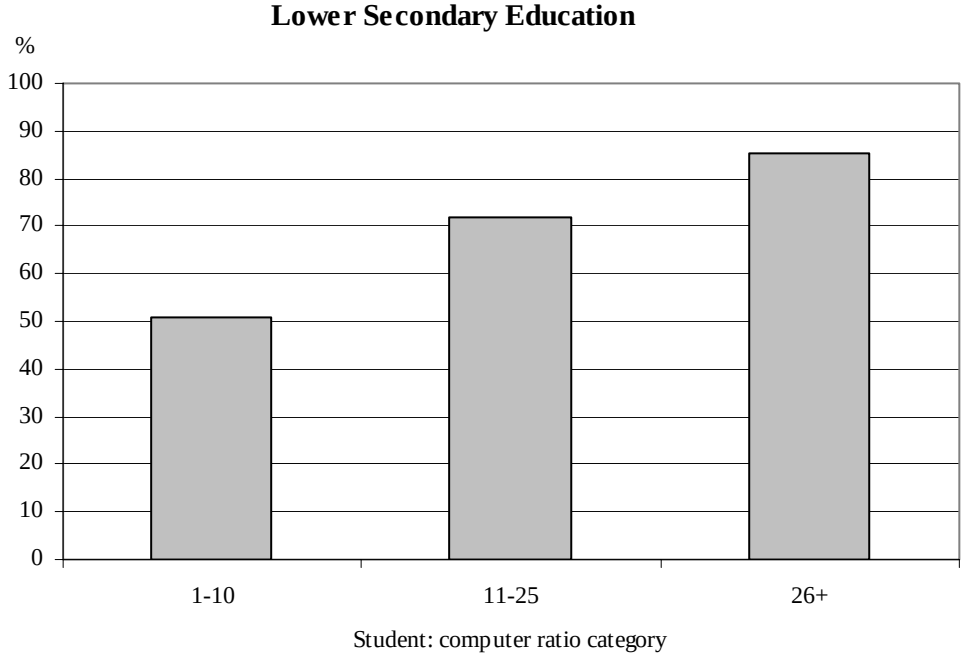


Figure 4.14 Breakdown for lower secondary education of percentages of school principals who indicated that a shortage of hardware was a main obstacle (at the grade range) by levels of student:computer ratios.

Despite the fact that student:computer ratios did improve considerably over the four years between 1995 and 1998, one of the major obstacles that schools still saw as hampering the realization of ICT-related goals was the lack of a sufficient number of computers. For political decision-makers this may be a frustrating observation, as it seems that the number of computers actually available 'is never enough'. However, a closer inspection of the data shows that the frequency of complaints about lack of equipment tended to decrease markedly in those schools that had increased their student:computer ratios. Figure 4.14 illustrates that in schools where the student:computer ratios were 25 or higher, approximately 80% of the respondents complained about a lack of equipment. However, this percentage dropped to 50 in those schools with student:computer ratios of 10 or lower.

Given the over-arching research theme of SITES Module-1, namely the potential that ICT has to facilitate the adoption and implementation of the emerging pedagogical paradigm, it is of considerable interest to analyze the relationship between indicators of ICT infrastructure and the paradigm indicators described in Chapter 3. Figure 3.9 in that chapter reveals a considerable co-variation between student:computer ratios and the emerging pedagogical paradigm. However, at this stage of SITES, it cannot yet be ascertained if this co-variation denotes a causal relationship.

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