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Obstacles to the integration of ICT in education: results from a worldwide educational assessment

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Abstract

The main focus of this article is on the perceptions of educational practitioners (at the lower secondary level) regarding obstacles that seriously impede the realization of ICT-related goals of schools. The results are from a worldwide survey among national representative samples of schools from 26 countries. The article contains a short summary of the design of this project, a review of main indicators regarding ICT (Information and Communication Technologies) in elementary and lower secondary schools, main obstacles and an exploration of the co-variation between obstacles and contextual factors at the country-level.

Keywords: Assessment; International comparisons; Indicators; Hardware; Computers; ICT; Internet

1. Introduction

Over the past 5 years, one may observe the existence of a worldwide societal debate about the future of our societies and the potential implications for the goals and organization of our educational systems [for instance, European Round Table of Industrialists (ERT, 1997); Panel on Educational Technology (PCACT/PET, 1997)]. The information metaphor has triggered off a whole set of wild speculations about the necessity of educational reforms that will allow future citizens to survive in an information society. Expectations that were mentioned in several influential policy documents are shown in Table 1, reflecting a shift from the learner as passive consumer of educational offerings to an active knowledge gathering and productive participant in educational activities. It seems that the current belief is that ICT is not only the backbone of the Information Society, but also an important catalyst and tool for inducing educational reforms that change our students into productive knowledge workers.

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Many governments have, in the late 1990s, developed plans to intensify their investments regarding ICT in education. The quick rise of the Internet and worldwide web (WWW) have led to the adoption of objectives to equip all schools with access to these facilities in a relatively short period of time.

ICT in education is an area which is in turmoil and in which many participants play a role. Forces that operate on the micro- and meso-level of the education system (that is at schools and in classrooms) may be influential in bringing about changes that are beyond the direct control of ministries of education. Therefore, it is important for educational decision making to periodically assess the actual situation of ICT in educational practice.

Many countries are regularly monitoring the status of ICT in education in order not only to account for the (sometimes huge) financial investments from public sources, but also to inform decisions about the content and directions of future policies. In addition to national assessments, governments are usually quite eager to find out how the implementation of ICT-related efforts are progressing in comparison with other countries.

The International Association for the Evaluation of Educational Achievement (IEA) decided in 1997 to conduct such comparisons by means of the Second Information Technology in Education Study (SITES). This study consists of three phases: Module-1 (1997–1999): a school survey, Module-2 (1999–2002): case studies of innovative ICT-practices, Module-3 (2001–2005): school, teacher and student surveys. Between November 1998 and February 1999, data were collected in representative samples of primary and secondary schools in 26 countries.

Table 1
Expected changes from education in the industrial society to education in the information

Actor	Education in the Industrial Society	Education in the Information Society
School	• Isolated from society	• Integrated in society
	• Most information on school functioning confidential	• Information openly available
Teacher	• Initiator of instruction	• Helps students find appropriate instructional path
	• Whole class teaching	• Guides students' independent learning
	• Evaluates student	• Helps student to evaluate own progress
	• Places low emphasis on communication skills	• Places high emphasis on communication skills
Student	• Mostly passive	• More active
	• Learns mostly at school	• Learns at school and outside school
	• Hardly any teamwork	• Much teamwork
	• Takes questions from books or teachers	• Asks questions
	• Learns answers to questions	• Finds answers to questions
	• Low interest in learning	• High interest
Parent	• Hardly actively involved in learning process	• Very active in learning process
	• No steering of instruction	• Co-steering
	• No life-long learning model	• Parents provide model

Source: Pelgrum, ten Brummelhuis, Collis, Plomp, Janssen Reinen (1997).

In this article, in addition to a review of main ICT-indicators for primary and lower secondary education, the main focus is on practitioners' views of what are the main obstacles to the realization of ICT-related goals in schools. This is followed by a presentation of results of explorations regarding contextual factors that may be associated with variations between countries. Time and space considerations have led to a decision to restrict these explorations to the level of lower secondary education.

2. Summary of SITES Module-1

The SITES focussed on assessing the current situation of ICT in education against the presence of pedagogical practices that are important for ensuring that citizens acquire the skills necessary to function well in the Information Society.

Education in the past was usually a matter of uni-directional transfer of information: from the teacher to the student. The main pedagogical approach was whole class teaching. Many argue that new pedagogical models need to be explored in order to prepare future citizens for life long learning. There is, as yet, little consensus in societies about what these new pedagogical models should encompass. There are notions that students should be trained to learn more autonomously and to get access to and digest information more independently than has been the case so far. However, what this means for the educational process is still rather unclear. Given that there is no recipe for education of the future, one may wonder to what extent schools already embrace the notion of more autonomous learning of students. If this learning can be measured in a reliable way via questionnaire techniques, it becomes possible to investigate in more depth which pedagogical approaches are associated with this concept. This consideration led to the development of *a first main question* for SITES: to what extent have schools adopted objectives and practices that reflect a focus on autonomous learning strategies?

It is often assumed that active learning can be facilitated by ICT. Active learning presupposes that the learner has easy access to information sources. Such access nowadays seems increasingly to be the province of the Internet and of interactive, locally available data bases, such as encyclopedia on CD-ROM. *The second main question* the study therefore addressed was this: which ICT infrastructure (equipment, software, access to the Internet and the like) is available in schools? Information related to this question may potentially help in understanding the extent to which the infrastructure supports the realization of new educational objectives.

It is known from previous research that educational innovations usually do not succeed if teachers are not provided with the skills and knowledge needed to carry them out. Training teachers is a very expensive activity and hence, often much neglected in large-scale innovations. For SITES it was therefore seen as important to pose this concern as the *third main question:* what staff development and support services exist with regard to ICT? Although teachers are the most important change agents at the educational work floor, what is perhaps even more important in the early stages of adopting innovations is the role played by leadership 'gatekeepers' such as school principals. The *fourth main question*, then, was to what extent does the school management offer a supportive climate for the use of ICT in the school?

The study was designed as a survey among a representative sample of schools in each country that participated in the study. Schools were sampled at three levels in the education system:

primary (I), lower secondary (II), and upper secondary education (III). The countries that participated at each of these levels are shown in Table 2, which also contains the number of schools that participated in the study.

The topics about which information was collected from the schools were (as shown in Table 3): curriculum, infrastructure, staff development, and management/organization. Also an (open) question was presented to school principals asking them to provide one example of the most satisfying experience with ICT in the school.

The data collection for the study took place between November 1998 and February 1999. The coordination center of the study was located at the University of Twente in The Netherlands. The results of this study were published in Pelgrum and Anderson (1999).

3. Summary of descriptive results

In this section a number of indicators from the study will be reviewed. Because of space limitations, this review will be limited to the data from primary and lower secondary education.

Indicators of the available *ICT infrastructure* are shown in Table 4. The student:computer ratio is conceived as indicators of the availability of computers, whereas the average percentage of multimedia machines (defined in the questionnaire as 'computers equipped with a CD-ROM and a sound card') provides an indication of the quality of the equipment. These two indicators differ quite considerably between countries as well as between school levels. Primary as well as lower secondary schools in Canada, Finland, Iceland, New Zealand, Norway and Singapore seem to be very well equipped in terms of quantity of hardware. The ratios in economically less developed countries were much less favorable. The general trend is that secondary schools have more computers than primary schools. However, the percentage of multimedia computers tends to be higher in primary schools.

Table 2
Number of schools participating per country and educational level in SITES Module-1

Country	School level			Country	School level		
	I	II	III		I	II	III
Belgium-French	~	137	140	Italy	205	190	186
Bulgaria	~	209	225	Japan	215	204	210
Canada	1397	860	786	Latvia	~	~	122
China Hong Kong	218	317	317	Lithuania	~	239	546
Chinese Taipei	212	210	235	Luxembourg	~	18	22
Cyprus	26	33	31	New Zealand	210	259	~
Czech Republic	~	255	235	Norway	1298	809	406
Denmark	~	229	~	Russian Federation	~	106	106
Finland	185	197	~	Singapore	192	145	30
France	309	296	293	Slovenia	~	~	157
Hungary	~	257	~	Slovak Republic	132	132	120
Iceland	137	103	27	South Africa	~	109	113
Israel	144	129	133	Thailand	~	426	~

I, primary level; II, lower secondary level; III, upper secondary level; ~, no participation at this level.

Only in some countries all schools had, by end of 1999, access to the Internet. This was the case in Canada, Finland, Iceland, Singapore and Slovenia. This does not necessarily mean that students use the Internet (see below).

It is often argued that indicators of infrastructure tend to be obsolete by the time that they are published. Empirical evidence for this statement is shown in Fig. 1, which contains a comparison of student:computer ratios from SITES Module-1 and comparable ratios that the author calculated[1] from data collected in 1995 in the Third International Mathematics and Science Study (IEA-TIMSS, see Beaton, Mullis, Martin, Gonzalez, Kelly, & Smith, 1996). Overall it seems that the typical country cut their student/computer ratios by slightly more than a half between 1995 and 1998. Several countries reduced their ratios even more rapidly, probably as a result of national programs to expand their educational ICT infrastructure. It is expected that in the forthcoming years indicators of ICT infrastructure will become available more frequently than has been the case until now, because in most of the international assessments that are currently underway (from OECD as well as IEA) these indicators are included.

Table 3
Topics addressed in SITES module-1

Curriculum
- ICT-related objectives of the school
- Presence of types of teaching and learning practices
- ICT attainment targets
- Realization of ICT-related objectives
- Use of e-mail/WWW for instructional purposes
- Percentage of students/teachers using WWW
- Internet-related activities of students
- Use of technology applications by students

Infrastructure
- Needs and priorities
- Perceived obstacles
- Expenditures
- Software
- Maintenance
- Number and types of computers
- Operating systems
- Processor types
- Hardware
- Access to e-mail/WWW
- Existence and content of Web home page
- Number of computers not in use
- Availability of peripherals
- Availability of software types
- Availability of software for school subjects
- Hardware- and software-related obstacles

Staff Development
- Prescriptions regarding training of teacher in the school
- Attendance by teachers
- Expenditures on staff development
- Types of internal information exchange
- Availability of in-house/external training courses
- Self-assessment of ICT skills

Management and organization
- Existence of written policies on ICT
- Priorities for external support
- ICT-related policy measures
- Principal attitudes towards ICT
- Use of ICT for administration/monitoring
- Technical support infrastructure
- Priorities for external support

Innovative practices
- Most satisfying ICT-related learning activities experienced

[1] With thanks to Rien Steen.

From the many *curriculum indicators* that were collected in SITES Module-1, we will review the ones that relate to new pedagogy, emphasis on the acquisition of ICT-related skills and the use of the Internet. The definitions of these indicators are explained below.

An attempt was made to measure (as an indication of the adoption of new pedagogical approaches) the presence of student controlled approaches to learning by means of ratings of school principals of the extent that the following activities were present in the schools:

1. Students developing abilities to undertake independent learning.
2. Providing weaker students with additional instruction.
3. Organizing teaching and learning so that differences in entrance level, learning pace, and learning route are taken into account.
4. Students learning to search for information, process data, and present information.
5. Students being largely responsible for controlling their own learning progress.
6. Students learning and/or working during lessons at their own pace.

Table 4
Indicators of ICT infrastructure in primary and lower secondary education

Country	Primary education			Lower secondary education		
	Ratio	Multimedia	Internet	Ratio	Multimedia	Internet
Belgium-French[a]	~	~	~	25	25	41
Bulgaria	~	~	~	238	8	26
Canada[a]	8	53	88	7	40	98
China Hong Kong	25	90	10	23	81	80
Chinese Taipei	81	55	55	25	35	62
Cyprus	183	69	17	216	44	11
Czech Republic	~	~	~	34	23	33
Denmark	~	~	~	9	47	85
Finland[a]	12	58	87	10	52	96
France[a]	25	~	24	17	41	55
Hungary	~	~	~	25	32	41
Iceland	13	58	98	12	60	100
Israel[a]	16	43	35	14	36	53
Italy[a]	88	78	28	16	45	73
Japan	28	72	69	14	56	58
Lithuania	~	~	~	90	15	56
Luxembourg	~	~	~	12	16	79
New Zealand[a]	14	61	77	8	25	89
Norway	13	40	56	9	43	81
Russian Federation[a]	~	~	~	121	9	4
Singapore	12	96	100	8	98	100
Slovenia	23	49	84	25	48	85
South Africa[a]	~	~	~	123	25	52
Thailand	~	~	~	62	21	25

Ratio: number of students divided by number of computers in the country; Multimedia: average across schools of percentages multimedia machines; Internet: percentage of schools having access to the Internet; ~, no participation at this level.

[a] Country did not satisfy all sampling criteria in one or both populations.

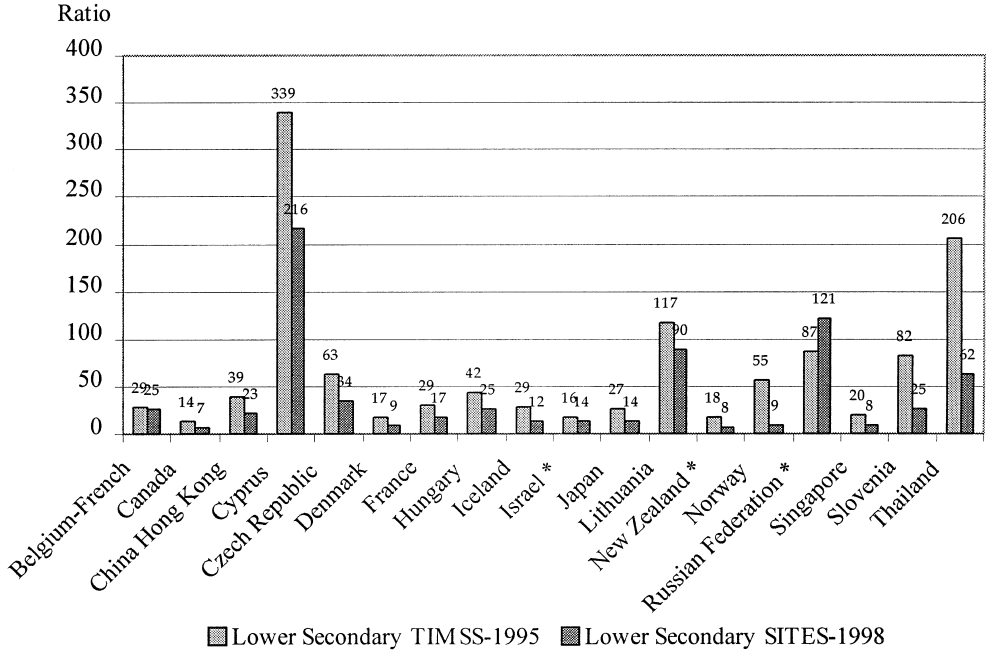
7. Students involved in cooperative and/or project-based learning.
8. Combining parts of school subjects with one another (multidisciplinary approach).

From this set of items, a composite index was calculated and transformed to a scale with a minimum of zero and a maximum of 100. The average values of this index for each country are shown in Table 5 under the heading 'Student controlled'.

With regard to expectations regarding the outcomes of *learning about ICT*, school principals were requested to indicate, on the basis of the school's objectives, which of the following skills students should have acquired by the time they had reached the end of the target grade:

1. Operating a computer (saving files, printing, keyboarding).
2. Writing documents with a word-processor (typing, editing, layout).
3. Making illustrations with graphical programs.
4. Calculating with spreadsheet programs (sheet creation, using formulas).
5. Writing simple programs (in e.g. Logo, Pascal).
6. Communicating via email with teachers and other students.
7. Sending, searching for and using electronic forms of information.

Also in this case a composite index on a scale between zero and 100 was calculated and the average value per country is shown in Table 5.



Notes: Estimates are for all schools, that is, including non-computer using schools. *: country did not satisfy all guidelines for sampling.

Fig. 1. Comparison of student/computer ratios in 1995 and 1998 for lower secondary education (includes all schools: computer using as well as non-using).

An indicator of Internet-use was based on the question whether the school used e-mail or the WWW for instructional purposes for students within the grade range.[2] The percentage of schools answering this question positively is shown under the heading 'Use Internet' in Table 5.

From the results that appear in Table 5, a number of main observations may be derived. First, the presence of pedagogical approaches that emphasize student-controlled learning varies considerably between countries. Overall, there seems to be a trend that this emphasis is higher in primary than in secondary education. At this stage of SITES the authors are hesitant to push the interpretation further. Are schools that score high on an indicator of emerging pedagogical practices really reform oriented? Or, alternatively, are countries that have high values on these indicators those that are most innovative in preparing their future citizens for the Information Society? These questions need to be answered before policy implications from the observations

Table 5
Curriculum indicators for primary and lower secondary education (see text for explanation)

Country	Primary education			Lower secondary education		
	Student controlled	ICT skills	Use Internet	Student controlled	ICT skills	Use Internet
Belgium-French[a]	~	~	~	53	39	37
Bulgaria	~	~	~	50	41	24
Canada[a]	68	57	74	63	60	83
China Hong Kong	38	29	10	36	62	32
Chinese Taipei	57	38	22	51	64	59
Cyprus	70	50	21	49	37	9
Czech Republic	~	~	~	56	58	22
Denmark	~	~	~	69	69	86
Finland[a]	64	41	82	59	61	95
France[a]	59	48	16	51	61	43
Hungary	~	~	~	69	61	34
Iceland	61	29	37	60	56	64
Israel[a]	63	44	20	57	60	35
Italy[a]	57	42	12	52	52	57
Japan	28	24	16	29	34	27
Lithuania	~	~	~	51	51	41
Luxembourg	~	~	~	52	60	98
New Zealand[a]	72	60	67	60	63	75
Norway	71	29	51	71	55	78
Russian Federation[a]	~	~	~	50	21	~
Singapore	54	55	48	52	68	71
Slovenia	56	30	28	61	70	71
South Africa[a]	~	~	~	52	42	32
Thailand	~	~	~	58	38	17

~, no participation at this level.

[a] Country did not satisfy all sampling criteria in one or both populations.

[2] In the national version of the questionnaires the grade range was defined as the target grade plus/minus 1 year. The target grade was the grade that corresponded with the SITES definition of student populations that would be targeted in Module-3 (a repeat of Module-1 extended with teacher and student surveys).

can be drawn. Secondary analyses and more in-depth observations and triangulation procedures in Module-2 of SITES (which is an in-depth qualitative study) will be necessary to acquire answers to these questions.

Another observation was that whereas some countries seem to emphasize the acquisition of ICT skills in primary education substantially (for instance, Canada, New Zealand, Singapore), this was much less the case in other countries (for instance, China Hong Kong, Iceland, Japan, Norway). Overall, the emphasis on the acquisition of these skills was higher in secondary schools. This probable reason for this trend is that in many countries informatics is a regular subject on the lesson table of secondary schools, whereas in primary schools such subject usually does not exist.

With regard to the use of the Internet, one may observe that in some countries (e.g. Canada and Finland) it is expected that students in primary as well as secondary schools use the Internet, this was to a much lesser extent the case in other countries (e.g. Cyprus, Israel, Japan).

From qualitative (Fullan, 1991) as well as quantitative studies (Janssen Reinen, 1996) it has been often argued that staff development is a very crucial factor in the process of adoption and implementation of ICT in education. It seems that schools are very much aware of the relevance of this issue, as most respondents indicated that it is their goal to train all teachers to use ICT (Table 6). However, it is also noteworthy to observe that in most countries (except in Singapore) there is a huge gap between ideal and reality. From earlier studies, it appeared that (next to many other conditions) the knowledge of the technical support personnel regarding instructional use of computers may be an important condition for facilitating staff development in the school. As indicator of this knowledge the technical respondents were asked to rate how well prepared they thought they were in each of the following areas:

- Application of software to track student progress.
- Didactical and organizational integration of computers in subjects.
- The use of specific programs for subjects.
- Evaluation and selection of instructional software.
- Use of computers for individualized learning programs.
- The use of multimedia applications.
- Adaptation of software to fit school purposes.

These ratings were transformed to a composite index on a scale between zero and 100 and the average values per country are shown in Table 6 under the heading 'Knowledge Tech. Resp.'. From this table one may infer that these ratings were relatively high in, for example primary education in Israel, Singapore, Slovenia and lower secondary schools in Hungary, Singapore, and Slovenia. On the other hand the ratings were comparatively low in, for example primary education in China Hong Kong, France, Japan and lower secondary education in Belgium-French, Cyprus, France, Luxembourg, Norway, and Thailand.

4. Obstacles as perceived by educational practitioners

This section and the following ones contain a further exploration of the data regarding the question "What are the top ten obstacles that educational practitioners perceive as serious

Table 6
Indicators of staff development

Country	Primary education			Lower secondary education		
	Training all teachers to use ICT		Knowledge Tech. Resp.	Training all teachers to use ICT		Knowledge Tech. Resp.
	Goal	Realized		Goal	Realized	
Belgium-French[a]	~	~	~	81	10	26
Bulgaria	~	~	~	71	2	35
Canada[a]	85	23	52	80	17	52
China Hong Kong	95	4	26	95	2	41
Chinese Taipei	91	23	53	97	15	45
Cyprus	85	3	42	38	0	25
Czech Republic	~	~	~	83	12	44
Denmark	~	~	~	85	19	47
Finland[a]	97	32	43	98	31	32
France[a]	73	3	27	82	5	29
Hungary	~	~	~	97	7	57
Iceland	80	10	52	78	8	52
Israel[a]	89	30	59	95	31	53
Italy[a]	86	23	42	90	14	48
Japan	74	16	26	67	12	33
Lithuania	~	~	~	88	15	50
Luxembourg	~	~	~	71	5	21
New Zealand[a]	95	30	54	93	22	48
Norway	95	20	31	97	24	21
Russian Federation[a]	~	~	~	51	6	48
Singapore	99	80	70	99	74	64
Slovenia	98	21	59	98	17	59
South Africa[a]	~	~	~	64	6	36
Thailand	~	~	~	90	48	10

Tech. Resp., the respondent (usually the Technology Coordinator) who performed the self-rating; ~, no participation at this level.
[a] Country did not satisfy all sampling criteria in one or both populations.

impediments for realizing their ICT related goals". These explorations were focussed on lower secondary schools.

The school principals and the technology experts in the school were given a list with potential obstacles, and they were asked to '*Indicate whether or not you consider each of the following to be* ***major obstacles*** *affecting the realization of your school's computer-related goals for students in grades* *-*.[3] The master-list of obstacles contained 38 statements. Displaying, descriptively, the results of the 24 countries that participated at the lower secondary level, would results in a matrix of more than 900 cells, which is difficult to digest. Therefore, the collected information was condensed to the average (across countries) of the percentage of respondents that checked an obstacle in each country. Next the list was sorted by country-average. The result is shown in Table 7.

As can be inferred from Table 7, the top 10 of obstacles (which happen to score, on average, above 50%) consisted of a mixture of material and non-material conditions. The most frequently mentioned problem was the insufficient number of computers. This problem did stand out already in 1989 and 1992 (Pelgrum, Janssen Reinen, & Plomp, 1993; Pelgrum & Plomp, 1993). Also in the top 10 are other material conditions, such as insufficient peripherals, not enough copies of software, and insufficient number of computers that can simultaneously access the WWW. In second place in frequency is the problem that teachers did not have sufficient knowledge and skills regarding ICT. Apparently, most countries did not yet succeed in realizing sufficient facilities to keep teachers up-to-date with regard to new technologies. Other non-material obstacles in the top 10 were: the difficulty to integrate ICT in instruction, scheduling enough computer time for students, insufficient teacher time, and the lack of supervisory and technical staff.

Table 7
List of obstacles sorted by average percentage respondents across countries

Obstacle	%	Obstacle	%
Insufficient number of computers	70	Quality teacher training too low	31
Teachers lack knowledge/skills	66	Software not adaptable enough	29
Difficult to integrate in instruction	58	Stud. know more than teachers	29
Scheduling comp. time	58	WWW: slow network performance	28
Insufficient peripherals	57	Lack of interest of teachers	27
Not enough copies of software	54	Difficult use low achieving studies	22
Insufficient teacher time	54	Telecom infrastructure weak	21
WWW: not enough simultaneous access	53	WWW: difficult finding information	21
Not enough supervision staff	52	WWW: information overload	20
Lack of technical assistance	51	Software curriculum incompatible	19
Outdated local school network	49	Lack administrative assistance	19
Not enough training opportunities	43	Software not in language instruction	18
WWW: no time teaching axplores	41	Lack support school board	17
WWW: no time school schedule	41	No plan prevent theft/vandalism	15
Lack info about software	38	Software culturally incompatible	12
WWW: not enough connections	35	Software too complicated to use	10
WWW: Insuffic. techn. support	34	Materials WWW poor quality	9
Not enough space to locate	32	WWW: complicated to connect	8
Weak infrastructure (telecommunications, etc.)	32	WWW: mail baskets overload	4

[3] See note 2.

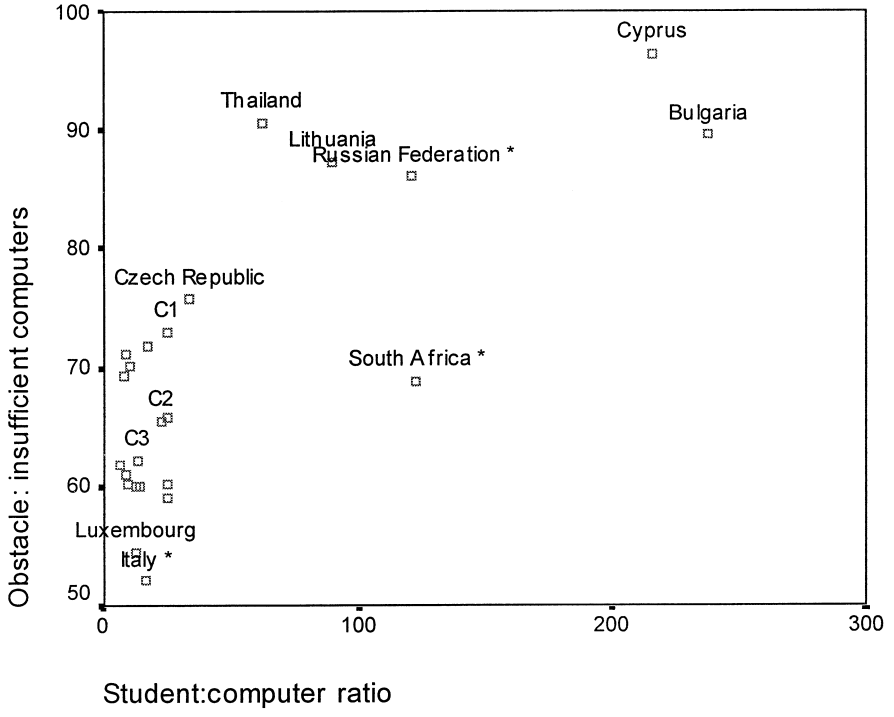
5. Contextual factors associated with the main obstacles

In the previous section it was shown what are the main ICT-related obstacles as perceived by educational practitioners. It should be mentioned that there was quite a substantial variation between countries in terms of respondents checking particular obstacles. For instance, for the first five obstacles of Table 7, the lowest and highest values were respectively: 52–96, 40–85, 32–88, 40–74, and 32–91. In this section, we will examine in more detail the following selection of obstacles that appeared in the top 10:

- Insufficient number of computers.
- Teacher lack knowledge/skills.
- Not enough computers with simultaneous access to WWW.

The main goal of this section is to throw further light on the variation between countries and on the question if there are any indications of co-variation between the perception of obstacles and contextual factors.

The first question that will be addressed concerns the co-variation between student/computer ratios and the obstacle 'insufficient number of computers'.

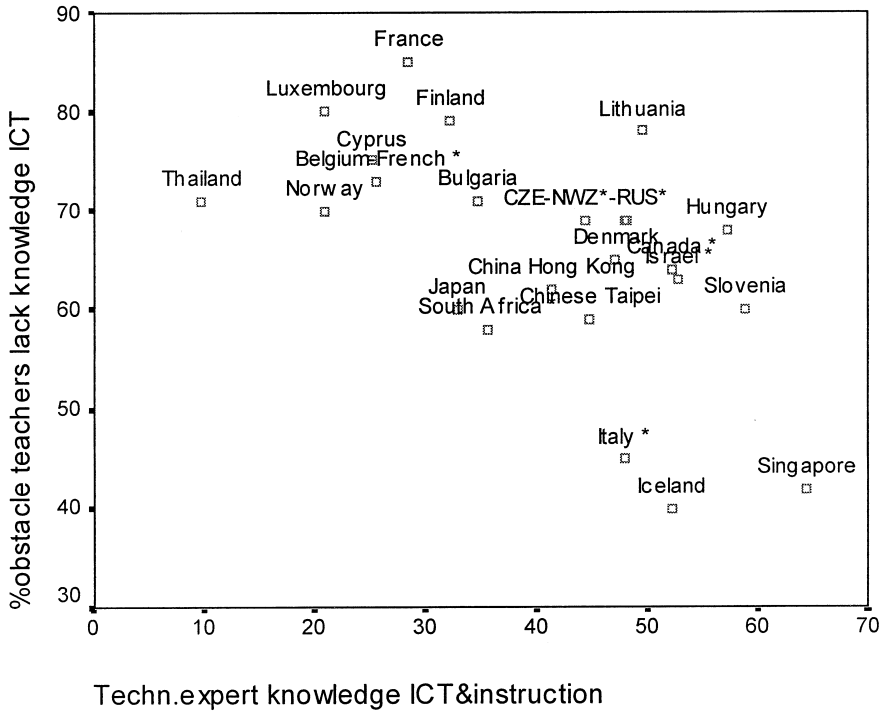


Notes. C1=Belgium-French*, Finland, France, New Zealand*, Norway; C2=China Hong Kong, Hungary; C3= Canada*, Chinese Taipei, Denmark, Iceland, Israel*, Japan, Singapore, Slovenia; *=country did not satisfy all guidelines for sampling

Fig. 2. Scatterplot of countries' percentages of respondents checking the obstacle 'insufficient number of computer' and the student:computer ratio per country ($r = 0.77$).

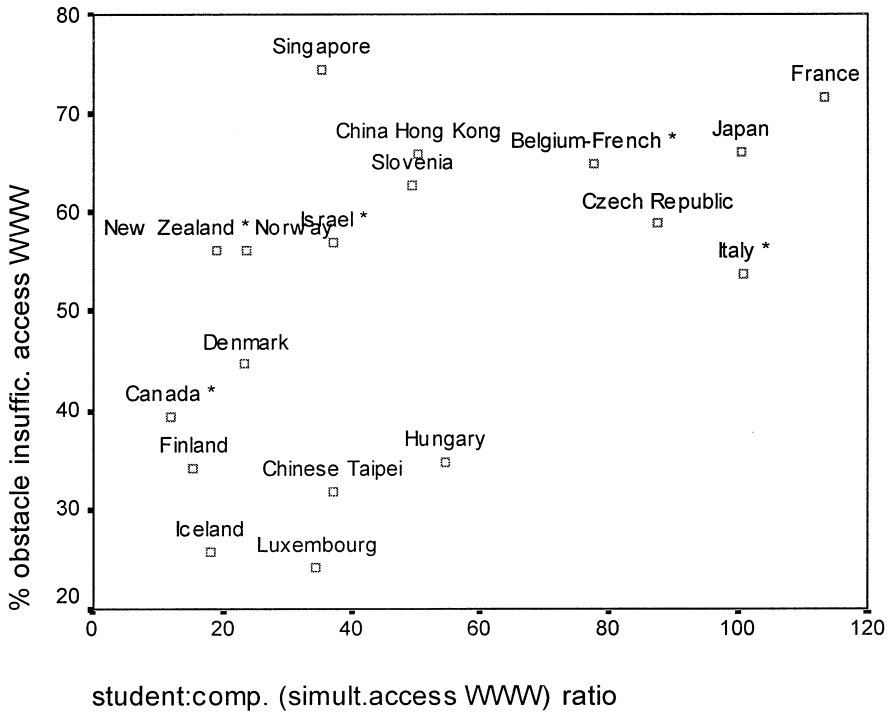
From Fig. 2, one may infer that there is a considerable co-variation between the student: computer ratio of countries and the percentage of respondents who indicated that the insufficient number of computers is a major obstacle. However, there seems to be especially a contrast between student:computer ratios of roughly 20 and higher and below 20. Pelgrum (1999) showed that even with ratios of 10 and lower, still 40% of the respondents complain about the lack of computers. Unfortunately, the number of observations (across countries) was too low to further differentiate schools with student:computer ratios below 10.

With regard to the secondly ranked problem (the lack of teachers' ICT-related knowledge and skills), one may also wonder under which circumstances this obstacle occurs less frequently according to the perception of educational practitioners. One may hypothesize an association between the occurrence of this obstacle and the adoption by schools of written policies and goals regarding ICT-related staff development, the existence of mechanisms for internal information exchange about ICT, the availability of ICT-courses, and/or the ICT competencies of the technology expert in the school. An examination of these associations revealed that, at the aggregation level of countries, substantial correlations only existed for internal information exchange (via the school ICT working group, the appearance of ICT as regular item in staff meetings, and exchange of information via internal and external courses). Also the knowledge/skills of technology experts (as measured by self assessments) regarding the instructional use of ICT appeared



Notes. *: country did not satisfy all guidelines for sampling.

Fig. 3. Scatterplot of percentages of school principals mentioning teachers' lack of ICT knowledge as major obstacle *and* an indicator of knowledge of technology experts of instructional use of ICT ($r = -0.57$).



Notes. Countries with student:WWW-computer ratio's of more than 120 not included in this graph: Bulgaria, Cyprus, Lithuanaia, Russian Federation, South Africa, Thailand; *=country did not satisfy all guidelines for sampling.

Fig. 4. Scatterplot of student:computer ratios (in terms of number of computers with simultaneous access to the WWW) and percentage of respondents mentioning the insufficient number of computers with simultaneous access to computers as major obstacle.

to be quite strongly associated with relatively low frequencies of reporting a lack of teachers' knowledge and skills by school principals. This last association is illustrated in Fig. 3.

It is interesting to note in Fig. 3 that in some countries (notably Thailand, Norway and Luxembourg) the technology experts rated their knowledge of instructional aspects of ICT very low, while this was very high in Singapore, Iceland, and Italy. This was associated with, respectively, a very high and very low percentage of school principals who reported that teachers lacked knowledge of ICT. It would not be implausible, also considering the other observed associations of mechanisms for ICT knowledge transfer inside the school, to hypothesize that technology experts in the school may facilitate (via their knowledge of how to use ICT in instruction) the knowledge and skills of teachers in the school.

Finally, the association between the occurrence of the obstacle 'not enough computers with simultaneous access to WWW' and the amount of equipment that actually had simultaneous access was examined. This exploration showed (as illustrated in Fig. 4) that there was, even among countries with relatively favorable conditions (for instance student/WWW computer ratios of below 40) quite a substantial variation in terms of percentage of respondents reporting major obstacles in this area. For instance, in Singapore with a student/WWW computer ratio less

than 1 to 40 the complaint rate was above 70%. This was the same for France with a ratio of more than 1 to 110.

6. Summary and discussion

This article started with a summary of design and descriptive results of Module-1 of the IEA Second Information Technology in Education Study. This worldwide assessment of ICT in education covered a large set of indicators. The main focus in this article was on obstacles that educational practitioners perceive as major impediments for realizing their school based ICT objectives. Among the top 10 of obstacles were material as well as non-material conditions. The major obstacles were: lack of computers and lack of knowledge among teachers. The co-variation between the occurrence of these obstacles and contextual factors were further examined.

Educational assessments (especially the international comparative ones) often lead to questions such as: what are other countries (who score better on certain indicators) doing differently than our country? Researchers involved in international comparative assessments are often inclined not to try to answer this question but rather to analyze the variation between students and/or schools within countries in order to find potential explanations for observed variation. It has often been claimed that the results of analyses of aggregated data may result in misleading interpretations. Postlethwaite (1999) argues, referring to the term 'ecological falacy', that strongly positive associations between aggregated data may well be based on strongly negative associations on lower aggregation levels. The purpose of this article has not been to deny this position. Rather this article is meant to document results of first steps of examining which contextual factors may ultimately help to explain variation between countries in terms of ICT related indicators. It is interesting to observe, for instance, strong positive associations between the complaints of educational practitioners and the availability of hardware in a country. Although at first sight, such a global observation may be seen as quite a trivial finding (analogous to the association between the operation of a light switch and the turning on and off of a lamp), closer observations of these associations may be more revealing for the interpretation of assessment outcomes and expectations of decision makers. For instance, it was observed that even under very favorable conditions still 40% of the educational practitioners indicated that a lack of hardware was a major obstacle. One may wonder if such observations should lead to further investments in hardware acquisition or maybe rather in dialogues about optimizing the use of the available equipment. Also it was interesting to observe how certain staff development conditions (and even the instructional ICT-related knowledge of technology experts in schools) were associated with a lower level of complaints among school principals about their teachers' lack of ICT knowledge and skills. This observation may be taken as an indication of the potential tenability of the hypothesis that the qualification of ICT support staff in the school is beneficial for the staff development of teachers.

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