THE USE OF COMPUTERS IN EDUCATION IN 18 COUNTRIES

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Introduction

The 1980s have shown a rapid increase in the infusion of new information technologies in most societies. The notion that computers are playing an important role in the life of every citizen is no longer debated. The question how education should react to these developments and what role computers can and should play in schools is still an issue of major debates. There are several theoretical perspectives on the role of computers in education and many claims exist as to the potential power of computers as instructional aids. Many countries have adopted policies for the systematic introduction of computers in education. However, the major question still is: How should new information technologies be introduced in education and to what degree are the expected effects of policies actually realized in educational practice?

The major goal of the Computers in Education study (Comped) of the International Association for the Evaluation of Educational Achievement (IEA) is to collect longitudinal and crossnational comparative data in order to contribute to the evaluation of policies on (the introduction of) computers in the countries that are participating in the project.

This paper contains a summary of results collected in stage 1 of the study (see below), more fully described in Pelgrum & Plomp (1991), and provides some possible implications for educational policy.

Goals and Design of the Study

The major goals of the study are to describe and analyze crossnationally as well as longitudinally how computers are used in schools by teachers and students, and what cognition, skills and attitudes students have with respect to new information technologies. The study consists of two stages. During stage 1 (1987-1990) data were collected at school and teacher level in three populations, namely elementary, lower secondary and upper secondary schools. In stage 2 (1991-1994) measures from stage 1 will be repeated and in addition measures at student level will be taken. The measures taken in stage 1 of the study were based on a conceptual framework characterizing the educational system in terms of levels of decision-making and identifying the factors which are hypothesized to

contribute to effect changes. These factors were taken from literature on educational change (e.g.: Fullan, Miles, & Anderson, 1988) such as the quality, clarity and relevance of the objectives and the characteristics of the innovation (content, materials, instructional strategies); support and leadership; staff development; experiences with innovations; and the existence of evaluation and feedback. The framework reflects the hierarchical structure of most educational systems, but acknowledges that decisions which promote or inhibit the implementation of computer-related curricula are made at all levels, which may cause discrepancies between decisions and expectations that exist at different system levels. An identification of these discrepancies may in itself be an important starting point for improvement measures in education.

In stage 1, data were collected by means of questionnaires from altogether about 60.000 respondents (principals, computer coordinators and teachers) from schools sampled in 19 educational systems. As not all samples are nationally representative, Appendix A contains a description of the population definitions used in each participating system. The Appendix also shows the number of cases for each category of respondents (Table A.1).

The Availability of Hardware

Table 1 shows that, in 1989, in many educational systems computers were not yet available for all schools.

For *elementary education* the access to computers was low in Japan and Portugal (respectively 25% and 29%), moderate in Belgium-French (54%), Israel (62%), the Netherlands (53%), while a high degree of access at school level can be observed in British Columbia (99%), France (92%), New Zealand (78%) and the USA (100%).

For *lower secondary education* in Belgium-Flemish, Belgium-French, British Columbia, Federal Republic of Germany, France, Luxembourg, the Netherlands, New Zealand, Switzerland and the USA three quarters or more of the schools had access to and used computers for instructional purposes; Greece, Japan and Portugal show low or moderate access rates of respectively 5%, 36% and 53%.

Most *upper secondary schools* in the educational systems that participated in this study have computers, while access to computers was still low or moderate in Greece (4%), China (61%) and India (7%). If computers are available, they are used for instructional purposes by most schools.

Table 1 shows that the median number of computers in *elementary schools* varies between 2-5 in Belgium-French, France, the Netherlands and Portugal, 10 in Japan and respectively, 17, 18 and 16 in British Columbia, Israel and the USA. In most countries elementary schools started quite recently with the introduction of computers (typically more than 50% of the schools started after 1986) with the exception of British Columbia and the USA where the median starting year was 1983.

In general, the median number of computers in *lower and upper secondary schools* is higher than in *elementary schools*. Comparing the first year of educational computer use across populations, one finds a stable trend of upper secondary schools starting first, followed by lower secondary schools and at last, the elementary schools.

Table 1: Proportion of Schools Having Computer over Years per Population and Country

Country / Educational System																		
Use of Computers	BFR	CBC	FRA	ISR	JPN	NET	NWZ	POR	USA									
Elementary schools																		
1985	.15	.69	.50	.28	.03	.09	.15	.02	.75									
1986	.24	.76	.79	.36	.09	.17	.29	.07	.82									
1987	.31	.87	.86	.45	.14	.35	.44	.14	.92									
1988	.34	.94	.88	.55	.18	.48	.60	.20	.94									
1989	.54	.99	.92	.62	.25	.53	.78	.29	1.00									
Lower secondary schools																		
	BFR	CBC	FRA	FRG	GRE	JPN	LUX	NET	NWZ	POR	SWI	USA						
1985	.56	.72	.70	.63	.00	.05	.93	.58	.85	.13	.28	.80						
1986	.70	.80	.88	.74	.00	.08	.93	.75	.90	.25	.40	.87						
1987	.78	.90	.94	.80	.01	.12	1.00	.82	.95	.35	.48	.94						
1988	.81	.94	.96	.89	.02	.17	1.00	.85	.97	.46	.58	.95						
1989	.93	1.00	.99	.94	.05	.36	1.00	.87	.99	.53	.74	1.00						
Upper secondary schools																		
	BFL	BFR	CBC	CHI	FRA	FRG	GRE	HUN	IND	ISR	JPN	NET	NWZ	POL	POR	SLO	SWI	USA
1985	.77	.65	.72	.26	.65	.94	.01	.84	.02	.49	.63	.48	.93	.18	.20	.39	.75	.86
1986	.86	.74	.80	.39	.79	.96	.02	.90	.04	.60	.75	.58	.95	.31	.34	.62	.85	.89
1987	.93	.79	.90	.44	.87	.98	.03	.94	.06	.68	.83	.62	.98	.44	.48	.65	.90	.96
1988	.97	.82	.94	.53	.93	.98	.03	.95	.07	.75	.88	.65	.99	.58	.62	.67	.94	.97
1989	.98	.93	1.00	.61	.99	1.00	.04	1.00	.07	.82	.94	.69	1.00	.72	.72	.94	.98	1.00

Notes - = data not collected, 1985-1988; recall: 1989; actual, 1990; expected

Table 2: Medians of First Year of Use, Student: Computer Ratio's and Number of Computers (according to computer coordinators). Adapted from Pelgrum & Plomp (1991)

Use of Computers	Country / Educational System														
	BFL	BFR	CBC	CHI	FRA	FRG	GRE	HUN	IND	ISR	JPN	LUX	NET	NWZ	POL
Elementary schools															
First year	-	86	83	-	85	-	-	-	-	86	87	-	87	87	-
Student:computer ratio 1989	-	28	21	-	23	-	-	-	-	17	14	-	64	62	-
# computers	-	5	17	-	2	-	-	-	-	18	10	-	2	2	-
Lower secondary schools															
First year	84	84	82	-	85	85	88	-	-	-	87	83	84	83	-
Student:computer ratio 1989	27	34	12	-	31	46	52	-	-	-	143	48	26	34	-
# computers	12	12	43	-	15	11	8	-	-	-	7	16	18	17	-
Upper secondary schools															
First year	83	82	82	86	83	80	86	83	86	84	85	-	83	82	87
Student:computer ratio 1989	32	38	12	43	26	48	44	28	95	26	32	-	34	37	53
# computers	12	11	43	23	24	14	17	17	2	20	25	-	25	18	10

Notes. - = data not collected, m = insufficient number of cases (n<50 or missing cases >20%)

However, the differences between countries regarding the access of schools to computers are quite large, and Pelgrum & Plomp (1991) showed for instance that many educational systems were, in 1989, at the level of British Columbia and the USA in 1985 or 1986 with respect to the median number of computers in schools.

The student:computer ratio varied substantially, for *elementary schools* between about 15-25 in British Columbia, Israel, Japan, France and the USA and almost two to three times as much in countries like the Netherlands and New Zealand. Exceptional is Portugal with a student:computer ratio of 301, which is caused by the fact that Portuguese elementary schools are quite large. It is interesting to note that the student:computer ratio in France suggests a more favorable picture for elementary schools than the absolute number of available computers. This can be explained by the relatively small size of elementary schools in France (with a median of 71 students compared to, for instance, 233 in Belgium-French and 830 in Portugal). On the whole, the student:computer ratio is more favorable in *secondary schools* than in elementary schools. There are however, again, large differences between countries, showing that in British Columbia and the USA the conditions for integrating computers in the school curriculum are most favorable, while in other countries the ratios are almost two to three times as high. It is also interesting to note that although Switzerland had a relatively low number of computers in lower secondary schools, the student:computer ratio was quite favorable (and almost at the level of the USA) due to the fact that Swiss lower secondary schools on the average are relatively small.

One of the questions arising from the results presented in Table 2 is whether schools have enough computers. This question is difficult to answer from a theoretical perspective because so many factors are involved, such as the goals of computer use, availability of adequate software, of trained teachers, etc. However, we may get a tentative answer by looking at the problems educational practitioners perceive as serious in using computers.

One of the questions presented to all respondents (principals, computer coordinators and teachers) contained a list of about 30 problems (related to hardware, software, teacher training and skills, and organization) which could be experienced as serious in using computers for educational purposes in the school. Respondents were asked to check each problem that they considered as serious in using computers in the school, but also to select from the list the five most serious problems. Table 3 contains the percentages of school principals and computer coordinators who checked a particular hardware problem.

From Table 3 it may be inferred that the lack of a sufficient number of computers and peripherals (although less frequently mentioned) was perceived as a serious problem by a large group of respondents in many countries. In some countries (for instance, in lower secondary schools in France, Germany, Luxembourg and Portugal) relatively large groups of respondents complained about the limitations of computers (like being out of date). In future analyses we will try to determine whether this is related to the type of computers available in the schools.

Table 3: Percentage of School Principals (P) and Computer Coordinators (C) Checking a Particular Hardware Problem as Serious in Using Computers in School

Hardware Problem	Country / Educational System																		
	BFL	CBC	FRA	ISR	JPN	NET	NWZ	POR	USA										
Elementary schools																			
Insufficient computers	P	69	77	72	54	63	85	76	79	72									
	C	68	73	71	49	58	81	78	78	63									
Insufficient peripherals	P	46	56	26	33	52	30	44	63	56									
	C	44	45	25	35	57	37	45	63	50									
Difficulty maintenance	P	18	30	50	29	27	3	20	13	12									
	C	20	29	52	26	31	2	17	15	14									
Limitations of computers	P	24	34	55	36	20	34	15	30	24									
	C	23	28	54	39	31	31	17	40	21									
Lower secondary schools																			
Insufficient computers	P	59	70	70	57	44	39	72	59	55	77	87	45	79					
	C	47	58	65	65	40	39	76	48	50	61	87	44	59					
Insufficient peripherals	P	39	47	50	34	40	51	68	59	34	62	71	24	61					
	C	37	34	33	22	39	56	76	22	31	46	65	24	45					
Difficulty maintenance	P	7	17	26	39	18	36	40	29	17	29	21	7	15					
	C	7	20	21	52	25	41	34	66	24	35	21	16	17					
Limitations of computers	P	24	22	30	53	45	19	36	48	14	23	40	19	32					
	C	27	27	30	61	49	16	31	78	21	32	45	34	26					
Upper secondary schools																			
Insufficient computers	P	57	70	70	64	67	43	44	45	69	62	64	58	79	44	91	87	33	71
	C	50	51	65	61	66	30	29	37	72	57	67	48	59	37	86	60	35	57
Insufficient peripherals	P	46	51	50	54	50	39	48	73	41	54	63	41	58	52	74	40	15	50
	C	41	44	33	64	46	41	21	62	45	49	64	27	49	53	68	44	15	34
Difficulty maintenance	P	10	18	26	55	35	18	28	47	43	32	34	25	32	61	21	29	12	14
	C	9	16	21	58	36	25	43	36	44	34	35	16	36	67	22	36	20	16
Limitations of computers	P	29	20	30	51	40	45	43	61	20	40	35	21	38	38	37	42	33	32
	C	35	36	31	65	38	49	59	55	23	47	43	26	49	41	39	62	42	29

Notes - = data not collected, m = insufficient number of cases (n<50 or missing cases >20%)

The Availability of Software

This survey contained a number of questions about the availability of software in the schools. The computer coordinators were asked to check which of the following types of programs were available in the school:

drill and practice, database, tutorial programs, lab interfaces: automatic, word processing, data acquisition, painting or drawing, programs to control devices, music composition, programs to control interactive video, simulation, CAD/CAM, recreational games, CAI authoring language, educational games, item banks, programming languages, record/score tests, spreadsheet, grade book, mathematics graphing, computer communication, statistics, and tools/utilities.

The results described by Pelgrum & Plomp (1991) show that, except for Portugal, in most participating countries more than 80% of the computer-using *elementary schools* possessed drill and practice software. For tutorial programs there were large differences between countries: in the USA it is quite common for schools to possess these programs, whereas, for instance, in France only 27% of the schools had programs of this type. Word processing software and educational computer games are also available in many schools, although the percentages for word processing found in France and Israel (respectively 66% and 62%) were relatively low. Databases and spreadsheets were less widespread. Furthermore, it is interesting to note that the availability of programming languages in elementary schools varies considerably between as well as within countries: About 70% or more of the schools in Belgium-French, France and Israel had programming languages available. This points to the potential use of LOGO. On the other hand, in some other countries (New Zealand, the Netherlands and the USA) only a relatively small number of elementary schools (18-34%) possessed programming languages.

In *lower secondary schools* the picture is somewhat different. Software for word processing, spreadsheets and databases was widely available in most countries. The availability of database programs was relatively low in Belgium-French, France, Germany, Japan and the USA. Programming languages were also widely available in lower secondary schools, although the percentages of schools possessing programming languages were relatively low in Belgium-French, Japan, the Netherlands and the USA (respectively 67%, 61%, 67% and 42%). Drill and practice and/or tutorial programs were available in many lower secondary schools in some countries (the Netherlands, New Zealand and the USA), but in a relatively small number of schools in other countries (for example, Belgium-Flemish, Greece, Portugal and Switzerland).

Many *upper secondary schools* (more than 70%) possessed programming languages (Portugal only 68%) and word processing programs (China only 27%). A general trend is that in comparison with lower secondary schools the availability of drill and practice and tutorial programs was somewhat lower in upper secondary schools, but spreadsheets, databases and more specialized programs (like programs for controlling devices or CAD/CAM programs) were available in more schools.

The computer coordinators were also asked to indicate for which school subjects software was available in the schools. A majority of *elementary schools* possessed software for mathematics and mother tongue. However, software for informatics (that is, learning about computers) was not as widespread.

Table 4: Percentage of Principals (P) and Computer Coordinators (C) Checking a Particular Software Problem as Serious in Using Computers in the School

Software Problem	Country / Educational System									
	BFL	CBC	FRA	ISR	JPN	NET	NWZ	POR	USA	USA
Elementary schools										
Insuff. software	P	64	62	46	57	83	67	53	82	47
	C	78	60	51	62	96	69	64	83	47
Softw. difficult	P	16	9	26	3	37	13	9	6	7
	C	8	10	23	4	42	17	12	8	4
Softw. not adaptable	P	31	23	42	14	62	38	16	24	21
	C	36	16	41	14	68	40	19	27	13
Poor manuals	P	14	10	26	9	45	18	14	8	8
	C	19	13	28	8	62	18	24	23	13
Lack info softw.	P	36	31	48	28	65	17	35	39	27
	C	47	31	47	25	76	21	40	45	16
Softw. other lang.	P	10	14	3	6	30	7	4	46	0
	C	15	8	3	4	29	4	4	43	0
Lower secondary schools										
Insuff. software	P	51	66	60	40	57	62	79	59	73
	C	66	66	58	53	63	82	98	85	73
Softw. difficult	P	7	11	5	21	17	16	56	4	22
	C	4	8	29	21	11	56	0	41	13
Softw. not adaptable	P	35	26	23	47	16	31	76	37	49
	C	37	25	19	49	17	37	78	26	42
Poor manuals	P	14	9	25	22	32	47	55	18	13
	C	17	23	29	32	34	65	62	11	16
Lack info softw.	P	16	38	40	55	34	50	76	37	21
	C	19	46	31	64	41	63	84	26	29
Softw. other lang.	P	19	16	4	4	6	50	43	26	11
	C	17	25	4	3	7	70	22	26	10
Upper secondary schools										
Insuff. software	P	45	72	60	81	56	53	80	79	59
	C	48	64	58	84	57	59	75	81	66
Softw. difficult	P	4	9	5	5	12	13	11	27	17
	C	4	7	8	11	17	19	18	21	17
Softw. not adaptable	P	26	26	23	22	33	15	27	39	36
	C	30	19	19	24	28	15	30	35	35
Poor manuals	P	19	13	25	21	23	38	49	45	18
	C	22	24	30	29	28	33	65	53	21
Lack info softw.	P	22	40	40	46	42	31	52	53	33
	C	15	40	31	42	46	45	58	59	32
Softw. other lang.	P	15	12	4	33	8	6	67	42	36
	C	19	14	4	37	5	6	69	40	36

Notes. - = data not collected, m = insufficient number of cases (n<50 or missing cases >20%)

In *lower and upper secondary education* many schools in the participating educational systems possessed some software for courses to learn about computers (informatics) and for mathematics. There are, however, remarkable differences. For instance, the percentage of schools that have software for mathematics in lower secondary education ranged from 10 % in Greece to about 95% in New Zealand and France. Similar differences were found for software that can be used in other courses, such as science and mother tongue.

This study did not record which programs are available in the schools, and whether there is any shortage of particular software, or what the quality of the available programs is. However, there are a few indicators that can throw some light on the last two questions. These indicators consist of the inventory of *problems* that was presented to the respondents with the request to check each problems (from a list of 30) that was experienced as serious. Table 4 contains the percentages of respondents checking a particular *software* problem.

Table 4 shows that a shortage of software was experienced as a serious problem by many respondents, while the lack of information about software and the adaptability of software was mentioned relatively frequently as the second problem, although these percentages are not very high. The observation from Table 4 is consistent with another question asking computer coordinators for the priorities for computer-related expenditures which yielded the need for a greater variety of instructional software as highest priority.

The Use of Computers in Existing Subjects

A first question to address is how many teachers are using computers. For a subset of countries in which data were collected regarding the number of teachers using computers, we were able to estimate the percentage of teachers in computer-using schools actually using computers for instructional purposes (see Figure 1). Although this is a rough indicator (even including teachers that use computers marginally), it is quite interesting to see in Figure 1 that in computer-using *elementary schools* most of the teachers in grades 4-6 used computers. However, in *lower secondary schools* in most countries the integration of computers in existing subjects was still an activity of a rather small group of teachers. In *upper secondary schools* the percentage of teachers using computers was higher than in lower secondary schools, except for Germany (mathematics and mother tongue), New Zealand (mother tongue) and Portugal. Especially revealing, but also promising for the near future, are the relatively high percentages of computer-using teachers in the USA, where in 1989 (compared to survey results from 1985, Becker (1992) a considerable increase of teacher use could be observed. Figure 1 also shows that there is a tendency for mathematics teachers more than teachers in other subjects to use computers more for their lessons. In New Zealand there is a relatively high proportion of mother tongue teachers in lower secondary schools using computers.

Figure 2 shows an overview of the subjects for which computers are used in schools (irrespective of the number of teachers using computers in a subject and, hence, different from Figure 1). This figure shows that (with regard to the traditional subjects, mathematics, science, and mother tongue and the new subject informatics) in elementary schools computers were most often used for mathematics and mother tongue.

Note: m = missing data.

Figure 1: Percentage of Teachers of Existing Subjects Using Computers in Computer Using Schools

Figure 2: Percentage of Schools Using Computers per Subject

In lower and upper secondary education the new subject informatics was available in most schools, while clearly mathematics was a relative favorite subject for computer applications in many countries, although the percentage of schools that used computers for mathematics differed greatly between countries (ranging in lower secondary schools from 89% in France to 36% in Belgium-Flemish).

In order to find out what teachers (computer users as well as non-users) see as the major obstacles in using computers one may look at the problems users experience as well as the reasons for not using computers as indicated by the non-using teachers. The results described by Pelgrum & Plomp (1991) show that the four problems that are most frequently mentioned are: lack of hardware, lack of software, problems with finding enough time to learn about computers or lack of time to prepare lessons in which computers are used. In elementary schools, teachers also frequently mentioned their lack of knowledge. The ranking of these problems in terms of relative frequencies differs from country to country and future analyses will be aimed at trying to identify which circumstances are of potential influence on what teachers perceive as problematic in using computers.

Staff Development and Teachers' Knowledge and Skills

The results described by Pelgrum & Plomp (1991) showed that staff development activities mainly consisted of introductory and application courses. Secondary schools in many systems offered courses in computer science/programming and in computer use in specific subjects. Teachers perceived school authorities as quite supportive of staff development. Furthermore the limited role of universities and (teacher) associations in providing teacher training was shown.

Computer related training mainly dealt with applications, problem analysis and programming. The data showed that pedagogical/instructional aspects were the least mentioned topics although computer-using teachers mentioned these topics more often than non-users.

Many teachers had informal contacts with colleagues within their schools.

The framework for the study referred to in the previous sections included the knowledge and skills of teachers in handling computers as one of the factors influencing the integration of computers in existing subjects. This factor is difficult to measure (not only in cross-national but also in national surveys) as testing of teachers in most countries is a rather controversial issue. In this study self-rating scales were used (Knowledge, Programming and Capability), consisting of a list of statements about computer-related knowledge and skills, asking teachers to indicate by checking 'yes' or 'no' whether they had the knowledge or could perform the action indicated in the statement. The items for each scale are listed below:

I know ... (KNOWLEDGE)

1. several advantages of computer use for instruction;
2. the difference between a word processor and a desktop publishing program;
3. criteria to judge the quality of a printer;
4. the trends in hardware development in the past 20 years;

5. what 'file extensions' are;
6. what a 'loop' means in programming;
7. what a 'relational database' is like;
8. what a 'bit' is defined as;
9. the difference between 'RAM' and 'ROM';

I can write a program for ... (PROGRAMMING)

1. adding up numbers;
2. using arrays;
3. storing data on a disk drive;
4. sorting data into a certain sequence;
5. printing the complete ASCII character set.

I am capable of ... (CAPABILITY)

1. exchanging data between different types of computers;
2. copying files from one disk to another;
3. editing documents with a word processor;
4. loading a data set from a disk drive;
5. creating a database-file;
6. evaluating the usefulness of software for my lessons;
7. adapting instructional software to my needs;
8. writing courseware for my own lessons.

The reliabilities of the scales for most groups of respondents is quite good ($\alpha > .80$).

Some evidence about the validity of these scales was collected in 1988 in England and Germany during the pilot phase of this instrument. That pilot test consisted of administering the self-rating scales in combination with a set of multiple-choice items related to each of the statements in the self-rating scales. Analyses of these data showed that both measures were similar in a relative sense (i.e., there were high correlations between the self-ratings and the multiple choice part), but there was also quite a high similarity in an absolute sense (almost all respondents failing on a particular multiple choice item checked 'no' on the corresponding self-rating item). On the basis of these results it was concluded that it was worthwhile to include the self-ratings in the study.

Figure 3 contains the results of the self-ratings by teachers in lower secondary schools. This figure shows that in some educational systems the median of the percentages for the non-using teachers in existing subjects on some of the three scales equals zero. The results show -as may be expected- that using teachers in existing subjects know more than their non-using colleagues. Pelgrum & Plomp (1991) showed that the scores for the using teachers in elementary schools are in general lower than the scores at the other levels. At elementary school level in the scale "Programming" in New Zealand and the USA the median score for both using and non- using teachers was zero, which, in combination with the other low scores on this scale, may be considered as an indicator of the low priority of programming among the using teachers. One might have expected that the computer education teachers in lower secondary schools would have higher scores than the using teachers in other subjects. Although, in general, this trend can be observed, in a number of educational systems the scores of the using teachers do not differ greatly from those of the computer education teachers (see, for example, the scale "Programming").

Knowledge

Country	Computer education	Exist subj. non use	Exist subj use
BFL	78	18	0
BFR	90	35	0
CBC	55	55	55
FRA	45	45	68
FRG	90	45	90
GRE	90	12	0
JPN	78	22	68
LUX	85	45	0
NET	90	45	0
NWZ	100	45	55
POR	78	45	0
SWI	90	55	78
USA	90	35	55

Computer education

Exist subj. non use

Exist subj use

Note m = missing data.

Figure 3: Percentage of Teachers in Lower Secondary Schools Agreeing with Statements per Self-Rating Scale

Some educational systems are noteworthy: In Switzerland on the scales "Programming" and "Capability", the using teachers and the computer education teachers do have the same scores. In other educational systems, there are sizable differences between the using teachers and computer education teachers on the scale "Programming", namely in lower and upper secondary schools in New Zealand and the USA. Further analysis is needed to explain this contrast in these educational systems and the much smaller differences in the other educational systems.

Discussion

This article contains some of the results from a description by Pelgrum & Plomp (1991) of the status of computer use in 1989 in 19 educational systems. Although the summary given here is rather short, still, a picture arises that can be very succinctly characterized as follows: Throughout the world there is a continuous (albeit quite unequal) development in the access of schools to computers; increasing amounts of computer equipment are installed in schools and -gradually- increasing numbers of teachers/students are using computers for instructional purposes. Despite this development there is still a lot of inequity in access to computers, even in highly developed countries, and educational practitioners feel that a number of basic conditions for using computers for instructional purposes have not yet been fulfilled: There is shortage of hardware, shortage of software, teachers are insufficiently trained and teachers don't have enough time to prepare the use of computers in their lessons adequately.

What do these results mean from an educational policy point of view? We will address this by looking at the following two derived questions: (1) Are the results in line with policy expectations? (2) Are there any indications from the results in what direction future policies should be developed? Before addressing these questions, we first want to discuss what seems a paradox in the above description.

Paradox Between Experienced Problems and Increased Use?

If teachers don't have enough time, how can such a relatively large group still use computers? And if teachers say that they are not knowledgeable enough, how do they make use of computers at all? A tentative interpretation may be as follows. Despite all the problems teachers expect before starting to use computers (which we may infer from reasons given for not using computers) and despite all the problems experienced by those colleagues who already use computers, the data collected in several surveys in the USA indicate that there has been a steady (although slow) increase over the years of the number of teachers using computers. So, although earlier pessimistic predictions about the problems related to the introduction of computers in education seem to have come true, this doesn't seem to lead to withdrawal among educational practitioners (that is, increasing numbers of schools and teachers refraining from using computers) as has been the case with other technological innovations in education, for example language laboratories. Apparently the negative perceptions of educational practitioners are being compensated in one way or another by positive expectations or perceptions. One possible important compensating factor is the expected educational impact of using computers which, in

general, is quite high especially in the USA (see Pelgrum, this issue). Also very significant may be the finding that teachers seem to observe positive changes as a result of using computers: Respectively 69, 61 and 52 per cent of the teachers of mathematics, science and mother tongue in lower secondary schools in the USA sample indicated that they observed an increased availability of feedback about student achievement, an increased interest of students, and increases in student achievement. Pelgrum & Plomp (1991) found similar patterns in other countries.

Hence, in summary, when looking at the trends in the data, it looks like the computer has past its first test of usefulness as an educational medium.

Are Computers Used as Expected?

We may now turn to the first question posed above which may be conceived as a second test of the usefulness of computers in education, namely whether the use of computers in educational practice is consistent with expectations put forward by enthusiastic proponents. One of the most provoking expectations expressed in the past was about the potential of computers to reshape education into an institution emphasizing the learning of productive skills by offering students an attractive learning environment heavily dominated by self-exploratory (by means of computer simulation) and problem-solving activities. Our data seem to demonstrate that this situation is still far from being realized as the use of computers in education often still is at a stage of what might be called low-level-adoption, such as learning about computers and particular applications (like word processing) and drill and practice in existing subjects, whereas simulations and self-explorations - indicators of high-level-use - are applied to a lesser extent. Hence, if we admit that the use of computers in education still is not meeting the expectations of enthusiastic proponents, we may turn to the second question raised above, that is: Which indications may be inferred from our findings as to the direction of future policies?

Possible Implications for Future Policies

In this paper we have shown that if we take the views of educational practitioners seriously quite a number of interrelated problems (the most prominent being: shortage of hardware and software, teacher skills and teacher time for lesson preparation) need to be solved. Although these problems are experienced at school level, policies directed at creating solutions may also be developed beyond the school framework. Given the amount of time required to effect changes in any of the domains related to each of these problem areas it seems realistic to make a distinction between short term and long term strategies with respect to the implementation of computers in education. In developing a short term strategy one may take certain limitations and currently popular patterns of (low level) computer use for granted and try to devise measures to consolidate and optimize the use of computers within these constraints, while a long term strategy would consist of focusing on realizing high level use. We will first give some examples of possible short term and long term strategies.

A *first example of a short term strategy* is related to limitations in the hardware infrastructure of schools. The hardware infrastructure available in many schools does not allow many teachers and students to use the equipment at the same time. As a consequence, as long as there is no drastic change in the number of computers per school or the organization of lessons as whole class activities, one may expect that the use of

computers will remain restricted to either a few teachers who can use computers intensively, or many teachers who use computers only incidentally with all students in their classes ('whole class use'). If the hardware structure is not going to change within the short term, then one might consider whole class use of computers. This way of using computers might offer a real alternative, namely the use of computers as an aid in teaching, for example for classroom demonstrations. With a limited number of computers in a school, this type of use would at least allow many teachers in parallel to use computers in their instruction. A clear advantage of such an approach could be that computers are thus integrated throughout the school curriculum in many subjects. Disadvantages are that additional equipment for each class is needed (like overhead plasma screens) and that students cannot profit directly from the interactivity characteristic of a computer. Adopting such a strategy will have consequences for the type of software to be acquired, but might also lead to increasing costs for software acquisition as programs need to be made available for the whole range of subjects in the school curriculum.

A second example of a short term strategy concerns the problem teachers experience in finding time to prepare lessons with computer use. Across countries principals, computer coordinators and teachers mention this problem as one of the major ones (it features almost consistently in the top four). This may be caused by the fact that usually applications of computers during a lesson requires preparatory activities different from the ones teachers are used to (which consists of using a textbook as the major source for lesson preparation). Assuming that teachers who use computers still use their textbook, for a short term strategy might be opted for, consisting of integrating software descriptions in the textbook by either educational publishers or software producers. Effects may be expected especially if during the development of materials the perspective of the 'teacher as learner' is taken into account. Courseware designed from this perspective must have many procedural specifications (careful "how-to-do" suggestions) which help the teachers to deal with the key problems of lesson preparation, namely lack of background knowledge and skills, changes in didactical role, and insufficient view on possible learning outcomes (Van den Akker, 1988). The importance of this approach to the time problems is that the shortage of time which is perceived as an important problem for teachers is not compensated by providing more time, but by trying to improve the quality of other variables in the teaching process (in this case the quality of the educational software and other curriculum materials).

Examples of *long term strategies* are much more difficult to give because such strategies should contain full elaborations of goals and means. We may interpret our findings regarding the status of computer use in 1989 as the first response of schools to the challenge to "join the computer revolution" (Walker, 1986, p. 35), that is, to start with the easiest applications, such as the teaching of computer education courses, and applications like drill and practice by taking the whole class to the computer lab. Walker rightly points to the fact that "anything else requires more money, more effort and expertise from teachers, and more variance from existing school practices" (p. 35). Should we be disappointed by this situation? Not necessarily so, if authorities and educators are willing to look at computers in education as a complex innovation to be introduced in educational practice and consequently, are ready to invest in designing long term implementation strategies aimed at creating new learning environments by means of new technologies. Walker (1986, p. 33) rightly states that "if even a small part of the visionary dreams of computer-based education is to be realized, major changes will be required in

the day-to-day activity and interaction patterns in classrooms. ... Developing these new patterns will require collaborative effort on a large scale sustained over a decade or more." If we look at the status of the use of computers in education from this perspective then we may consider the present situation the beginning stage of a long process that may take many years. If policy makers, administrators, teachers and courseware developers consider the present situation from such an implementation perspective, and if they are willing to take initiatives contingent with such a situation by choosing short term strategies as part of long term strategies, then we may expect a development away from the easiest responses that preserve traditional schooling, to innovative approaches aimed at creating challenging learning environments with the help of new technologies. In devising long term plans insight is needed into how different factors in the process of implementation of computers in education affect each other. It is hoped that further analyses of the data resulting from stage 1 and the data to be collected in stage 2 of this study will, in the near future, contribute to the increase of our knowledge concerning the way different factors affect the pace and direction of the implementation of computers in education.

Summary

In 1989, the IEA Computers in Education study collected data on computer use in elementary, lower- and upper secondary education in 22 countries. This article contains results from 19 educational systems (18 countries).

The article shows statistics related to the availability and the use of hard- and software, the problems experienced in using computers in schools and the attitudes towards computers of the principals in the sampled schools. The results show that in the past few years quite drastic changes have taken place in the number of schools equipped with computers and in the number of computers available in schools. Despite this fact, in most educational systems computers still are used by a limited number of teachers, and mainly for teaching students about computers; the integration of computers in existing subjects is increasing quite slowly. The major problems that are experienced in schools deal with teacher time, the lack of sufficient software of high quality, and the training of teachers.

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APPENDIX A

National Target Population and Sample Sizes

Belgium-Flemish

Population 2 (lower secondary education) and Population 3 (upper secondary education).
All (state, province/community and catholic) schools offering comprehensive general or comprehensive technical/arts education.

Belgium-French

Population 1 (elementary education)
All (state, province/community and catholic) schools, except special education (3,7% of all students).
Population 2 (lower secondary education)
All (state, province/community and catholic) schools offering comprehensive general or comprehensive vocational education (technical and arts). Excluded is vocational education (22,8% of all students) and special education (3,9% of all students).
Population 3 (upper secondary education).
All general secondary and vocational schools, except special education (3,9%).

Canada-British Columbia

Population 1 (elementary education), Population 2 (lower secondary education) and Population 3 (upper secondary education).
All schools.
For the Principal and Computer Coordinator questionnaires no distinction was made between Population 2 and Population 3.

China

Population 3 (upper secondary education).
All schools in the cities/provinces Beijing, Shanghai, Xingxiang city (Henon province), Inner Mongolia, Guangxi Zhuang autonomous region, Jiling, Anhui, Sichuan, Guangdong provinces.

France

Population 1 (elementary education).

All schools except private education (15% of students) and special education (less than 0,5% of students).

Population 2 (lower secondary education).

All schools except private education (students in "Collèges": 20% of all students) and special education.

Population 3 (upper secondary education).

All schools except private education (3% of students).

Federal Republic of Germany

Population 2 (lower secondary education) & Population 3 (upper secondary education).

All schools in 9 Bundesländer (58% of all students).

Greece

Population 2 (lower secondary education) & Population 3 (upper secondary education).

All schools except private and evening schools (altogether 4% of all students).

Hungary

Population 3 (upper secondary education).

All schools.

India

Population 3 (upper secondary education)

All schools in Delhi and Utter Pradesh, Maharashtra, West Bengal and Tamil Madu (which are the states with the maximum number of computer using schools (in respectively the regions NORTH, WEST, EAST AND SOUTH)).

Israel

Population 1 (elementary education).

All schools except special education (7% of all students).

Population 3 (upper secondary education).

All academic schools and technological schools with courses leading to certification. This excludes vocational education as well as independent schools (about 4% of all students).

Japan

Population 1 (elementary education) and Population 2 (lower secondary education).
 All schools except special education.
Population 3 (upper secondary education)
 All general and vocational schools.

Luxembourg

Population 2 (lower secondary education)
 All general and technical secondary schools.

The Netherlands

Population 1 (elementary education).
 All schools except special education.
Population 2 (lower secondary education)
 All schools except (5% of all students) international transition year, English stream, individual agricultural education, agricultural education and nautical education.
Population 3 (upper secondary education).
 All general secondary, social nursery, economical/administrative and technical schools. Excluded are all other vocational schools (about 6.4 % of all students). Teachers were only sampled from general secondary schools.

New Zealand

Population 1 (elementary education).
 All schools with students in standard 4 except the Correspondence School and special education.
Population 2 (lower secondary education)
 All schools with students in form 3, except the Correspondence School and special education.
Population 3 (upper secondary education).
 All schools with students in form 7, except the Correspondence School and special education.

Poland

Population 3 (upper secondary education)
 All schools.

Portugal

Population 1 (elementary education).

All schools in the public school system of the continental territory, except distance education.

Population 2 (lower secondary education) & Population 3 (upper secondary education).

All schools in the public schools system of the continental territory.

Slovenia

Population 3 (upper secondary education).

All schools.

Switzerland

Population 1 (elementary education).

All schools in the French speaking part with students in the age of 10 years.

Population 2 (lower secondary education).

All schools except schools in cantons Argau, Genève, Vaud.

Population 3 (upper secondary education).

All schools except schools in canton Genève.

USA

The sampling frame included all U.S. schools, public and private, that contained a 4th grade or higher, plus vocational and "alternative" high schools. The frame excluded separate schools for the special education population and also excluded schools that only exist to provide part-day or part-year pull-out classes for students from other schools.

Each school was allocated to one or more of three sub-frames, "primary", "lower-secondary", or "upper-secondary", depending on whether it contained a 5th grade, 7th or 8th grade, or 10th, 11th, or 12th grade.

Sixth-grade-only schools were allocated to the primary sub-frame and 9th-grade-only schools to the lower-secondary sub-frame.

Table A 1 (continued): Number of Cases per Educational System and Category of Respondents

Country / Educational System																		
Lower secondary schools	BFL	BFR	CBC	FRA	FRG	GRE	JPN	LUX	NET	NWZ	POR	SWI	USA					
Teachers science																		
non using	73	53	128	145	91	138	259	30	132	88	45	199	113					
using	2	4	17	61	48	0	74	2	13	22	13	25	75					
undetermined	0	0	0	3	0	1	2	0	9	0	3	0	1					
Teachers mother tongue																		
non using	69	64	75	98	84	132	299	27	122	76	26	167	137					
using	7	6	63	56	42	0	19	0	9	62	8	42	76					
undetermined	0	0	0	9	1	4	0	0	4	0	1	0	0					
Upper secondary schools	BFL	BFR	CBC	CHI	FRA	FRG	GRE	HUN	IND	ISR	JPN	NET	NWZ	POL	POR	SLO	SWI	USA
Principals																		
non using	6	6	0	90	4	0	426	2	408	33	49	56	0	143	65	5	16	1
using	254	192	138	329	360	198	30	306	471	151	613	160	133	429	155	74	303	424
undetermined	0	0	0	0	24	0	5	3	1	0	0	34	0	1	0	6	5	0
Coordinators																		
non using	0	0	0	3	3	1	0	0	3	0	57	0	0	2	10	0	0	31
using	224	137	118	277	359	193	29	282	469	148	549	170	138	313	155	37	282	337
undetermined	1	6	2	5	2	7	0	5	1	0	44	0	1	150	66	14	0	42
Computer teachers																		
non using	4	1	2	12	14	1	7	15	15	4	83	1	1	0	18	7	30	0
using	349	133	104	275	325	91	76	282	458	244	415	9	136	177	137	46	576	285
undetermined	2	0	0	0	4	0	4	0	0	2	3	1	0	0	6	10	8	0
Subject teachers total																		
non using	310	181	179	0	373	262	137	704	385	163	1931	97	273	297	116	129	558	311
using	57	37	77	35	168	68	2	148	295	16	209	33	138	65	44	7	140	254
undetermined	1	0	0	0	4	1	13	0	0	0	7	7	0	1	0	13	4	0
Teachers math																		
non using	130	70	74	0	139	107	45	226	140	55	510	32	80	120	50	47	167	99
using	30	23	13	19	72	41	2	61	114	5	93	24	70	23	27	1	59	77
undetermined	1	0	0	0	3	1	5	0	0	0	0	0	0	0	0	11	2	0
Teachers science																		
non using	110	68	58	0	132	102	39	204	138	59	830	35	100	154	42	30	204	97
using	17	12	28	16	78	25	0	78	167	10	103	8	53	41	14	6	60	83
undetermined	0	0	0	0	0	0	7	0	0	0	5	6	0	1	0	1	1	0
Teachers mother tongue																		
non using	70	43	47	0	102	53	53	274	107	49	591	30	93	23	24	52	187	115
using	10	2	36	0	18	2	0	9	14	1	13	1	15	1	3	0	21	94
undetermined	0	0	0	0	1	0	1	0	0	0	2	1	0	0	0	1	1	0

Table A.1: Number of Cases per Educational System and Category of Respondents

Elementary schools	Country / Educational System									
	BFR	CBC	FRA	ISR	JPN	NET	NWZ	POR	USA	USA
Principals										
non using	102	1	33	101	157	102	101	152	0	
using	145	152	340	159	206	113	379	100	425	
undetermined	0	1	15	0	0	14	4	3	0	
Coordinators										
non using	8	0	6	0	29	1	3	10	80	
using	69	136	315	156	186	125	361	90	307	
undetermined	2	0	4	2	151	1	2	152	28	
Teachers										
non using	153	40	21	21	664	26	61	0	163	
using	75	337	188	305	370	193	329	0	271	
undetermined	0	0	0	0	13	1	1	0	1	
Lower secondary schools	BFL	BFR	CBC	FRA	FRG	GRE	JPN	LUX	NET	NWZ
Principals										
non using	61	14	0	7	26	367	99	0	19	1
using	221	172	138	393	382	60	264	27	237	122
undetermined	5	0	0	19	2	6	0	0	6	0
Coordinators										
non using	3	1	0	0	3	2	33	0	0	0
using	131	112	120	413	299	113	216	27	236	127
undetermined	6	3	0	0	6	39	105	0	1	1
Computer teachers										
non using	55	6	11	0	0	99	64	0	3	4
using	144	55	30	0	51	55	136	66	192	103
undetermined	1	0	0	0	0	1	4	1	4	0
Subject teachers total										
non using	226	178	327	401	244	408	811	80	404	248
using	24	17	100	258	219	6	178	2	48	146
undetermined	1	0	0	15	2	7	2	0	13	0
Teachers math										
non using	84	61	124	158	69	138	253	23	150	84
using	15	7	20	141	129	6	85	0	26	62
undetermined	1	0	0	3	1	2	0	0	0	1

(continued on next page)