New technologies in education: trends, risks and opportunities

by Ulf Fredriksson

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New technologies in education: trends, risks and opportunities

One of the most radical changes in many societies over recent decades has been the development of new technologies in the area of information and communication. These changes are even sometimes referred to as an "information revolution" and it is assumed that societies are in the process of developing into what has been called "the information society" or "the knowledge society". These changes have affected education and will probably in the future affect the development of education even more. The purpose of these papers is to discuss some of the changes we have seen in this field and the kind of developments we may expect. Due to the importance of these developments, there is a need for teacher unions to reflect on their strategies related to the use of new technologies in education.

1.   Changes in society

During the second part of the last century, computers and the use of computers went through a rapid and profound change. In the 50's and the 60's computers were huge machines used to make complicated calculations and to store large databases. Gradually in the 70's and the 80's computers turned into desk-tops, not only used for calculations but also for word processing. Progressively, computers replaced typewriters in offices and homes. In the 90's the computers became even smaller and portable computers, referred to as lap-tops, became more common. The computers were no longer only calculators and typewriters, but also became instruments for communication. Through the development of and the expanded use of e-mail and the World Wide Web (www), people got the opportunity to send and receive message and to find information through their computers. The computers became an important complement to the telephone, the fax and the ordinary post service. On top of this development, the use of computers has further developed in many other areas of relevance to a range of specific tasks.

1.1.   In business

In the 50's a few enterprises had computers which were usually located at special centres. Today, computers are found in almost all types of enterprises. Table 1 below gives some indications of this development.

The figures in the table do not give the whole picture of the use of computers in working life, but they give an idea about how widespread ICT[1] is and the rapid changes which have taken place during recent years.

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[1] ICT - Information and Communication Technology

Table 1.   Level of Internet access in enterprises

Country	% of enterprises with access to internet	
	2000	*2001*
Austria	84	99
Belgium	79	93
Denmark	87	96
Finland	92	99
France	58	73
Germany	82	96
Greece	54	83
Iceland	94	:
Ireland	77	95
Italy	72	91
Japan	45	:
Luxembourg	55	85
Netherlands	65	91
Norway	73	:
Portugal	64	66
Spain	67	92
Sweden	90	99
United Kingdom	63	84
: no information available		
Source: Eurostat, 2002		

1.2.   In the home

In the same way as new technologies have become an integrated part of activity at many workplaces the use of computers and access to computers have increased in the home. Table 2 gives a picture of the level of Internet access in homes.

Table 2.   Level of Internet access in homes

Country	% of homes with access to internet			
	1998	*1999*	*2000*	*2001*
Austria	6.8	12	38	47.2
Belgium	:	12	29.2	36.4
Denmark	8.2	35	51.6	58.6
Finland	17.2	21	43.5	50.2
France	3.9	8	19	30.1
Germany	24.6	11	27.1	38.4
Greece	7.1	3	11.7	9.9
Iceland	:	:	:	69.7
Ireland	8.4	6	35.5	47.6
Italy	6.1	7	23.7	33.5
Japan	:	19.1	34	:
Luxembourg	14	17	36.3	43
Netherlands	19.6	21	54.8	63.8
Norway	:	:	:	58.2
Portugal	3.4	4	18.1	26.1
Spain	5	6	15.7	24.7
Sweden	39.6	51	53.8	60.7
United Kingdom	10.7	17	40.9	49.3
United States	:	30	46.7	:
: no information available				
Source: Eurostat, 2002				

It should be kept in mind that the figures above mainly cover information from industrialised countries. Table 3 below gives figures on the number of computers per thousand inhabitants and the number of Internet hosts per 100,000 inhabitants in different regions of the World.

Table 3.   Number of computers per thousand inhabitants and number of Internet hosts per 100,000 inhabitants in different regions of the World (1997)

Region	Number of computers per thousand inhabitants	Number of internet hosts per 100 000 inhabitants
More developed regions of which:	274	3411
Northern America	388	7106
Asia / Oceania	223	1357
Europe	204	1336
Countries in transition	35	116
Less developed regions of which:	12	16
Sub-Saharan Africa	8	21
Arab States	10	5
Latin America / Caribbean	31	49
Eastern Asia / Oceania	13	18
Southern Asia	2	1
Least developed countries	1	0
World total	58	515

Source: UNESCO, 2000

As can be seen in the table there are huge variations between regions. These differences are often referred to as the "digital divide".

2.   New technology in education

Based on the statistical information given above, it can be concluded that computers and ICT are used at many workplaces and in many homes in the industrialised countries. But what is the situation in schools? According to OECDs indicators (OECD, 2002) show that for many 15-year-old, daily contact with computers is much more likely to occur in the home than at school.

There are mainly two sources available which can offer the internationally comparable information needed to answer this question; the statistics from the European Union presented in the report "*Basic Indicators on the Incorporation of ICT into European Education Systems. Fact and figures*" (European Union, 2001) and the findings of the SITES[2] study. Results from SITES have so far been published in a report "*ICT and the Emerging Paradigm for Lifelong Learning. An IEA Educational Assessment of Infrastructure, Goals, and Practices in Twenty-six Countries*", (Pelgrum & Anderson, 2001) and in "*Education at a Glance*" (OECD, 2001). This information mainly covers the industrialised countries. The information from the

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[2] SITES - Second Information Technology in Education Study

European Union covers the 15 EU countries[3] and the SITES project has covered 26 countries[4], but not all information from SITES covers all the 26 countries. Internationally comparable information about new technology and education in other parts of the world is available to a much lesser degree.

2.1.   Access to computers and the internet

IEA[5] conducted a large study on Computers in Education to assess the which and how computers are being used in education in 12 different countries (Pelgrum, Jansen Reinen, & Plomb; 1993). Data was collected on two occasions, in 1989 and in 1992, making it possible to see what changes took place over time. An increasing number of schools acquired access to computers between 1989 and 1992, but a substantial number of primary and lower secondary schools in several countries still did not posses computers for instructional use in 1992. In almost all countries, the number of computers in schools increased considerably in the three years, but most equipment still consisted of quite old fashioned machines. Also, the availability of instructional tool software increased between 1989 and 1992, but shortages of software were still seen as a problem in many countries.

More recent and detailed information from Eurostat/Eurydice in table 4 gives a slightly different picture, as well as the information from the SITES study presented in table 5 and from the PISA[6] study presented in table 6.

Based on the figures in tables 4, 5 and 6, three conclusions can be drawn: 1) There are big differences between the schools systems in the European countries concerning the availability of computers and access to the Internet. 2) In some countries there are considerable differences between the number of computers available and the number of computers available with an Internet connection. 3) In almost all countries the availability of computers is higher in secondary education than in primary education.

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[3] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom

[4] Belgium (Fr.), Bulgaria, Canada, China (Hong Kong), China (Taiwan), Cyprus, Czech Republic, Denmark, Finland, France, Hungary, Iceland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, New Zealand, Norway, Russian Federation, Singapore, Slovak Republic, Slovenia, South Africa and Thailand.

[5] IEA - International Association for the Evaluation of Educational Achievement

[6] PISA - Programme for International Student Assessment

Table 4. *Number of pupils per computer and number of pupils per computer with an Internet connection*

Country	Number of pupils per computer		Number of pupils per computer with an internet connection	
	primary	secondary	primary	secondary
Austria	8.9	8.5	17.0	10.5
Belgium	11.0	8.0	32.5	14.2
Denmark	4.2	1.5	6.0	2.0
Germany	19.2	13.7	52.3	22.0
Greece	29.4	15.2	80.6	22.0
Finland	7.5	6.8	11.9	7.5
France	14.1	9.4	43.9	21.4
Ireland	11.6	8.3	30.1	13.1
Italy	20.8	8.9	55.1	18.9
Luxembourg	2.0	6.3	5.1	6.7
Netherlands	8.3	9.1	43.2	15.4
Portugal	17.0	16.4	36.3	36.9
Spain	11.2	12.4	30.0	25.3
Sweden	9.7	4.1	13.4	4.8
United Kingdom	11.8	6.4	23.5	8.9

Source: European Commission/Eurydice (2001)

Table 5. *Ratio of total number of students to total number of computers available to students (1998 - 1999)*

Country	Primary education	Lower secondary education	Upper secondary education
Belgium (Fr.)	m	29,7	32.2
Czech Republic	m	43.7	17.4
Denmark	m	11.7	m
Finland	16.3	13.5	m
Hungary	m	35.6	m
Iceland	20.5	18.8	17.0
Italy	157.7	30.1	24.4
Luxembourg	m	15.6	16.3
Netherlands	27.0	19.5	m
Norway	22.9	13.8	5.8

m = missing data

Source: International Association for the Evaluation of Educational Achievement (IEA)/SITES, quoted from OECD: Education at a glance. OECD Indicators 2001.

Table 6. Ratio of students to computers (2000)

Country	Ratio of students to computers 50th percentile (median)
Austria	7
Belgium	11
Czech Republic	15
Denmark	8
Finland	8
France	11
Germany	22
Greece	28
Hungary	9
Iceland	10
Ireland	14
Italy	12
Latvia	5
Luxembourg	9
Norway	6
Poland	26
Portugal	36
Russian Federation	10
Spain	21
Sweden	8
Switzerland	9
United Kingdom	5

Source: OECD PISA database, 2001, quoted from OECD: Education at a glance. OECD Indicators 2002.

An interesting question, which is reflected in tables 7 and 8, is the extent to which computers in schools are used. Table 6 shows the percentage of teachers in primary education who had used computers and/or the Internet in the classroom in 2001

With the exception of Greece, Luxembourg, Portugal and Spain, a majority of the teachers in primary education had used computers in the classroom sometime during year 2001. More than 50% of the primary teachers had used the Internet in the classroom in Denmark, Finland, Ireland, Sweden and United Kingdom.

Table 7.   Percentage of teachers using computers and/or Internet in the classroom. Primary education. 2001

Country	Teachers using computers (%)	Teachers using internet (%)
Austria	59	23
Belgium	86	34
Denmark	88	69
Germany	37	11
Greece	12	4
Finland	95	78
France	76	27
Ireland	95	80
Italy	65	26
Luxembourg	27	27
Netherlands	96	34
Portugal	39	18
Spain	46	19
Sweden	80	54
United Kingdom	100	56

Source: European Commission/Eurydice (2001)

Table 8 shows how many hours per week teachers in primary education who had used computers in the classroom in 2001 actually claimed that they had used the computers.

Table 8.   Average periods during which primary schoolteachers used in the classroom, in hours per week in, 2001

Country	Average periods during which primary schoolteachers, who state that they use computers with their pupils, used computers (with or without internet connections) in the classroom, in hours per week in, 2001
Austria	2.2
Belgium	3.7
Denmark	3.1
Germany	2.9
Greece	4.3
Finland	3.9
France	3.4
Ireland	6.8
Italy	3.1
Luxembourg	4.1
Netherlands	7.5
Portugal	2.8
Spain	3.1
Sweden	5.8
United Kingdom	7.9

Source: European Commission/Eurydice (2001)

On average those primary teachers within the EU who used computers with their pupils did so for five hours a week. There are significant differences between the countries. In the UK, those teachers who used computers did so for about 8 hours a week and in Austria for about 2 hours. It should be kept in mind that, in the UK, almost all primary teachers used computers in the classroom, while in Austria about

40% of the primary teachers did not use computers at all in the classroom. In Greece, those 12% of the primary teachers who used computers used them on average 4.3 hours a week. The remaining 88% of Greek primary teachers did not use computers at all.

Table 9 shows the percentage of teachers in secondary education who had used computers and/or the Internet in the classroom in 2001.

Table 9. *Percentage of teachers using computers and/or Internet in the classroom. Secondary education. 2001*

Country	Teachers using computers (%)	Teachers using internet (%)
Austria	83	66
Belgium	70	51
Denmark	86	79
Germany	53	38
Greece	26	14
Finland	83	75
France	52	34
Ireland	71	60
Italy	82	58
Luxembourg	41	41
Netherlands	73	43
Portugal	41	24
Spain	39	23
Sweden	79	68
United Kingdom	100	67

Source: European Commission/Eurydice (2001)

With the exception of Greece, Luxembourg, Portugal and Spain, a majority of the teachers in secondary education had used computers in the classroom sometime during 2001. More than 50% of the secondary teachers used the Internet in the classroom in Austria, Belgium, Denmark, Finland, Ireland, Italy, Sweden and United Kingdom. It should be added that teachers of computer science were included in the figures used to calculate the percentages indicated in table 8. It can be noted that the use of computers in secondary education seems to be less frequent than in primary education. In total in the EU, 71% of the primary teachers used computers in the classroom on some occasion, while the corresponding figure for secondary education was 60%.

Table 10 shows the reasons given by teachers in secondary education why they have not used computers and/or the Internet in the classroom in 2001.

Table 10.   Teachers' reasons for not using the Internet with pupils. Secondary education. 2001

Country	Problems of access	Internet of little relevance or interest	Difficulty in using facilities
Austria	46	29	26
Belgium	90	36	14
Denmark	30	66	11
Germany	116	34	4
Greece	69	27	19
Finland	13	75	0
France	85	38	36
Ireland	86	23	11
Italy	42	44	15
Luxembourg	66	49	4
Netherlands	73	16	10
Portugal	72	20	19
Spain	64	25	8
Sweden	49	60	10
United Kingdom	118	37	6

The percentages shown are sometimes over 100, because the teachers were able to give several reasons for not using internet.

Source: European Commission/ Eurydice (2001)

With the exception of Denmark, Finland, Italy and Sweden, the most common reason for teachers not using the Internet with the pupils is problems of access. When the teachers have indicated that they have problems of access to the Internet, the reasons for this may be that the classrooms do not have Internet connection facilities or that the schools do not have computers or Internet connections. It should be noted that those countries, in which a fairly high percentage of the teachers said that they did not use the Internet with pupils because it was of little relevance or interest, were in most cases countries with comparatively good access to computers and Internet. Obviously, when access to computers and the Internet is at a high level, there is still a considerable number of teachers who deliberately choose not to use these tools. Reasons given for regarding the Internet as of little relevance or interest are that the teachers do not find it helpful for work in their subjects or that the information on the net is not in the language of the country concerned. A comparatively small percentage of teachers claim the Internet is not used because of difficulties using it. Such difficulties could be either that the teachers do not know how to use it or that not enough students have sufficient skills to use it. The only country where this reason is given by more than a third of the teachers is France.

Data from SITES (Pelgrum & Anderson, 2001) indicates that a fairly high percentage of the schools who have computers in the countries covered by the study have computers which are not used. The most common reason why the computers are not used seems to be that they are outdated. Lack of knowledge of how to use the computers among teachers and students seems to be a minor reason for not using computers. Data from SITES also indicates that, in most of the countries covered by the study, more than 50% of the primary school pupils had access to the Internet. In most of the countries, there seem to be plans in place aimed at ensuring that almost all of the schools have Internet access before 2001. The picture concerning lower secondary education is more diverse. Countries like Iceland already have 100% of the schools linked to the Internet while in other countries such as the Czech Republic, 33% of the lower secondary school students are in schools linked to the

Internet. In many countries, plans exist to see that almost all of the schools will have access to the Internet before the end of 2001. The Czech Republic and Hungary will still have a large number of students in lower secondary schools without Internet access after 2001. The picture for the upper secondary schools is basically the same as for the lower secondary schools.

When the availability of different software in schools was examined in the SITES study, it was found that, of the softwares covered in the study, Internet browsers seemed to be the most common in several countries and educational games the least common. Countries with a fairly good access to computers also seem to be the countries that overall had better access to different types of software.

2.2.   How are computers used in education?

The next question of importance is to examine how computers are used in schools. The IEA study on Computers in Education in 1992 (Pelgrum, Jansen Reinen, & Plomb; 1993) tried to examine how computers had been used in education in 12 different countries. The most popular use of computers at that time in schools was for teaching about computers and applications and how to handle them. Only a minority of the students used computers regularly in subjects like Mathematics, Science and Mother Tongue. Results from TIMSS[7] (Beaton et al.; 1996) suggested that the weaker students used computers in school to a larger extent then the "better" students, at least in Science and Mathematics.

A group of researchers (Harasim, Hiltz, Teles, & Turoff; 1995) asked teachers who had used the Internet as a part of the learning process what changes they had observed. These teachers had observed the following changes;
-      the role of the teacher changed to that of facilitator and mentor;
-      students became active participants; discussions became more detailed and deeper;
-      access to information resources expanded significantly;
-      learners became more independent;
-      access to teachers became equal and direct;
-      interactions among teachers were increased significantly;
-      education became learner centred; learning became self-paced;
-      learning opportunities for all students became more equal; learner-learner group interactions were significantly increased;
-      teaching and learning increased;
-      the teacher-learner hierarchy broke down: teachers became learners, and learners became teachers.

Based on studies in the field, COMMITT[8] (Plomb, Brummelhuis, & Rapmund; 1996) identified three stages that teachers pass through on their way to becoming experienced technology users;
1)   The teachers use computers to support traditional methods of teaching, such as drill-and-practice, text orientation, whole group lectures and seatwork.

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[7] TIMSS - The Trends in International Mathematics and Science Study
[8] An advisory Committee for the Dutch Ministry of Education, Culture and Science (COMMITT - Committee on MultiMedia In Teacher Training)

2)   The teachers gain confidence and use technology as part of more innovative instruction, including team teaching, interdisciplinary project-based instruction, and individually paced instruction.

3)   The teachers enter an inventive stage in which they experiment and change, using technology to support active, creative and collaborative learning.

The results from the SITES study (Pelgrum & Anderson, 2001) seem to indicate that the student : computer ratio is the factor which has the strongest influence on the development of new pedagogical practices in schools.

Table 11 shows the extent to which the principals involved in the PISA study believed that learning was hindered by a lack of computers in their schools.

In the OECD countries, more than 37 % of the students of 15 years-old were enrolled in schools where principals reported that learning was hindered to some extent or a lot by the lack of computers for education.

Table 11.   The extent to which learning is hindered by a lack of computers for instruction (2000)

Country	Not at all (%)	Very little (%)	To some extent (%)	A lot (%)
Austria	30	32	23	15
Belgium	49	32	15	3
Czech Republic	37	25	28	10
Denmark	32	40	21	6
Finland	16	41	35	7
France	39	33	23	5
Germany	20	30	35	15
Greece	15	17	40	28
Hungary	69	18	9	4
Iceland	26	29	41	4
Ireland	34	24	30	12
Italy	42	26	26	6
Latvia	25	35	24	16
Luxembourg	24	53	23	n
Norway	12	28	52	9
Poland	33	29	27	12
Portugal	27	35	31	8
Russian Federation	11	3	31	55
Spain	43	27	23	7
Sweden	21	29	40	11
Switzerland	40	37	19	4
United Kingdom	35	33	24	7

n =magnitude is either negligible or zero

Source: OECD PISA database, 2001, quoted from OECD: Education at a glance. OECD Indicators 2002.

2.3.   Teachers' knowledge about computers

Another important question is what knowledge and skills teachers have in using computers and, linked to this, the extent to which they have received training and had opportunities to get training.

Table 12 shows the percentage of students in schools whose principals have indicated that the school had adopted policy goals to train all teachers to use ICT and the percentage reflecting these goals were almost completely or fully realised.

Table 12.	Goals and realisation of goals for training teachers in ICT (1998 - 1999)					
Country	Primary education Goals		Lower secondary education Goals		Upper secondary education Goals	
		Realisation		Realisation		Realisation
Belgium (Fr.)	m	m	81	10	78	11
Czech Republic	m	m	83	12	84	17
Denmark	m	m	85	19	m	m
Finland	97	32	98	31	m	m
Hungary	m	m	97	7	m	m
Iceland	80	10	78	8	79	7
Italy	86	23	90	14	91	17
Luxembourg	m	m	71	5	71	5
Norway	95	20	97	24	97	24

m = missing data

Source: International Association for the Evaluation of Educational Achievement (IEA)/SITES, quoted from OECD: Education at a glance. OECD Indicators 2001.

As can be seen in the table, most students in those countries for which data exists seem to be in schools where goals have been set to train teachers in ICT. It can also be noted that a much lower percentage of students are in schools where these goals have been realised.

Table 13 shows the percentage of primary schoolteachers and secondary schoolteachers who had received official training in 2001 in the use of computers and/or the Internet in their teaching.

Table 13.	Percentage of primary schoolteachers and secondary schoolteachers who have received official training in the use of computers and/or the Internet in their teaching. 2001	
Country	Primary schoolteachers (%)	Secondary schoolteachers (%)
Austria	58	75
Belgium	48	62
Denmark	70	68
Germany	39	37
Greece	35	43
Finland	77	81
France	43	48
Ireland	83	71
Italy	61	53
Luxembourg	43	35
Netherlands	67	60
Portugal	39	38
Spain	68	62
Sweden	67	63
United Kingdom	80	70

Source: European Commission/Eurydice (2001)

On average 52% of the primary teachers in the EU have received training and 50% of the secondary teachers. The figures given by the European Commission/Eurydice are generally higher than the figures from the SITES study. One reason for this can of course be that the EU figures are more recent than the SITES figures. If that is the explanation, it can be assumed that a large number of teachers in the EU countries actually have received ICT training during the last 2 - 3 years.

Table 14 shows the percentage of teachers in the EU who have received official training in the use of computers and/or Internet, broken down by age, gender and, in the case of secondary teachers, in which subject they teach.

The pattern seems to be more or less the same, irrespective of the age of the teacher and the gender of the teacher. Also, in the case of subjects, there do not seem to be any big differences between different groups of subject teacher in secondary education.

Table 14. *Percentage of primary teachers and secondary teachers in the EU who have received official training in the use of computers and/or Internet*

	Primary teachers who have been officially trained in the use of		Secondary teachers who have been officially trained in the use of	
	computers	*internet*	*computers*	*internet*
20 - 29 years old	62	46	50	39
30 - 39	57	40	46	35
40 - 49	60	40	49	33
50 and over	62	37	47	30
Men	62	44	49	34
Women	60	39	47	32
Sciences	-	-	49	34
Social sciences	-	-	43	31
Humanities	-	-	44	27
Languages	-	-	52	37
Professional/technical courses	-	-	46	27
Computing	-	-	54	40
Others	-	-	44	31

Source: European Commission/Eurydice (2001)

According to SITES (Pelgrum & Anderson, 2001), general introductory courses seem to be the type of courses most often available and most of these courses are available as "in-house" courses. Other types of courses seem to be available to a lesser extent, but more frequently as external courses. Training on software seems to be less common than training on hardware. The most frequent software courses are introductory course for applications / standard tools and these courses seem to be more often in-house than external. It is less common for teachers to have participated in other types of courses and, when they have participated in such courses, they have more often been external courses than in-house training. Most of the courses available for teachers in the field of ICT training on the Internet and multimedia seem to be introductory courses. In countries where the use of computers in schools tends to be more common, these courses are in-house, while in other countries they are available externally. More advanced courses in this field are

less common, and more often offered externally than in-house. Pelgrum and Anderson (2001) conclude, based on their data, that "*the most prevalent arrangements involved informal contacts, computer coordinators, courses run by external agencies and in-school courses*" (p. 165).

It is also of great interest not only to know what training the teachers working in schools have received, but also the extent to see to which ICT is included in the education of future teachers. Table 15 shows to what extent ICT is made a compulsory element in teacher education, a core curriculum option or if there is institutional autonomy. "Core curriculum option" refers to one of a range of subjects offered by a teacher education institution, from which the teacher students have to select a limited number in order to cover part of their compulsory minimum curriculum. "Institutional autonomy" means that teacher education institutions are free to decide whether training in ICT is compulsory or not.

Table 15. *Inclusion of ICT in initial education of all teachers (except specialist ICT teachers, 2000/2001*

Country	Education of primary teachers	Education of teachers in lower secondary education	Education of teachers in upper secondary education
Austria	Compulsory	Compulsory	Core curriculum option
Belgium	Compulsory	Compulsory	Compulsory (Dutch speaking)
			Institutional autonomy (French and German speaking)
Bulgaria	Institutional autonomy	Core curriculum option	Core curriculum option
Cyprus	Compulsory	Compulsory	Compulsory
Czech Republic	Institutional autonomy	Institutional autonomy	Institutional autonomy
Denmark	Compulsory	Compulsory	Compulsory
Estonia	Compulsory	Compulsory	Compulsory
Finland	Compulsory	Compulsory	Compulsory
France	Compulsory	Compulsory	Compulsory
Germany	Core curriculum option	Core curriculum option	Core curriculum option
Greece	Compulsory	Not provided	Not provided
Hungary	Institutional autonomy	Institutional autonomy	Institutional autonomy
Iceland	Compulsory	Compulsory	Compulsory
Ireland	Institutional autonomy	Institutional autonomy	Institutional autonomy
Italy	Core curriculum option	Core curriculum option	Core curriculum option
Latvia	Compulsory	Compulsory	Compulsory
Liechtenstein	Institutional autonomy	Not provided	Not provided
Lithuania	Compulsory	Compulsory	Compulsory
Luxembourg	Compulsory	Compulsory	Compulsory
Malta	Compulsory	Compulsory	Compulsory
Netherlands	Compulsory	Compulsory	Compulsory
Norway	Compulsory	Compulsory	Compulsory
Poland	Institutional autonomy	Institutional autonomy	Institutional autonomy
Portugal	Institutional autonomy	Institutional autonomy	Institutional autonomy
Romania	Institutional autonomy	Institutional autonomy	Institutional autonomy
Slovakia	Institutional autonomy	Institutional autonomy	Institutional autonomy
Slovenia	Compulsory	Compulsory	Compulsory
Spain	Compulsory	Institutional autonomy	Institutional autonomy
Sweden	Compulsory	Compulsory	Compulsory
United Kingdom	Compulsory	Compulsory (England and Scotland)	Compulsory (England and Scotland)
		Institutional autonomy (Northern Ireland and Wales)	Institutional autonomy (Northern Ireland and Wales)

Source: European Commission/Eurydice (2001)

It can be noted that, in most countries, ICT training is included as a compulsory subject in all types of teacher education. In the countries where the teacher education institutions have autonomy, ICT training may be included, but not always.

2.4.   New technologies in the curriculum

Another area to examine is the extent to which ICT has been included as a part of the teaching offered in schools. All the EU countries and the candidate countries

have official policies which encourage the use of information and communication technologies in primary and secondary education (European Commission/Eurydice, 2001). Table 16 shows whether ICT is included in the curriculum or not and the approach to ICT in the curriculum.

Table 16.   Inclusion of ICT and approaches to ICT in the curriculum

Country	Primary education	Secondary education
Austria	Used as a tool for other subjects	Included in the curriculum
Belgium	Used as a tool for other subjects	Included in the curriculum
Bulgaria	Separate subject	Included in the curriculum
Cyprus	Not included in the curriculum	Included in the curriculum
Czech Republic	Not included in the curriculum	Included in the curriculum
Denmark	Used as a tool for other subjects	Included in the curriculum
Estonia	Separate subject and used as a tool for other subjects	Included in the curriculum
Finland	Used as a tool for other subjects	Included in the curriculum
France	Used as a tool for other subjects	Included in the curriculum
Germany	Used as a tool for other subjects	Included in the curriculum
Greece	Not included in the curriculum	Included in the curriculum
Hungary	Separate subject	Included in the curriculum
Iceland	Separate subject and used as a tool for other subjects	Included in the curriculum
Ireland	Used as a tool for other subjects	Included in the curriculum
Italy	Not included in the curriculum	Not included in the curriculum
Latvia	Not included in the curriculum	Included in the curriculum
Liechtenstein	Used as a tool for other subjects	Included in the curriculum
Lithuania	Not included in the curriculum	Included in the curriculum
Luxembourg	Used as a tool for other subjects	Included in the curriculum
Malta	Used as a tool for other subjects	Included in the curriculum
Netherlands	Separate subject and used as a tool for other subjects	Included in the curriculum
Norway	Used as a tool for other subjects	Included in the curriculum
Poland	Separate subject and used as a tool for other subjects	Included in the curriculum
Portugal	Used as a tool for other subjects	Included in the curriculum
Romania	Separate subject	Included in the curriculum
Slovakia	Not included in the curriculum	Included in the curriculum
Slovenia	Separate subject and used as a tool for other subjects	Included in the curriculum
Spain	Used as a tool for other subjects	Included in the curriculum
Sweden	Used as a tool for other subjects	Included in the curriculum
United Kingdom	Separate subject and used as a tool for other subjects	Included in the curriculum

Source: European Commission/Eurydice (2001)

For primary education the countries have been categorised in four groups; those which have not included ICT in the curriculum, those where ICT is used as tool for other subjects, those where ICT is a separate subject and those where ICT is both a separate subject and used as a tool in other subjects. Out of the 30 countries covered in the table, there are seven where ICT is not included in the curriculum for primary education.

For secondary education there were only two categories, those which had included ICT in the curriculum and those which had not. Only one country had not included ICT in its curriculum.

3.   Will the new technologies affect education?

Section 2 tried to give an overview of the present situation, but an even more important question is how information and communications technologies will affect schools and the teaching profession in the future. As was noted above, all the EU countries and the candidate countries have official policies to encourage the use of information and communication technologies in primary and secondary education (European Commission/Eurydice, 2001). In the Presidency Conclusions of the Lisbon European Council, the Council called on "*the Member States to ensure that all schools in the Union have access to the Internet and multimedia resources by the end of 2001, and that all the teachers are skilled in the use of the Internet and multimedia resources by the of 2002;*" (Lisbon European Council: Presidency Conclusions, Paragraph 11).

Obviously there is a strong will among most governments to increase the use of ICT in education. The interesting question is what changes can we expect to come out of this wish? During the last 100 years, we have witnessed enormous changes in society. Some of these changes have been reflected in the day-to-day life in schools, but it is probably correct to say that they have not changed the basic structure of education. During recent years, we have experienced what is often described as an increased speed of change. Will these changes be incorporated and adapted to the present structures within the education system or will they lead to changes in the whole structure, reshaping education in a way which has not been seen earlier? Some observers have predicted that the new technologies will "revolutionise" education. On the other hand, it can be noted that predictions of radical changes in education have been made earlier and the actual change has seldom been as radical as predicted.

In the report "*Teaching and learning for the future*" (Plomb, Brummelhuis, & Rapmund; 1996) COMMITT has tried to predict in what way computers may change the learning process in schools. They identified two approaches to learning in schools; teacher oriented and student oriented learning. COMMITT assumes that information and communication technology is an adequate medium to support the shift towards student oriented ways of learning. Few people seem to believe today that a broader introduction of new technologies will lead to the disappearance of the teacher, but that the role of the teacher will change.

3.1.   Arguments for and against changes

Often, when predictions about future developments are discussed, there is a tendency to assume that these changes are unavoidable. Obviously no changes are unavoidable, there are always a window of opportunity; but in order to use that opportunity there is a need to know in which direction you would like to change things.

Basically, in the case of ICT in education, there could be arguments for and against the use of ICT. A reason for being sceptical towards the use of ICT in schools, which has been expressed by teachers, is that students need training to read, write and count in the traditional way. If schools are not providing this training the students will never learn it. The use of computers is something which the students can learn at home.

An argument for the use of ICT in education is that the use of computers is becoming a more and more integrated part of everyday life. Much of the practical application of knowledge is linked to the use of ICT. In the same way that schools have a task to provide students with knowledge about other tools which can be used to communicate and get information, there is a responsibility to help the students to learn to use the computer as a tool in a good, efficient and responsible way.

3.2. The digital divide

There is also another important dimension to this. The digital divide was mentioned above to describe the difference between the industrialised countries and the developing countries in respect of computers. A similar digital divide also exists within many countries. Even if access to computers and Internet has increased rapidly in recent years, there are still in many countries large groups of families who do not have access to computers. It is likely that this group will get smaller and smaller, but it cannot be ignored that in many societies there will always be groups without computers. Even in a society where almost everyone has computers, there will be differences between those who have access to the most modern computers and those who will still use models which are not up-to-date with the latest technical development. In the same way that all people do not have the latest models of cars, people will have different models of computers. Already today, computer literacy is a prerequisite for many jobs and those who have not had the possibility to learn to use the most up-to-date computers and the newest programmes are disfavoured. This may be even more evident in the future.

In this context schools may have an important role to play in bridging the digital gap between homes. If schools provide access to the most modern computers and the use of the most up-to-date programmes, this creates a better opportunity for children from disadvantaged homes to obtain the same skills and knowledge as those from more wealthy homes.

3.3. Education and technological change

There is often a belief that education cannot change much and that present structures will remain more or less as they are. Many other sectors of society have changed radically over the years. Over the last 100 years farming has changed from being very labour intensive to a situation where a much smaller number of people are needed to produce the same amount of food as was produced earlier. Banking has changed in the last twenty years to become much less labour intensive than it used to be and highly automatised. The question is whether education is likely to be confronted with similar changes or if the nature of education is so different from many other sectors in society that there will be no important changes.

In the past, many types of new technologies have not been fully integrated into the everyday life of schools. Both in the case of radio and television, many visions existed about how these media could change education. In most cases the impact of these media on education was rather limited. Some people would argue that the same will be the case for computers. These persons would argue that the vision of what computers can do in education is exaggerated.

Another issue is the ownership of the tools used in schools. There is no doubt that teachers have had a strong ownership of the written word, as it has appeared in books and on paper. It is also clear that teachers have, to a much lesser degree, had an ownership of other media used in schools. The question in the case of ICT is who will take the lead in developing the use of new technologies in education. Will the production of hardware and software for education be controlled by the big computer companies, the publishing houses or the teachers?

4.   Three areas for changes

When the future impact of ICT in education is discussed it may be helpful to define three areas in which change can be expected in one way or another; the delivery of education, the methodology used in teaching and the content of education. Delivery is to be understood as the whole system in which education is offered, methodology as the different methods and approaches used for teaching and content what to teach.

4.1.   Delivery

ICT opens up a possibility for structuring education in a way which is not synchronous. The students and the teacher do not need to be present at the same time in the same room. Such education has traditionally been referred to as distance learning and often nowadays as "virtual schools".

Distance learning has been used in many countries where distances have been an obstacle to providing all children and young persons with good education. Often radio and television in combination with letter correspondence have been the method for doing this. With ICT, this type of education can be radically improved and is suddenly not only an option for those far away from a school, but even an alternative to traditional schools. So far has this development has been strongest in the area of higher education, where institutions such as the British Open University and the American Phoenix University have attracted large groups of students. There are fewer examples of distance learning in secondary and primary education.

Distance learning has often been presented as an opportunity for non-traditional students to get an education. The question for the future is whether distance learning will remain as a complement to traditional face-to-face education or if it will be the basis for a development of radically new forms for teaching and learning. There have been many discussions about the growing "network society". Will this development also include a trend towards "network schooling"? The growing interest in so called "home schooling" should be seen in this context. Home schooling is

schooling organised in the home of the child by her/his parents. Parents can of course use ICT to support each other in a network of "home schools".

Another aspect in this context is the commercial interests in education and ICT. ICT opens up possibilities for companies to sell and market education in new ways. Such initiatives could be complementary to traditional education, but it could also be in competition with the institutions providing public education.

4.2. Methodology

Even if the impact of ICT will not radically change the whole system of delivery of education, there is scope for changes in the methodology used by teachers in schools. The COMMITT study (Plomb, Brummelhuis, & Rapmund; 1996) identified three stages that teachers pass through on their way to becoming experienced technology users. In the first step, the teachers used computers to support traditional methods of teaching, such as drill-and-practice, text orientation and whole group lectures. It is obvious that word processing programmes can help the teacher to produce texts in a much more professional way than earlier. It is also obvious that PowerPoint presentations can be a way of making traditional lectures more interesting.

The next step should be to use technology as part of more innovative instruction, including, team teaching, interdisciplinary project based instruction, and individually paced instruction. Examples of this can be found in some schools. The results from the SITES study (Pelgrum & Anderson, 2001) seem to indicate that the factor of greatest importance in stimulating such a development is to lower the student : computer ratio.

The third step is characterised by the teachers entering into an inventive stage in which they experiment and change, using technology to support active, creative and collaborative learning. Obviously, this may be what is happening today in classrooms well equipped with Internet linked computers and with teachers with good computer knowledge. The full potential of ICT may not have been fully realised yet and there is a lot of new-thinking which needs to be done to capitalise these opportunities.

It is also possible that the results of new methodological approaches to teaching may result in the development of different types of "blended models" where teaching in school is combined with longer or shorter periods of distance learning.

It should be kept in mind in this context that ICT may not only change what is happening in the classroom, but also what is happening in the school as a whole and the contacts between teachers, parents and students. In schools with classes with their own homepages, parents do not need to figure out their children's homework, they will just click into the homepage of the class and get all the relevant information they need.

4.3.   Content

In this context it is relevant to distinguish between ICT as an object, as an aspect and as a medium. ICT as object means teaching and learning about technical functions of ICT. ICT as aspect refers to ICT as an integrated component in another subject. ICT as medium refers to ICT used as a tool or an aid in teaching and learning (Plomp & van den Akker, 1995).

ICT is not only a tool which can be used by schools, it is also a tool which students will have to use their whole life, in their professional lives and in their private lives. This raises the question of what do you young people need to learn in order to be able to work and live in the "information society". An obvious answer is that they need to learn how to improve their learning. In the same way that this answer is obvious it is also clear that the knowledge about how you "learn to learn" has to be improved. An element in this is probably the ability to seek, find, select and use information. When the amount of information is increasing, the skill is not to find just any information, but to find the right information. In order to do that, the ability to establish an overview of large amounts of information and to evaluate information critically becomes crucial. The important question is what type of skills and knowledge young people need to obtain in schools in order to do this.

The things mentioned above are mainly intellectual skills, but to which extent other skills are needed could also be discussed. In spite of many discussions about the future of reading, it can be noticed that a large part of the activities a person is involved in when sitting in front of a computer screen is actually reading. Good reading skills seem to be crucial skills also for the future, but will the reading habits be the same? Is reading in front of a computer screen different from the reading of a text on a paper? Earlier, schools spent much time on teaching the pupils how to write well. Today, with the use of computers it seems to be of equal importance to be able to write well and fast on a keyboard. Perhaps keyboard training is as essential as the training to use a pen?

5.   Questions for the future

The development of ICT raises several important questions:
- What will the future schools be like and what would we like them to be?
- What will be the role of the teacher and what role would we like teachers to have in future?
- How will the development of ICT in education affect the role of commercial interests in education?
- How can the digital divide be overcome, both at an international level and at a national level?

These questions, in combination with the discussion above about changes in the delivery of education, methodology and content, may be of crucial importance for the future of the education systems and the teachers. From that perspective, is it necessary for teacher unions to try to look into the future. Teacher unions need to find answers to a number of strategically important questions.

6.   Summary

Computers and ICT have become features of daily life in society, at work places and in the homes in most industrialised countries.

Computers and ICT are increasingly used in schools, but large number of schools still have no access or limited access to new technologies. A growing number of teachers frequently use computers and ICT in their classrooms, but in some countries there are also large groups of teachers who do not use computers at all. An increasing number of teachers have received some training in the use of computers and ICT, but still about half of the teachers in the EU countries have so far received no training. Training in the use of computers and ICT seems to be included in the pre-service education of teachers in most countries.

Governments have expressed a strong wish to increase the use of ICT in schools. It seems reasonably to assume that the changes we have seen in schools in respect of new technologies are only the beginning of what may be radical changes. Changes can take place in the general way in which education is delivered, in the practice in the classrooms and in the content of education.

The crucial question for the future is what changes can we expect to see and what changes we wish to see. In this context it is important for teacher unions to think strategically about these questions.

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Acronyms

COMMITT	Committee on MultiMedia In Teacher Training
ICT	Information and Communication Technology
IEA	International Association for the Evaluation of Educational Achievement
PISA	Programme for International Student Assessment
SITES	Second Information Technology in Education Study
TIMSS	The Trends in International Mathematics and Science Study, formerly known as the Third International Mathematics and Science Study

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