Chapter 2

GETTING RETURNS FROM INVESTING IN EDUCATIONAL ICT

SUMMARY

All OECD countries have invested heavily in ICT in schools. The equipment is being deployed for a range of purposes including improving school information systems and teaching ICT skills. But is it also being used to improve teaching and learning?

Country differences in the quantity of hardware and software remain important. Just as important is the amount that students use computers. Many students still do not use computers very much at school. Students more often use computers to send emails and access the Internet than to use educational software. One of the most important contributions to learning can be in helping low achieving students become more confident.

The biggest barriers preventing computers from transforming learning concern the capacity of teachers to integrate them into their practices, limited by organisational or time constraints or their own knowledge. Change will only be possible when improvements in the capacity to use computers are combined effectively with other forms of educational innovation.

1. INTRODUCTION

Successive waves of technology – film projectors, video cassette recorders, computers – have been enthusiastically adopted within education: the new technologies have been seen as a key to educational reform and improvement. Enthusiasm for the potential of information and communications technology (ICT) to improve the quality of teaching and learning has occurred in two phases. In the 1980s, computer aided instruction appeared to provide an opportunity to standardise teaching, reduce variation in student performance arising from varying teacher quality, and reduce teaching costs. Since the mid-1990s the rapidly falling cost of personal computers, the capacity to integrate personal computers with other forms of information technology, the advent of the Internet, and the ease with which these technologies can be networked, have revived enthusiasm for the use of ICT within education. For some, these new forms of ICT are an opportunity to tailor teaching and learning strategies more closely to individual student needs and learning styles, raising performance in key educational skills. For others, the new technologies provide a key to unlocking the dream of lifelong learning: making it possible for learning to be separated from the confines of time and space represented by the timetable and the classroom; giving learners more control over their learning through making access to important information independent of the teacher; making co-operative learning possible; bringing a wider range of learning providers into the circle; allowing key learning skills such as information search and problem solving to develop; making learning more student-centred.

Box 2.1 National policies for ICT in education: Korea and New Zealand

Korea's national plan for ICT in education focused, in its initial 1996-2001 stage, upon putting ICT infrastructure in place. By the completion of the first stage all schools were connected to the Internet, and all classrooms had at least one PC. There were ten students per computer in elementary schools, seven in middle schools, and six in high schools. All teachers had a PC/notebook. The second stage of the plan, which covers the 2001-2005 period, concentrates upon the purposes of ICT and the ways in which ICT is used. The plan is firmly centred around the goals of ensuring that the education system can assist Korea to become a knowledge-based society. The goals of the national strategy include: ensuring that the entire nation can develop ICT skills for a knowledge-based society; creating an information culture in Korea with equal access to information; and improving the effectiveness of the ways in which ICT is used in education. Within primary and secondary education the steps to be adopted include: revamping the curriculum to increase computer literacy and computer use so that ICT can enhance the country's competitiveness; ensuring that ICT is integrated into the curriculum of all subjects; using ICT to promote co-operative learning and information search and sharing; the development of multimedia educational materials and software; and staff development (so that one third of teachers take ICT training each year) encompassing both teachers' ICT skills and training in the use of ICT for teaching. The national strategy also encompasses ICT in tertiary education, including the establishment of a cyber university; the adoption of ICT within adult learning; and the increasing use of ICT to make educational administration more effective by, for example, improving student and parent access to student information.

New Zealand's 2002-04 strategy for ICT in schools focuses upon students, teachers, school principals, school communities, the curriculum, and ICT infrastructure. Its goals include using ICT to: develop higher-order thinking and information skills; extend teachers'

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and school principals' ICT capacities through both inter-school co-operation and on line activities; build partnerships in ICT use between schools and their communities; and develop quality online learning resources. All schools were to be provided with high-speed Internet access by the end of 2004. The strategy has included providing all school principals with laptops, giving all permanent full-time secondary teachers the opportunity to lease a laptop, and a "Computers in Homes" initiative targeted at students from low income and disadvantaged schools.

Sources: Woo and Pang (2002) and Ministry of Education and Human Resource Development and Korea Education and Research Information Service (2002). See also *www.moe.go.kr* and *www.keris.or.kr*; Ministry of Education, New Zealand (2002) and *www.minedu.govt.nz*

Box 2.1 provides two examples of the ways in which countries have been developing policies for the use of ICT in education. These show how ICT is coming closer to the centre of educational policy making. Yet at the same time there have been dissenting voices. Cuban (2001) for example argues that the new technologies have been "oversold and underused". Zemsky and Massy (2004) argue that use of the Internet and other technologies as learning platforms have not delivered the results industry experts anticipated. Elsewhere the OECD has described use of ICT in schools as "… disappointing, particularly when compared with the diffusion of ICTs in other parts of society" (OECD, 2004c, p. 235). This chapter draws upon OECD evidence to describe patterns of investment in ICT, largely within secondary schools,[1] and to assess whether the educational returns that have been gained from ICT have been commensurate with the level of investment. It explores barriers that are preventing schools from realising their ICT-related goals, and concludes by suggesting what needs to be done if countries are to gain improved educational benefits from their investments in educational ICT.

2. INVESTMENTS IN EDUCATIONAL ICT

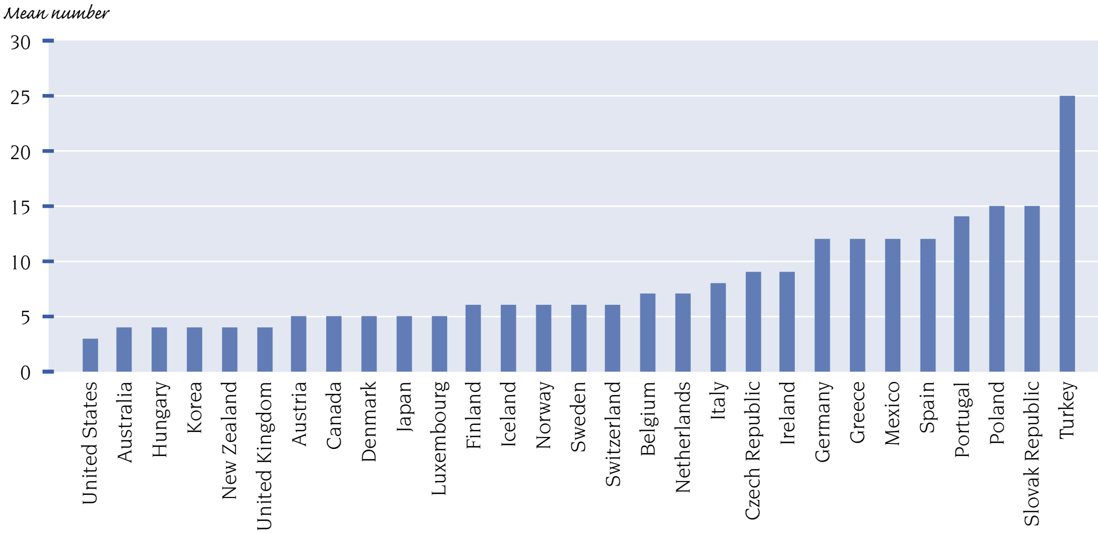
All OECD countries have invested heavily in ICT within their education systems over the last decade. The absolute scale of this investment is not easy to quantify. A quite rough estimate for the late 1990s by the OECD's Centre for Educational Research and Innovation (CERI) put the annual investment, across all OECD countries, at around USD 16 billion (OECD, 1999).

While it is difficult to accurately estimate the level of investment in educational ICT across OECD countries, a useful proxy indicator of relative levels of investment is the number of students per computer: the lower this number, the higher the investment. Data gathered for PISA, the OECD's Programme for International Student Assessment, provide such an indicator for 15-year-old school students in 2003. Figure 2.1 shows that in 2003, the number of 15-year-old students per computer ranged from a low of 3 to a high of 25. These figures suggest that investment in ICT has been around four to five times or more higher in countries such as Australia, Hungary, Korea, New Zealand, the United Kingdom and the United States than in countries such as Poland, the Slovak Republic and Turkey.[2] Neither overall national wealth nor the relative priority that countries place upon educational expenditure can explain most of the variation between countries in their levels of investment in educational ICT (Box 2.2).

1. Comparable data that can shed light upon patterns of investment in ICT in other sectors of education such as primary schooling and tertiary education are not available.

2. Computers are, of course, only one form of investment in educational ICT. Additional investments are made in software, peripheral devices such as printers and scanners, Internet connections, local networks, teacher training, maintenance and support staff.

Figure 2.1 Mean number of 15-year-old students per computer, 2003



Source: PISA database.

Data for Figure 2.1, p. 71.

It is also clear that ICT investments in education have grown at a rapid rate in recent years. This has been stimulated by growth in computing power for a fixed unit of investment, by the increasing accessibility of the Internet, and by the new educational possibilities afforded by both. There are now signs of convergence between countries on at least some indicators of students' access to ICT. Two sets of OECD data indicate the scale of this growth. The first is the OECD's International Survey of Upper Secondary Schools (ISUSS) (OECD, 2004a), which shows very rapid development in the availability of ICT in schools between the mid-1990s and 2001. In that survey school principals were asked to estimate the year in which three ICT elements were introduced to their school: standard software applications such as word processing and spreadsheets; access to the Internet; and e-mail. Across the 11 countries for which comparable data were available, the proportion of students attending schools with access to the Internet grew from 24% to 97% between 1995 and 2001 (Figure 2.3), so earlier inequalities in access have greatly reduced. In the same period the percentage of students attending schools where teachers and students used e-mail grew from 13% to 89% and the proportion attending schools where standard software packages were used grew from 80% to 98% (OECD, 2004a). Data from the United States show that over a similar period (1994-2000) the proportion of public schools with access to the Internet grew from 35% to 98%. Even more strikingly, the proportion of public schools' individual classrooms with Internet access grew from only 3% to 77% (National Center for Education Statistics, 2001).

The very rapid speed with which ICT has been penetrating schools in OECD countries in more recent years is illustrated by a comparison between the number of 15-year-old students per computer revealed by the 2000 and 2003 PISA surveys: investment levels in most countries appear to have at least doubled in only a three-year period. In countries such as Greece, Mexico and Portugal, where very few computers were available for 15-year-old students in 2000, investments grew by a factor of five or more. For example in Mexico the number of students per computer fell from 81 to 12 over the period, and in Greece it fell from 58 to 12. Even in countries where the number of students per computer was already low in 2000, investments seem to have close to doubled in a very short period. In the United States the number of students per computer halved: from six to three. In Denmark it fell from ten to five (Table 2.1).

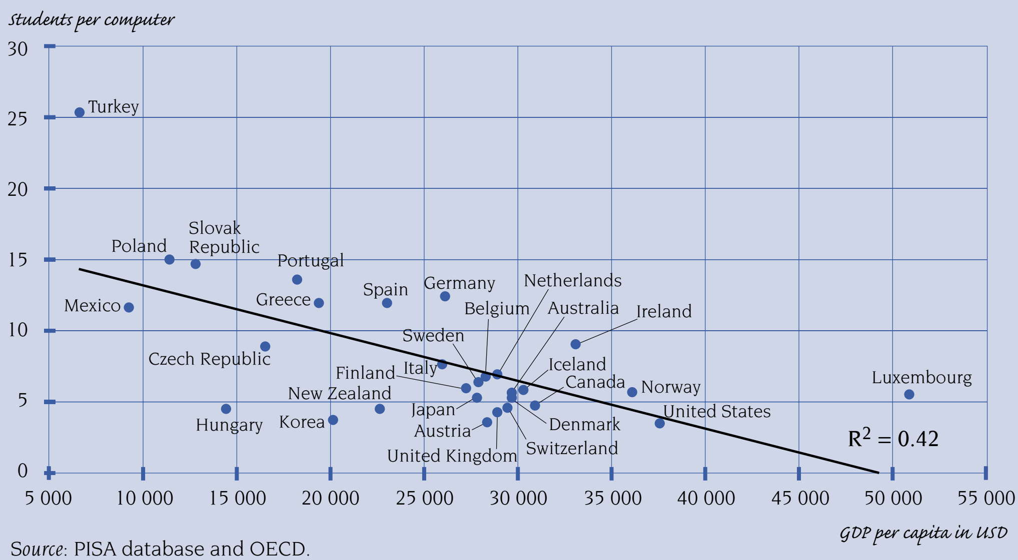
Box 2.2 How much does national income determine investments in educational ICT?

Some countries that have few computers per student have relatively low GDP per capita, and in some that have many, GDP per capita is relatively high. This might seem to suggest that either national income or relative educational expenditure is a significant driving force behind the national investments in educational ICT. However GDP per capita in fact accounts for only 42% of the variation in the number of 15-year-old students per computer in 2003, and national expenditure on non-tertiary education as a percentage of GDP explains even less: only 2%. Figure 2.2 shows that there is wide variation in the number of students per computer, and hence in the level of national investments in educational ICT, at any given level of GDP per capita. For example among pairs of countries with roughly similar GDP per capita:

- Turkey had twice as many students per computer as Mexico.
- Spain had about three times as many as New Zealand.
- Germany had about three times as many as Australia.

Hungary and Korea are other countries in which the level of investment in educational ICT for 15-year-olds is higher than would be expected on the basis of national wealth alone.

Figure 2.2 Students per computer and GDP per capita, 2003



Source: PISA database and OECD.

Data for Figure 2.2, p. 71.

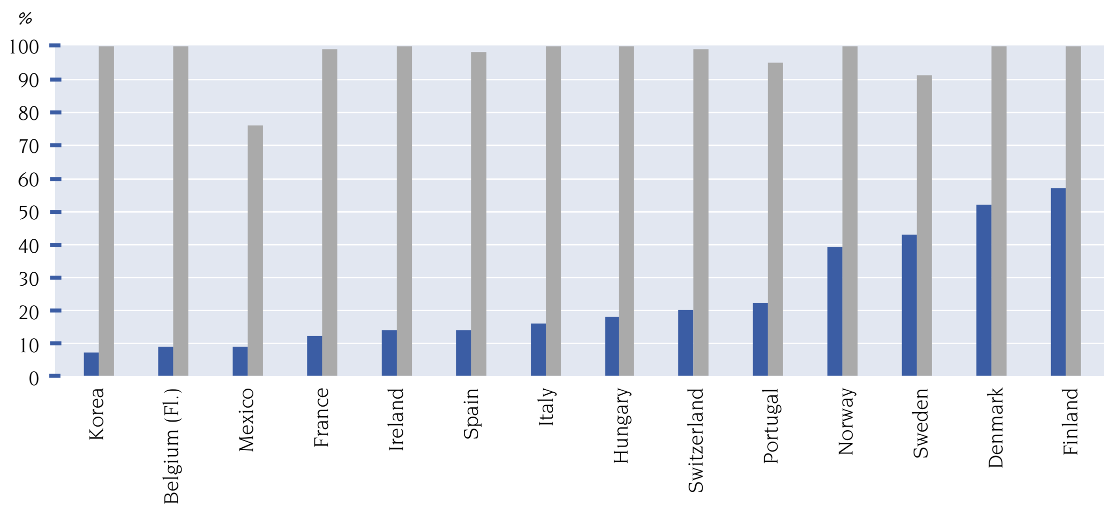
During the rapid expansion in investments in educational ICT that started in the mid-1990s, policy efforts in OECD countries, particularly within schools, concentrated upon equipping educational institutions with hardware and software, and, to a lesser extent, upon trying to ensure that teachers were able to use the new technologies. As the level of investment has grown, and as the technology has become more pervasive, attention is increasingly turning to how ICT can be integrated into the curriculum, and into the teaching and learning process in order to produce better learning outcomes.

Table 2.1 Mean number of students per computer, 2000 and 2003

	2000	2003
United States	6	3
Australia	6	4
New Zealand	7	4
Norway	7	6
United Kingdom	8	4
Korea	10	4
Austria	10	5
Denmark	10	5
Luxembourg	10	5
Finland	10	6
Iceland	11	6
Hungary	12	4
Switzerland	12	6
Sweden	12	6
Japan	14	5
Belgium	15	7
Italy	16	8
Ireland	16	9
Spain	24	12
Germany	24	12
Czech Republic	26	9
Poland	40	15
Greece	58	12
Portugal	74	14
Mexico	81	12

Source: PISA database.

Figure 2.3 Percentage of upper secondary students attending schools with access to the Internet, 1995 and 2001



Source: OECD (2004a, Table 3.7).

Data for Figure 2.3, p. 72.

3. ASSESSING THE EDUCATIONAL IMPACT OF ICT

3.1. Why have countries invested in educational ICT?

There have been several reasons for countries equipping schools, tertiary education and adult learning institutions with ICT:

- One reason, although probably not the most important, has been a belief that ICT can help to reduce the cost of education: making some of its ancillary processes (enrolling students, keeping track of lending books from libraries, managing large assessment systems, personnel records and the like) more efficient; or reducing the teaching costs that are at the heart of education.
- A second, and more important reason, has been to ensure that nations are not left behind in a world in which information-based technology is an important source of economic growth and enterprise productivity (OECD, 2003a; OECD, 2004b), and in which ICT is strongly linked to the upskilling of the labour force (Green, Felstead and Gallie, 2000). Closely related to this is parents' and students' concern that the education system should equip young people with the skills that are important for individual success in the labour market (OECD, 2004c).
- A third reason is the belief that ICT is now an essential tool for everyone living in knowledge-based societies so that all citizens – young people and adults – need to acquire a minimum level of ICT competence. This has made ICT important in school education (OECD, 2004c) as well as resulting in it becoming a significant issue in adult education in many OECD countries (Selwyn, 2003).
- A fourth reason, a main focus of this chapter, has been the belief that ICT offers a powerful tool to improve the outcomes of education: to improve the quality of teaching and to improve the quality of students' learning (OECD, 2001).
- A fifth reason has been to improve management and accountability processes within education: for example by improving the information available to classroom teachers on student performance, and the information that is available to educational managers on outcomes at the school and system level.

The multiplicity of policy goals, which can be seen in the examples given in Box 2.1, complicates the task of evaluating the impact of such investments. Each can lead to different decisions about appropriate hardware, software, operating systems, curriculum content, student access, teacher training strategies and the like. For example, the need to create a cadre of highly-skilled ICT specialists could result in the concentration of equipment in computer laboratories with limited student access. A need to ensure that all citizens are computer literate would provide broad access to all students and adults, with a focus upon the software and operating systems commonly found in everyday life and in the commercial world. A focus upon improving teaching and learning, on the other hand, would require wide student access from an early age, might focus ICT resources in the compulsory years of schooling where the foundations of learning skills are laid, and would put resources into the development and use of specialised educational software, and into teacher training strategies that focus upon the improvement of pedagogical skills with ICT, not just upon using common applications packages. Within any one country all of these approaches may be occurring at once.

A further complication, when trying to assess the educational impact of ICT, is that countries can have different expectations about the ways in which ICT might be able to improve educational outcomes. The educational goals of one might not reflect those of another. Two broad positions on the benefits that should be expected from investing in educational ICT can be observed. On the one hand there is a view, perhaps illustrated most clearly in the case of the United States (see for example Archbald, 2001), that ICT can be judged by the extent to which it is able to improve student performance on standardised tests. Another view, perhaps illustrated best in some of the Nordic countries, is that ICT is an ideal tool for the achievement of lifelong learning: raising the motivation to learn (by giving learners more control over the content, timing and mode of their learning); and developing key learning skills such as co-operative learning, problem solving, information acquisition and analysis, and autonomous learning. See for example Castells and Himanen (2002); Delegation for ICT in Schools (2002); Ministry of Education, Denmark (1998).

This chapter does not try to reconcile these several perspectives. Rather it looks at evidence on the extent to which computers are used in schools and the purposes for which they are being used, regardless of such different rationales. It goes on to look at barriers to access and use.

3.2. The extent of computer use

In some OECD countries many students are likely to have considerable difficulty in gaining access to computers. For example in Germany, Greece, Mexico, Poland, Portugal, the Slovak Republic, Spain and Turkey there are 12 or more 15-year-old students for each computer (Figure 2.1). In such countries, it is likely that only some students can gain enough access for this to have an educational impact. On the other hand in countries such as Australia, Hungary, Korea, New Zealand, the United Kingdom and the United States the number of students per computer (three to four) is small enough. This means that more students are likely to get access to computers, and to use them at school.

Having computers in a school is one thing. Using them is another. Drawing on data from the 2003 PISA survey, Table 2.2 shows that quite different patterns of computer use can exist in countries with the same ratio of students per computer. Even in countries with highest levels of investment in ICT in schools, computers do not seem to be used most of the time. For example Hungary and Korea had the same number of students per computer in 2003 (four). However in Korea 42% of 15-year-old students used a computer at school less than once a month or never, compared to only 9% in Hungary. Denmark and Japan both had five 15-year-old students per computer. However in Denmark 68% of 15-year-olds use a computer almost every day or a few times a week, but in Japan only 26% use it this often at school. Germany and Mexico each had one computer for every 12 15-year-old students. Yet in Germany only 23% of 15-year-olds used a computer almost every day or a few times each week, compared to 54% in Mexico.

Table 2.2 also shows that in only a handful of countries do computers appear to have become an every day piece of equipment in the school. Denmark, Hungary and the United Kingdom are the only countries in which two thirds or more of 15-year-olds use a computer at school either almost every day or a few times each week.

These patterns point to significant under-utilisation of investment in the ICT that is available in schools in some OECD countries. Another explanation could be that in some countries the use of computers in schools is heavily concentrated among a relatively small group of students. Whichever is the case, the outcome would be a less than optimal impact of ICT on most students' learning.

The data in Table 2.2 have been used to construct an index of the average frequency with which 15-year-old students use computers at school. The values of this index can be compared to an identical index constructed from the same question in the PISA 2000 ICT questionnaire. The index for 2003 shows that 15-year-old students use computers at school most frequently in Australia, Denmark, Hungary and the United Kingdom. All were countries that were leaders in the use of computers by 15-year-olds in 2000 (Figure 2.4). The countries in which computers were used least frequently by 15-year-old students in 2003 were Germany, Ireland, Japan and Korea. Although the sample of countries for which this index can be constructed was smaller in 2000 than in 2003, Germany and Ireland were also countries in which 15-year-old students had relatively little contact with computers at school in 2000.

In nearly all countries for which values of the index can be calculated in 2000 and 2003, Figure 2.4 shows that the average frequency of use rose in three years. In the Czech Republic and Mexico average use rose by 34% and 65% respectively over the period, and in Germany it rose by 27%. However in Ireland and Finland average use fell, even if only slightly, over the period, and in Belgium there was no change.

Table 2.2 Students per computer and frequency of use of computers at school, 2003

		15-year-olds using computers at school (%):				
	15-year-old students per computer	Almost every day	A few times each week	Between once a week and once a month	Less than once a month	Never
United States	3	20	23	28	21	8
Australia	4	15	44	27	11	3
Hungary	4	6	74	10	4	5
Korea	4	4	25	29	14	28
New Zealand	4	21	22	26	23	8
United Kingdom	4	23	48	15	10	5
Austria	5	11	42	31	9	7
Canada	5	15	26	31	21	8
Denmark	5	23	45	25	6	1
Japan	5	2	24	33	16	25
Finland	6	4	32	41	18	5
Iceland	6	5	36	40	13	6
Sweden	6	15	33	30	15	6
Switzerland	6	3	27	36	21	13
Belgium	7	2	25	35	19	20
Italy	8	4	47	20	11	18
Czech Republic	9	5	36	44	7	8
Ireland	9	2	22	27	16	32
Germany	12	1	22	28	27	21
Greece	12	4	41	27	9	19
Mexico	12	8	46	16	10	20
Portugal	14	5	29	25	26	15
Poland	15	2	42	34	10	12
Slovak Republic	15	4	38	30	7	21
Turkey	25	7	39	8	6	40

Source: PISA database.

Figure 2.4 Average frequency with which 15-year-old students used computers at school, 2000 and 2003

Note: A value of 0.0 on the index corresponds to "Never"; a value of 1 to "Less than once a month"; a value of 2 to "Between once a week and once a month"; a value of 3 to "A few times each week" and a value of 4 to "Almost every day".

Source: PISA database.

Data for Figure 2.4, p. 72.

3.3. What are the computers used for?

Two OECD school surveys shed light upon the ways in which young people are using computers. The ICT questionnaire in PISA 2003 contained twelve questions asking students how often they used computers for specific purposes. Whilst it did not distinguish between use at school and use in other locations such as the home, the responses, which are summarised in Table 2.3, shed interesting light on the educational benefits that might result from the use of ICT by 15-year-olds.

Across the OECD as a whole, 15-year-olds most commonly report that they use computers frequently for electronic communication (e-mail or chat rooms), to surf the web (which might, of course, be for school-related purposes), and to play games, followed by downloading music and word processing. Educational software is the least common type of use, followed by programming and spreadsheets. Of the twelve items included in the questionnaire, using computers to learn school material was ranked eighth. In all of the 25 countries educational software was the least common type of frequent use for computers. Across the OECD as a whole, an average of 49% of 15-year-olds reported that they never use educational software, and 28% that they never use computers for learning school material. Only in Mexico, Poland and Turkey did as many as a quarter of 15-year-olds say that they use educational software almost every day or a few times a week. And only in Denmark and Portugal did half or more of all 15-year-olds report that they used computers to learn school material almost every day or a few times a week. The difference between the intensity with which 15-year-olds use computers for purposes such as surfing the web and playing games on the one hand, and the frequency with which they use them for obviously school-related purposes on the other, is quite striking. For example in Sweden, 75% of 15-year-olds use computers fairly frequently for electronic communication. Yet only 5% regularly use educational software, and only 23% regularly use computers to help them with school work.[3]

3. In Japan only 11% of 15-year-olds reported that they used computers frequently for anything. This raises the intriguing possibility that a focus upon the use of computers is too narrow, and that increasing attention should be paid to the ways in which young people use other electronic media such as mobile phones.

Table 2.3 15-year-olds reporting that computers are used either almost every day or a few times a week for twelve specific purposes, 2003 (%)

	Electronic communication	Internet search	Games	Internet music downloads	Word processing	Internet software downloads	Internet collaboration	Learning school material	Drawing, painting, graphics	Programming	Spreadsheets	Educational software
Australia	69	74	50	58	70	47	43	32	32	25	22	10
Austria	58	62	43	50	60	38	26	31	28	23	25	9
Belgium	71	60	50	58	49	44	33	24	19	23	17	7
Canada	83	75	59	77	62	58	49	29	35	29	17	9
Czech Republic	48	54	53	33	46	27	30	26	28	19	22	15
Denmark	63	68	58	43	65	38	34	51	22	20	18	15
Finland	59	40	53	38	27	30	13	18	18	11	6	3
Germany	54	53	52	48	49	37	21	27	24	23	19	11
Greece	36	45	61	50	45	46	26	23	45	28	27	22
Hungary	48	42	61	33	53	24	33	31	30	17	32	10
Iceland	71	73	53	33	44	43	25	38	23	22	14	11
Ireland	34	38	47	58	34	24	17	16	26	13	15	9
Italy	41	54	57	47	59	44	25	44	41	31	31	20
Japan	22	26	19	12	17	9	7	5	9	3	8	1
Korea	73	59	57	79	32	47	49	19	15	8	7	6
Mexico	47	50	45	46	38	36	40	45	48	32	32	25
New Zealand	69	65	56	58	54	47	39	30	33	25	22	12
Poland	45	44	56	40	47	32	38	26	40	28	32	25
Portugal	53	58	60	50	53	41	44	57	29	34	28	15
Slovak Republic	29	36	57	23	44	19	26	32	33	20	23	18
Sweden	75	62	57	62	47	44	28	23	25	18	8	5
Switzerland	58	57	43	47	45	37	26	20	22	21	19	8
Turkey	43	38	56	47	43	40	29	32	45	37	32	26
United Kingdom	69	65	58	58	66	49	41	34	36	27	31	19
United States	71	74	62	64	62	52	42	36	41	33	22	18
Average	56	55	53	49	48	38	31	30	30	23	21	13

Source: PISA database.

Indeed between the 2000 and 2003 PISA surveys there appears to have been a decline in some of the more explicitly educational use of computers by 15-year-olds. For those countries for which comparable data are available for both surveys, Table 2.4 shows the percentage of 15-year-olds who in each survey reported that they either used computers to learn school material or used educational software either almost every day or several times a week. For each of these uses the average across the 15 countries declined in the period. In all 15 countries the reported use of educational software fell, with the average decline being around 50%. In the case of using computers to learn school material the average decline was smaller, but in some countries such as Ireland and the United Kingdom it was quite marked.

Table 2.4 15-year-old students reporting that they frequently[1] use computers to learn school material or that they frequently use educational software, 2000 and 2003 (%)

	School material, 2000	School material, 2003	Educational software, 2000	Educational software, 2003
Australia	43	32	23	10
Belgium	21	24	18	7
Canada	32	29	18	9
Czech Republic	18	26	19	15
Denmark	54	51	11	15
Finland	24	18	8	3
Germany	33	27	23	11
Hungary	26	31	19	10
Ireland	25	16	26	9
Mexico	54	45	38	25
New Zealand	38	30	26	12
Sweden	39	23	12	5
Switzerland	21	20	13	8
United Kingdom	57	34	34	19
United States	47	36	28	18
Average	35	29	21	12

1. Frequently indicates either almost every day or a few times each week.
Source: PISA database.

A cautious conclusion about the real extent to which ICT is being used in schools to improve teaching and learning emerges from data gathered in the OECD's International Survey of Upper Secondary Schools. In that survey, school principals were asked the extent to which students used computers for six different purposes, and in this instance the questions focused strongly on pedagogical processes (see Table 2.5). Getting information from the Internet was the most commonly reported use, with around two thirds of upper secondary students across all OECD countries being reported to do this a lot. In Sweden half or more, and in Norway nearly half, of all upper secondary students are reported to use computers frequently to develop independent learning skills or to supplement the teacher. In Denmark around 40% of upper secondary students are reported to use computers a lot to develop independent learning skills and to combine parts of subjects. However in other countries, fewer students are reported to use ICT frequently for this purpose – in Ireland and Spain, fewer than one student in six.[4]

4. A similar conclusion emerges from the IEA international TIMSS reports which show that even in countries with high classroom availability, the use of computers in over half of all lessons is extremely rare at 4th and 8th grades in maths and science (*http://isc.bc.edu/timss2003i/intl_reports.html*).

Table 2.5 Percentage of upper secondary students attending schools where principals report that computers are used a lot for various educational purposes, 2001

	Obtaining information from the Internet	Developing skills of independent learning	Providing additional instruction and practice opportunities	Allowing students to learn/work at their own pace	Combining parts of school subjects	Learning by simulation
Belgium (Fl.)	64	18	15	13	6	7
Denmark	93	39	23	32	44	22
Finland	75	22	13	9	7	4
France	65	35	6	13	21	16
Hungary	73	18	7	17	21	27
Ireland	43	15	24	6	3	4
Italy	53	37	29	17	37	28
Korea	80	37	11	31	17	17
Mexico	37	37	26	41	29	11
Norway	95	42	52	20	20	14
Portugal	59	30	18	21	13	18
Spain	37	16	10	11	8	13
Sweden	91	58	49	25	20	13
Switzerland	72	33	12	13	18	12
Average	67	31	21	19	19	15

Source: OECD (2004a, Table 3.14a).

The OECD's work on adult learning (OECD, 2003b; Pont and Sweet, 2003) highlights many innovative uses of ICT to improve teaching and learning within the corporate world and in post-secondary education. However outside of these settings, and in particular within community settings and in those locations where the least qualified adults undertake courses of study, it points to a relatively limited use of ICT to improve the quality of teaching and learning. Selwyn (2003) highlights evidence from the United Kingdom indicating that the most common purpose of ICT courses offered within adult education settings is to develop basic ICT literacy. A number of countries however have launched projects to combine the teaching of ICT skills with the use of ICT as a tool to deliver course content. The *Aulas Mentor* in Spain, the *Plazas Communitarias* in Mexico and the Transformer Bus in the United States (OECD, 2003b) are programmes that have managed to reach especially disadvantaged adults to use ICT for learning. In the United Kingdom Learndirect provides an information technology platform for learning in easily accessible places.

The evidence reviewed above suggests that we cannot assume that large investments in ICT have everywhere had a large positive impact on learning outcomes. Nevertheless, for some schools and students the impact of being well supplied with ICT, and of the available equipment being used effectively, might bring benefits. Case studies can help to shed some light on this, and these are drawn upon in Section 6 below. First, however, the following section considers more specifically evidence about whether the use of ICT improves learning.

4. CAN ICT IMPROVE LEARNING?

Existing experimental studies provide little guidance overall on the impact of contemporary forms of ICT upon learning outcomes, and even less on their impact upon the motivation to learn or the development of key learning skills. This is for two reasons: it is hard for such evidence to pick up the wider learning outcomes that ICT might be expected to improve; and it is hard for research to keep up-to-date with the rapidly evolving potential of technology.

First, much of the existing research is fairly narrowly focused upon a limited range of learning outcomes that are easily measurable, such as scores on standard tests, and upon activities and school subjects such as mathematics in which large numbers of students participate so that sample sizes can be maximised. This ignores the enormously diverse ways in which modern ICT is currently being used within education in all OECD countries. In schools it is now common to see ICT being used by students to write essays, find information for projects and assignments, compose music, share ideas with students in other schools, conduct simulations, build databases, create works of art and do detailed architectural drawings. Frequently only small numbers may be doing any one of these at any one time, and the outcomes of what they are doing may be difficult to measure.

The second limitation of much of the existing experimental evidence is that it is dated. Large studies take a long while to conduct, to analyse and to report, and as a result are often useful largely as a guide to yesterday's technologies and yesterday's pedagogy. For example a recent large scale and widely reported study of the impact of ICT upon mathematics and language scores (Angrist and Lavy, 2002) was carried out between 1994 and 1996, before the Internet became a common tool or educational ICT was widely networked, and studied computer aided instruction on stand-alone PCs. A third limitation is that many studies are not strong methodologically, with poor designs and inappropriate analyses.

Within these constraints, syntheses of the existing research such as Kulik (2003) and Torgerson and Zhu (2003) provide some qualified support for proponents of the use of ICT to improve learning. The outcomes for reading skills are unclear but point to inadequate implementation strategies. However evaluations do support the capacity of word processors, or simply access to computers and to the Internet, to develop writing skills. They also provide some support for the proposition that ICT can at times improve outcomes in mathematics and the natural sciences, although individual effects are often weak and findings are inconsistent. Similarly a recent large United Kingdom study (Impact2) has shown statistically significant relationships between use of ICT and attainment at several stages of education (BECTA, 2002). As well as raising performance on standardised tests, an important potential benefit of the use of ICT is to raise performance indirectly by strengthening the motivation to learn and developing learning skills. As described below, evidence suggests that this can be especially valuable for low achievers.

4.1. ICT and low achieving students

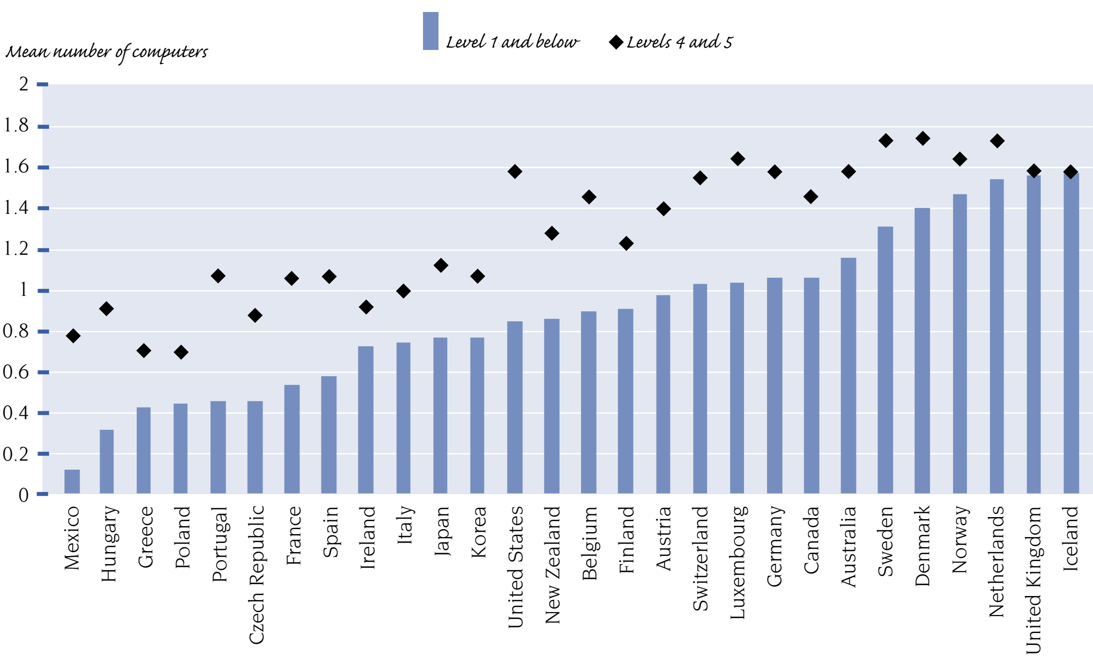
Whether countries see ICT as a tool to improve standard test scores or to improve the motivation to learn and learning skills, the greatest overall gains will result from improving outcomes for the lowest achievers: their potential gains are greater than those whose achievement levels are already high. PISA 2000 data can help to shed light on whether, and in what ways, ICT might help to improve learning outcomes among low achievers, and on some of the barriers to improvement. In addition to gathering data on student achievement in literacy, mathematics and science, the first round of PISA data collection in 2000 included a special student computer familiarity questionnaire. Questions about ICT availability and use were also included in the main questionnaire completed by all students and in the school questionnaire completed by school principals.[5] Using PISA data, Sweet and Meates (2004) provide an initial report on the relationship between 15-year-olds' literacy achievement levels and access to and patterns of use of ICT. This analysis provides some encouraging messages, but also many challenges for schools in ensuring that the weakest students can benefit from using ICT.

5. The IT questionnaire, the student questionnaire, and the school questionnaire can be found at *www.pisa.oecd.org*

One generally encouraging message to emerge from analysis of PISA data is that within many OECD countries the number of students per computer in the schools in which the weakest students[6] are located is generally no lower than the number of students per computer in other schools. And there are some countries – Denmark, Germany, Italy, Japan, Korea, the Netherlands and Portugal – in which the schools where the lowest achievers are concentrated are the ones that have the greatest number of computers. These are important findings. There are some exceptions however. In the Czech Republic, France, Mexico and Poland, low achieving students tend to be located in schools with the highest number of students per computer.[7] In Mexico, for example, the number of students per computer is around six times as high in the schools where the weakest students are found as it is in the schools containing the most able students (129 compared to 21). And in France the number of students per computer is around 50% greater in schools where the lowest achievers are located than in the schools where the highest achievers are located (15 compared to 10).

Another encouraging message is that in all OECD countries, low achieving 15-year-olds seem to be just as interested in using computers as other students. No statistically significant differences emerge on a scale of interest in ICT between the scores of the lowest literacy achievers and other students.

Figure 2.5 Mean number of computers in the homes of the lowest and highest achievers, 2000



Source: PISA database.

Data for Figure 2.5, p. 73.

6. Defined as those scoring at Level 1 or below on the PISA combined reading literacy scale. The study defined high achievers as those scoring at Levels 4 and 5 on the combined reading literacy scale.

7. In the case of France the explanation is likely to be that weaker 15-year-old students are more likely to be in a *collège* and the better students in a *lycée*.

A further finding of importance to schools is that in nearly all OECD countries, low achievers' access to ICT is both greater, and more equitable, in the school than it is in the home. There is an extremely strong and significant trend for low achievers to report less access to ICT in the home than do high achievers. Figure 2.5 compares the number of computers in the homes of the lowest achievers with the number in the homes of the highest achievers. In the United States, as an example, the average number of computers in the homes of those scoring at Level 1 or below on the PISA combined reading literacy scale is 0.8, compared to 1.6 in the homes of those scoring at Levels 4 and 5: half as many. In Hungary, there is an average of 0.3 computers in the homes of the lowest achievers, compared to 0.9 in the homes of the highest achievers: one third as many. Similar trends emerge when access to the Internet and the use of educational software in the home are analysed. So schools, in most OECD countries, cannot assume that if low achievers do not get access to ICT in school the home will compensate. The reverse is true. There is a very strong digital divide in the home as a function of literacy level, and this is much less evident in the school. Schools and school systems have, as a result, an important role to play in helping to ensure that low achievers have access to ICT, either within normal school hours or through special programmes outside of them.

The analysis presents schools with a number of other challenges. For example when those schools in which computers are scarce are analysed, it is generally more common for low achievers to report that they have little access to computers than it is for high achievers. And so within-school practices are just as important in ensuring access to ICT as is the general availability of computers across schools.

Another challenge is to raise the motivation and confidence of low achievers in using ICT. While in all countries low achieving 15-year-olds are just as interested in computers as are other students, in most countries they report much lower levels of confidence in using computers than do high achievers. With the exception of a small number of countries their relative levels of comfort with and perceived ability to use computers are far below their relative level of interest in them (Figure 2.6).

Figure 2.6 Low achievers' interest in, comfort with and perceived ability to use computers, 2000[1]

1. Each country's score on each of the indexes shows how low achievers in that country compare to the average for all students in the OECD. Both indexes are standardised to an OECD-wide mean of 0.0 and a standard deviation of 1.0. Values are arranged in order of low achievers' interest in computers.

Source: PISA database.

Data for Figure 2.6, p. 73.

Nevertheless some limited case study evidence suggests that motivational barriers to the use of ICT can be addressed, and that ICT can, in particular, be a tool for improving low achievers' interest in learning. Pelgrum (2004) reports that 10% of the case studies in the Second International Technology in Education Survey (SITESM2) contained evidence of a particular impact of ICT upon low ability students or students at risk. While quantitative evidence from SITESM2 does not throw much light upon whether ICT can help to fight low achievement, Pelgrum reports that case studies point to the frequency with which ICT use among low achievers is associated with improved motivation, self-esteem and self-confidence. For example the case studies report that use of ICT in learning can motivate weaker students by enabling them to present their work more neatly, revealing hidden strengths, tailoring instruction more closely to individual needs, providing more frequent feedback, and allowing them to work independently. Wilhelm (2004) similarly reports case studies in which the impact of ICT upon low achievers' motivation to learn appears to be more significant than its measured impact upon performance.

5. WHAT ARE THE BARRIERS TO ICT IMPROVING THE QUALITY OF TEACHING AND LEARNING?

Limited resources are a barrier to the more effective educational use of ICT in most OECD countries and are quite significant in some. For example ISUSS data show that in Ireland and Mexico school principals report that three quarters of all upper secondary students are affected by insufficient numbers of computers, and similar numbers of students by equipment that is outdated. Even countries such as Denmark and Norway, where computers in schools are more plentiful, report problems with insufficient or outdated equipment (OECD, 2004a, Table 3.16a).

The constraints that prevent ICT being used to improve the quality of teaching and learning are not a simple matter of the level of investment in hardware. They can also be a result, as pointed out above, of insufficient use of the hardware that is available. They can also be the result of the ways that ICT resource policies are phrased. For example where national ICT resource policies are directed to achieving targets such as a certain number of students per computer, or a given proportion of schools or classrooms connected to the Internet, individual schools may not be able to purchase other types of hardware that may allow a better and more creative integration of ICT into the teaching process – such as digital cameras, scanners or colour printers (Kugemann, 2002). A more flexible way of phrasing ICT resource policy priorities might avoid such problems.

These examples illustrate a more fundamental point: the barriers that prevent ICT being used as well as it could to improve the teaching and learning process are linked to the heart of the teaching and learning process, to the organisation of educational institutions, and to the ways in which education systems are organised. A simple illustration of this point comes from a key finding from the OECD's International Survey of Upper Secondary Schools. In that survey, principals highlighted four obstacles to them reaching their ICT development goals, each of which affected 60% or more of all students across the OECD. These were:

- Difficulty in integrating computers into classroom instruction.
- Problems in scheduling enough computer time.
- Teachers' lack of knowledge in using computers as a teaching tool.
- Teachers not having enough time to prepare lessons that use computers (OECD, 2004a, Table 3.16a).

These four problems are not likely to be resolved without addressing the timetable, teachers' knowledge and skills, and the allocation of time within schools. By itself, then, the introduction of

ICT into schools is unlikely to result in improved learning outcomes. The skills of the teacher and the organisation of the school are key factors that need to be tackled. Lack of teacher interest in ICT or teacher resistance to ICT do not seem to be the most important barriers: the ISUSS survey found that only around a third of students, in the countries surveyed, were in schools where this was reported to be an obstacle, compared to the two thirds who were in schools where difficulty in integrating computers into classroom instruction was reported to be a problem (OECD, 2004a, p. 124). A similar conclusion about teachers' ICT-related motivation emerges from analysis of the SITESM2 case studies (Pelgrum, 2002).

Certainly some OECD countries have been treating the ICT skills of teachers as a serious issue in recent years. They have invested considerable resources in providing computers for teachers to use, and in ICT training programmes for teachers. Box 2.1 above illustrates the extent of such programmes in the case of Korea and New Zealand. The OECD's ISUSS survey found that in all the countries surveyed except Belgium (Flemish Community), France and Italy, teachers had better access to computers than did students (OECD, 2004a, p. 79). It also found that in 2000-01 half of all Danish upper secondary teachers took part in ICT-related staff development activities, and that in Finland and Norway the proportion exceeded 40%.

Nevertheless it is reasonable to ask whether the type of ICT-related training that teachers are receiving is either sufficient or of an appropriate type. For example although in Denmark, Finland and Norway in 2000-01 high proportions of teachers received ICT-related training, Norwegian principals reported that 87% of upper secondary students attended schools where teachers' lack of knowledge or skills in using computers for instructional purposes was a barrier to the achievement of schools' ICT goals. In Denmark and Finland 59% and 66% respectively of upper secondary students attended schools where this was reported to be the case. So the nature, and not just the quantity, of the ICT-related training that teachers receive is clearly important if the potential of ICT to improve teaching and learning is to be realised. That training needs to go beyond the development of ICT skills to also focus heavily upon the pedagogical skills needed to integrate ICT into the curriculum and the classroom.

By itself training of an appropriate type will not result in more effective uses of ICT unless the organisational and structural barriers that exist within the school are also addressed. Box 2.3 gives an example of a comprehensive national programme to develop teachers' ICT skills which concentrated upon the development of pedagogical skills, and which also took account of the ways in which the schools are organised.

Box 2.3 Sweden's National Action Programme for ICT in Schools (ITiS)

During the four-year period 1999-2002 Sweden ran a very large programme to improve the quality of teaching and learning, costing some €190 million. ITiS was both an ICT project and a school development project. It had seven components:

- In-service training for 60 000 teachers in teams.
- A multimedia computer provided to all participating teachers.
- Funds to improve schools' Internet access.
- E-mail addresses for all teachers and all students.
- Funds to develop the Swedish Schoolnet and to support the European Schoolnet.
- Measures for students with special needs.
- Awards for excellent pedagogical contributions.

...

The programme covered all schools: pre-school, compulsory and upper secondary. The content of the training was project-based, and topics were selected by teams of teachers within their own schools. Each team carried out an interdisciplinary problem-based pupil oriented development project together with its group of students. Nearly all training occurred within the school itself, with strong external support systems for teachers built in from external tutors, and associated training seminars for local school boards and school politicians.

Source: Delegation for ICT in Schools (2002).

6. WHAT ARE THE OPPORTUNITIES FOR OVERCOMING THESE BARRIERS? LESSONS FROM INNOVATIVE SCHOOLS

Whatever the problems and barriers outlined above, an encouraging message from OECD work on ICT and education is that in all countries examples can be found of schools that have adopted an innovative approach to the use of ICT, and which have succeeded in integrating it into their teaching processes to improve students' learning. The OECD's Centre for Educational Research and Innovation (CERI) has conducted 94 case studies in 23 countries to understand how ICT relates to educational innovation (Venezky and Davis, 2002). The case studies illustrate the barriers that need to be overcome within the school if ICT is to improve students' learning, but more importantly they illustrate steps that can be and have been taken to surmount these barriers. The case studies are varied. For example they include a school in the United States that used ICT to facilitate the introduction of an inquiry-based learning programme, and a school in the Netherlands in which ICT was used to help the school move towards self-study. The level of technology introduced ranged from the development of a sophisticated intranet in a school in Singapore that allowed wide sharing of information on curriculum resources and extended the possibilities for communication between schools, parents and communities, to a school in Mexico that made innovative use of graphical calculators for teaching purposes.

One of the key questions explored by the case studies is whether ICT is itself a sufficient condition for educational innovation, or whether an innovative approach to teaching and learning is a precondition for the effective use of ICT. Several of the schools did report that the introduction of ICT had led to changes in pedagogy. For example a Finnish secondary school reported that it led to more student-centred learning, and that students became more active in collecting, processing and constructing information. Nevertheless in many other schools ICT proved to be not a catalyst for change, but an enabler of changes that had already been planned and decided. For example in one Irish primary school ICT was only one of the ways, along with a school play, music and other activities in which the school was extending more student-centred approaches to learning. In most cases ICT proved to be an enabling technology that helped the process of school reform. It provided opportunities for change. This was by far the more common experience. Box 2.4 illustrates this process in the case of two Australian schools.

For most of the case study schools, the adoption of ICT was not a single step, but an ongoing process. Teachers did not all adopt ICT simultaneously, but the use of ICT spread gradually through the teaching force. Thus the integration of ICT into teaching involves its adoption by individual teachers in the context of their own subject.

The case studies indicate that a number of factors are important in successfully implementing ICT so that it results in improved teaching and learning. No single factor determines success, but there are a number that may be present in varying degrees, depending upon circumstances.

Box 2.4 ICT in two innovative schools in Australia

Bendigo Senior Secondary College and Glen Waverley Secondary College are both public high schools in the State of Victoria in Australia. Over a three-to-five year period both decided to shift their curriculum delivery to be project-based, to emphasise student autonomy in learning, and to shift teaching from being teacher-centred to teacher-guided. School management and teacher planning teams set teaching and learning goals for their schools: for teachers, students and administrators. Continuous improvement is an important part of each school, and both regard themselves as learning organisations. Steps taken to reform the schools have included: revised management structures and decision-making processes to increase staff involvement; an expanded and revised curriculum; extensive professional development and an annual staff appraisal process; and a revised timetable and more flexible patterns of student access.

Both schools developed intranets for submission of student work and for student learning. The staff contribute lessons and support materials to their online systems. While ICT was a factor in some decisions, the emphasis on student autonomy was principally driven by pedagogical reasons, not ICT. Nevertheless, once integrated into the schools, ICT opened up further opportunities for innovation and the schools based their reforms upon a belief that well integrated ICT enhances teaching and learning.

Source: Toomey, EkinSmyth and Nicolson (2000).

Access to adequate technology was a prerequisite for successful adoption of ICT for improved teaching and learning. However with limited computer availability, some schools have given courses that develop ICT skills first priority in access, often leaving those teachers wanting to use ICT to improve their teaching practice with little or no access. Access to the Internet is of particular importance for schools. By providing access to the resources of the web, the Internet access can facilitate learning that is centred on student research. In addition Internet access enables a whole range of communication activities, including links with other schools, allowing parent access or allowing distance learning. However it was found to be important for access to the Internet to be fast and reliable, rather than delivered through slow dial-up connections, which were commonly found to be frustrating. A lack of suitable educational software was found to be a barrier to use of ICT in some cases. ICT use was further limited by problems with technical support. In most schools, technical difficulties were reported as a major barrier to usage, and a source of frustration for students and teachers. Where there were formal arrangements in place for providing technical support, the structures varied widely. Some schools reduced a teacher's workload slightly to allow time for technical work. In some cases full-time technical specialists were hired. Despite the variety of structures, the overwhelming view was that technical support was both inadequate and a major barrier to the development of ICT. The US corporate standard of a full-time technical support person for every 50 computers was beyond the wildest dreams of most schools.

But equipment and resources alone were not found to be enough: some very well-equipped schools found that few of their teachers made use of ICT. This finding focuses attention on the importance of teacher skills and attitudes. The case studies show that teachers need sufficient ICT skills to make use of the technology and to feel confident enough to use the technology in a classroom setting. But teachers also require insights into the pedagogical role of ICT, in order to find meaningful uses for the technology in their teaching. No matter what teachers' ICT skills, they need to see the educational potential of ICT. Almost all of the case study schools reported some staff development activities aimed at preparing teachers to use ICT. Many of the schools used peer-tutoring systems, where experienced ICT users were encouraged to act as mentors to teachers with less experience, and released from teaching duties to do so. In some cases the training was not provided in the school, which was experienced as a problem, in contrast to the in-school development models such as those found to be common in Denmark. Another problem with staff development models is that participation in training was often voluntary, thus reaching mainly those with an existing interest in ICT. And schools also stressed the importance of funding for release time. Box 2.3 illustrates a successful ICT staff development model that attempts to address these problems.

The case study schools highlighted a series of other factors that played an important role in the adoption of ICT. School leadership emerged as one of the key issues. A second major factor was the presence among the staff of an ICT champion. The curriculum was also a powerful factor. In schools, particularly where there are high-stakes examinations, the curriculum has a very strong role in steering the nature of the educational activity. Some countries reported that appropriate use of ICT was actively encouraged in curricular documents. Highlighting the potential of ICT within the existing curriculum is of course just part of the solution. If the aim of ICT implementation is to facilitate more problem solving and inquiry-based learning, curricula may have to be adapted to re-focus on these aims. Where education systems relied on examinations involving recall of a specific body of facts, the implementation of a student-centred educational reform using ICT was more problematic. Other factors found in case study schools that appeared to have successfully integrated ICT into their teaching were teacher release time, and adjustment to the timetable to allow for small group work or individual research.

7. CONCLUSION

The evidence reviewed in this chapter points to a number of barriers that are preventing countries from realising substantial educational benefits from their investments in ICT. These include inadequate levels of investment; insufficient use of the equipment that has been purchased; insufficient emphasis upon teacher development; and inappropriate teacher development. In many OECD countries learning is not a major focus of young people when they use computers.

Whilst the evidence from different sources is not always consistent, it seems as if only a limited number of OECD countries are in a position to gain significant educational benefits from their investments in educational ICT in schools, even though many individual schools within particular countries are at the forefront of innovation. Some of the Nordic countries, Australia and New Zealand are among the countries that appear to have made investments in educational ICT that are large enough to allow most students to gain access to the technology fairly frequently, and they are countries in which the technology does not appear to sit unused or to be infrequently used. In this group of countries investment in equipment has often been complemented by extensive teacher training, and patterns of computer use by young people, both within the school and outside it, more often point to uses that emphasise educational and learning purposes. In these countries one can also at times see an awareness of the importance of treating improved educational uses of ICT as a specific case of the general need to improve teaching and learning and to reform schools. A basic problem in gaining improved educational benefits from ICT, no matter how strong the benefits in terms of the production of ICT skills for the labour market and for everyday living, is that too frequently countries have seen it mainly as a technological issue, and not as an issue in school reform and school improvement.

Strikingly similar messages emerge from the OECD work on ICT in education that has been reviewed here and from OECD work on the relationship between investment in ICT and the productivity of firms (OECD, 2003a). In the case of business performance the message is very clear. By itself ICT does not necessarily raise productivity. In order to capitalise on the potential of ICT to improve productivity, firms need to innovate, changing the nature of their products and processes. Investment in ICT needs to be complemented by other investments such as changes in the organisation of work and changes in workers' skills. Installing ICT will not compensate for poor management, lack of skills, lack of competition or a low ability to innovate. It has been argued (Carnoy, 2002) that in business the most common use of ICT has been to increase productivity by analysing employee performance and working with employees to improve it. This form of management is highly underdeveloped in education, where the vast body of data on student performance available to schools is unused through lack of teacher and educational manager skills in using ICT for data based management. Improving such skills could make it easier for teachers not only to track the performance of their own students over time, but allow them to see the relationship between the introduction of certain practices and improvement in student performance. Such improvement in teacher capacity could be a promising future direction for improving the capacity of ICT to contribute to the quality of education.

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Data for Figure 2.1

Mean number of 15-year-old students per computer, 2003

	Mean number
United States	3
Australia	4
Hungary	4
Korea	4
New Zealand	4
United Kingdom	4
Austria	5
Canada	5
Denmark	5
Japan	5
Luxembourg	5
Finland	6
Iceland	6
Norway	6
Sweden	6
Switzerland	6
Belgium	7
Netherlands	7
Italy	8
Czech Republic	9
Ireland	9
Germany	12
Greece	12
Mexico	12
Spain	12
Portugal	14
Poland	15
Slovak Republic	15
Turkey	25

Source: PISA database.

Data for Figure 2.2

Students per computer and GDP per capita, 2003

	GDP per capita[1]	15-year-old students per computer
Australia	28 500	4
Austria	29 500	5
Belgium	28 400	7
Canada	31 000	5
Czech Republic	16 700	9
Denmark	29 800	5
Finland	27 400	6
Germany	26 300	12
Greece	19 500	12
Hungary	14 600	4
Iceland	29 800	6
Ireland	33 200	9
Italy	26 100	8
Japan	28 000	5
Korea	20 300	4
Luxembourg	50 900	5
Mexico	9 400	12
Netherlands	29 100	7
New Zealand	22 800	4
Norway	36 100	6
Poland	11 500	15
Portugal	18 400	14
Slovak Republic	13 000	15
Spain	23 200	12
Sweden	28 100	6
Switzerland	30 400	6
Turkey	6 800	25
United Kingdom	29 000	4
United States	37 600	3

1. In USD using purchasing power parities.
Source: PISA database and OECD.

Data for Figure 2.3

Percentage of upper secondary students attending schools with access to the Internet, 1995 and 2001

	1995	2001
Korea	7	100
Belgium (Fl.)	9	100
Mexico	9	76
France	12	99
Ireland	14	100
Spain	14	98
Italy	16	100
Hungary	18	100
Switzerland	20	99
Portugal	22	95
Norway	39	100
Sweden	43	91
Denmark	52	100
Finland	57	100

Source: OECD (2004a, Table 3.7).

Data for Figure 2.4

Average frequency with which 15-year-old students used computers at school, 2000 and 2003

	2000 index	2003 index	% change 2000-03
Denmark	2.7	2.8	6
United Kingdom	2.4	2.7	15
Hungary	2.5	2.7	10
Australia	2.3	2.6	11
Austria	m	2.4	m
Sweden	2.2	2.4	6
United States	2.0	2.3	14
New Zealand	1.9	2.2	18
Czech Republic	1.7	2.2	34
Iceland	m	2.2	m
Canada	m	2.2	m
Poland	m	2.1	m
Mexico	1.3	2.1	65
Finland	2.3	2.1	-6
Italy	m	2.1	m
Greece	m	2.0	m
Slovak Republic	m	2.0	m
Switzerland	1.6	1.9	14
Portugal	m	1.8	m
Belgium	1.7	1.7	0
Turkey	m	1.7	m
Japan	m	1.6	m
Korea	m	1.6	m
Germany	1.2	1.6	27
Ireland	1.5	1.5	-1

Note: A value of 0.0 on the index corresponds to "Never"; a value of 1 to "Less than once a month"; a value of 2 to "Between once a week and once a month"; a value of 3 to "A few times each week" and a value of 4 to "Almost every day".

Source: PISA database.

Data for Figure 2.5

Mean number of computers in the homes of the lowest and highest achievers, 2000

	Mean number of computers in the homes of 15-year-old students who on the PISA combined literacy scale scored at:	
	Level 1 and below	Levels 4 and 5
Mexico	0.12	0.76
Hungary	0.31	0.89
Greece	0.42	0.69
Poland	0.44	0.68
Portugal	0.45	1.05
Czech Republic	0.45	0.86
France	0.53	1.04
Spain	0.57	1.05
Ireland	0.72	0.90
Italy	0.74	0.98
Japan	0.76	1.10
Korea	0.76	1.05
United States	0.84	1.56
New Zealand	0.85	1.26
Belgium	0.89	1.44
Finland	0.90	1.21
Austria	0.97	1.38
Switzerland	1.02	1.53
Luxembourg	1.03	1.62
Germany	1.05	1.56
Canada	1.05	1.44
Australia	1.15	1.56
Sweden	1.30	1.71
Denmark	1.39	1.72
Norway	1.46	1.62
Netherlands	1.53	1.71
United Kingdom	1.55	1.56
Iceland	1.56	1.55

Source: PISA database.

Data for Figure 2.6

Low achievers' interest in, comfort with and perceived ability to use computers, 2000

	Index of interest	Index of comfort and ability
Australia	-0.20	0.12
Denmark	-0.20	-0.17
New Zealand	-0.19	-0.06
Czech Republic	-0.18	-0.56
Canada	-0.16	0.19
United States	-0.15	-0.45
Ireland	-0.13	-0.39
Belgium	-0.09	-0.02
Hungary	-0.06	-0.52
Finland	-0.01	-0.29
Switzerland	0.01	-0.46
Mexico	0.04	-0.39
Sweden	0.08	0.03
United Kingdom	0.18	-0.20
Germany	0.23	-0.31
Luxembourg	0.24	-0.02

Source: PISA database.

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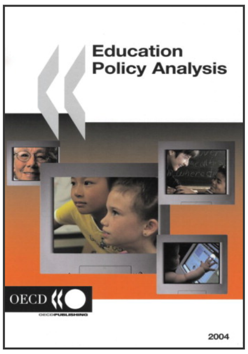

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