Visions of the Information Society

ICTs for education and building human capital

This paper was prepared by Frances Cairncross, Management Editor of The Economist, and Kaija Pöysti, Partner in Blue White Venture, a consulting company. "ICTs for education and building human capital" forms part of the *Visions of the Information Society* project managed by Lara Srivastava <lara.srivastava@itu.int>, Policy Analyst in the Strategy and Policy Unit of the International Telecommunication Union (ITU). More information can be found at http://www.itu.int/visions. The views expressed in this report are those of the authors and do not necessarily reflect the opinion of ITU or its membership.

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1 Introduction

Education is one of the main keys to economic development and improvements in human welfare. As global economic competition grows sharper, education becomes an important source of competitive advantage, closely linked to economic growth, and a way for countries to attract jobs and investment. In addition, education appears to be one of the key determinants of lifetime earnings. Countries therefore frequently see raising educational attainment as a way of tackling poverty and deprivation.

In developing countries, education is also linked to a whole batch of indicators of human development. Education of women influences the health of children and family size. The experience of Asian economies in particular in the past two decades has demonstrated the benefits that public investment in education can bring. In richer countries, education is seen as important not just in the early years, but also in later life. As the pace of technological change quickens and as the workforce in many rich countries grows older, education offers a way to improve and update the skills and capabilities of the workforce.

There are, however, many constraints on delivering education to the right people at the right time. In developing countries, there is frequently a shortage of qualified school teachers. People may live in scattered communities in rural areas. Money for books and teaching materials may be scarce. In wealthier countries, money is also a problem: in particular, the cost of university education has risen sharply, and students are increasingly expected to meet all or part of the cost directly. But, at the level of higher education and training, the problem is often also one of time. Students who are already in full-time employment find it hard to take part in a university course offered at conventional times of day. Finally, employers, keen to train staff, are often acutely conscious of the costs of taking people away from their main job in order to attend training courses. They are therefore eager for more efficient and flexible ways to deliver information to employees.

All these factors have encouraged an interest in the use of information and communications technologies (ICT) to deliver education and training. Computers began to appear in school and university classrooms in the more advanced countries around the early 1980s. Broadband connections to schools and universities became commonplace in wealthier countries in the second half of the 1990s. In developing countries, experience is more limited. This is not necessarily a bad thing, as it should allow those countries to learn from the investments of richer countries.

Initially, educators saw the use of ICTs in the classroom mainly as a way to teach computer literacy. Most now see a broader role: that of delivering many kinds of learning at lower cost and with higher quality than traditional methods of teaching allow. In addition, schools and universities increasingly use ICTs, as do other large organizations, to reduce the costs and improve the efficiency of administration.

By far the largest investments so far in ICTs have been in the United States. The United States' budget for the use of technology in schools is enormous: since 1989, the US Department of Education has invested almost US$1 billion in the use of technology in public education.[1] Not surprisingly, most of the work developing educational ICTs and their most widespread applications are in the United States. And, as a result, many of the evaluations of ICTs have been carried out in the United States. Some lessons from American experience will be universal. Others will be peculiar to that country's education system, which at the higher level involves more private money and enterprise than does higher education in most other countries.

In examining the development of ICTs in schools, universities and training, an important distinction should be made. In the case of schools, teachers primarily use ICTs in the school as an instructional device. "Distance" learning is rarely part of school teaching. In the case of higher education and training, students are more likely to use ICTs partly to learn at a distance from the instructor. Different teaching techniques are thus probably required in the two areas of education.

Also important to remember is the fact that most investment in education is publicly financed. Indeed, some has been driven more by politics than education policy. Computers and broadband connections have a high level of visibility; that makes them an attractive way for politicians to claim to be upgrading education with public money.

Even when politicians are not involved, the most measurable spending on ICTs in education is generally the result of public policy rather than private choice. However, private investment in ICTs also occurs. Some is by companies, using ICTs for training programmes. In addition, many students acquire home computers partly for educational purposes; many, especially in richer countries, use their computers for study and homework. One important question is whether public investments in ICTs in education, made at the behest of administrators or politicians, have been less successful than private investments, made by students on their own account. Certainly, public-sector investors in ICTs in education need to be aware of the way corporate employers are approaching the use of ICTs in training, in case there are lessons to be learned.

In making investments in ICTs in education, policy-makers have often had conflicting goals. Sometimes, the emphasis is on teaching computer skills and literacy; sometimes, on improving the quality of education, giving students access to a wider range of resources than they could otherwise enjoy, or teaching in a more effective way. Often, a subtext is that ICTs are a way to save money. That may mean reaching more people without a comparable increase in costs—and thus improving the productivity of the education system—or widening access, to reach students such as the housebound at a lower cost than would otherwise be entailed. In addition, ICTs are sometimes seen as a way to widen the times at which education is available. Obviously, it is impossible to meet all these goals simultaneously with a single tool.

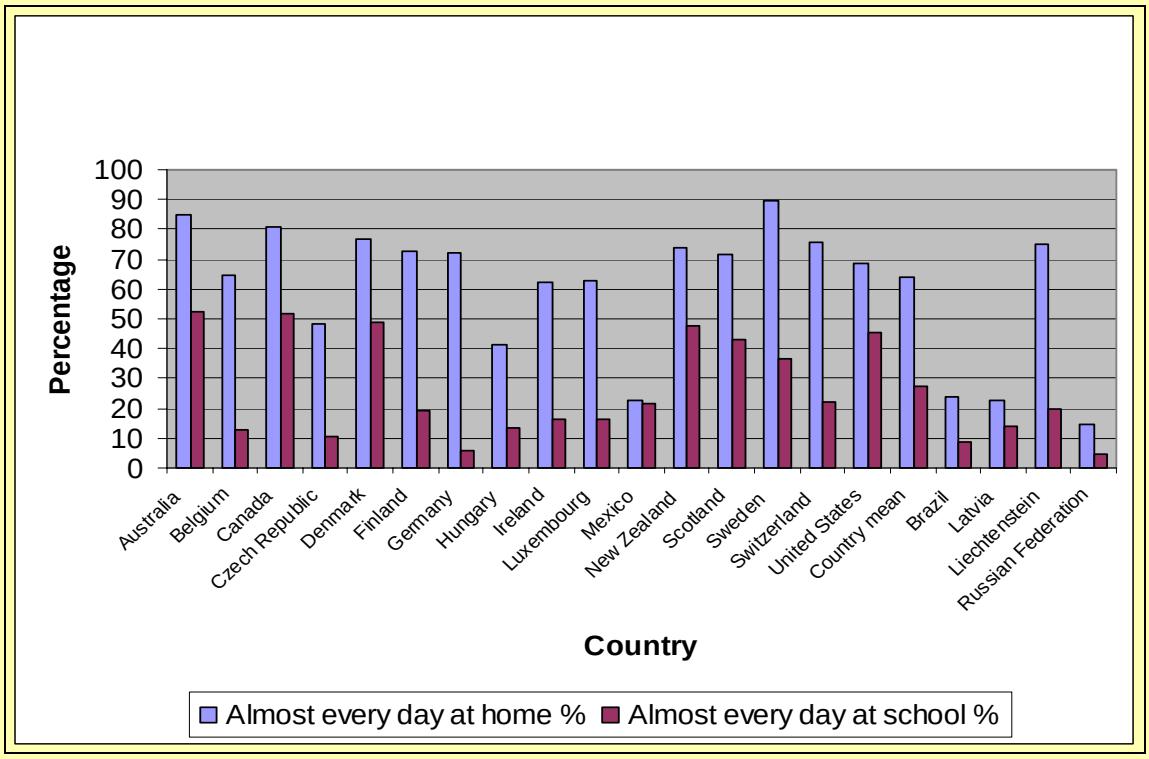
If ICTs can be used effectively to improve the delivery of education, they offer worthwhile prizes: in particular, lower costs and wider access. But policy-makers increasingly want to see value for money and clear evidence that educational investments will deliver commensurate benefits. And some of the early enthusiasts for ICTs in education have become more cautious, or even downright sceptical. This paper examines the conditions that need to be met if ICTs are to improve the delivery of education sufficiently to justify the investment involved. Where those conditions are not met, educators may do better to stick to the age-old recipe of “chalk and talk”.

2 The differing background

The potential for using ICTs well in education and in building human capital depends on a number of factors that differ from one country to another, and especially between developed and developing countries. It is important for countries to bear these differences in mind when making investments. What works in a country with high levels of computer access and low telephone costs will not necessarily transfer to somewhere with few computers and expensive connection charges.

One of the most important differences between countries is the availability of hardware. A computer is essentially an individual device, most useful for one person at a time. Everywhere, youngsters tend to have better access at home than at school. In Sweden, for example, an OECD survey of 15-year-olds in 2000 found that 90 per cent had almost daily access to computers at home, but only 37 per cent at school. In nearby Latvia, by contrast, only 15 per cent of 15-year-olds had near-daily access at home, and a mere 5 per cent at school. At university level, computer ownership is almost universal in richer countries.[2] In developing countries, it is far lower (see Figure 1). This inevitably affects the ways ICTs can be applied.

Figure 1: Availability of computers at home and at school for 15-year-olds, 2000



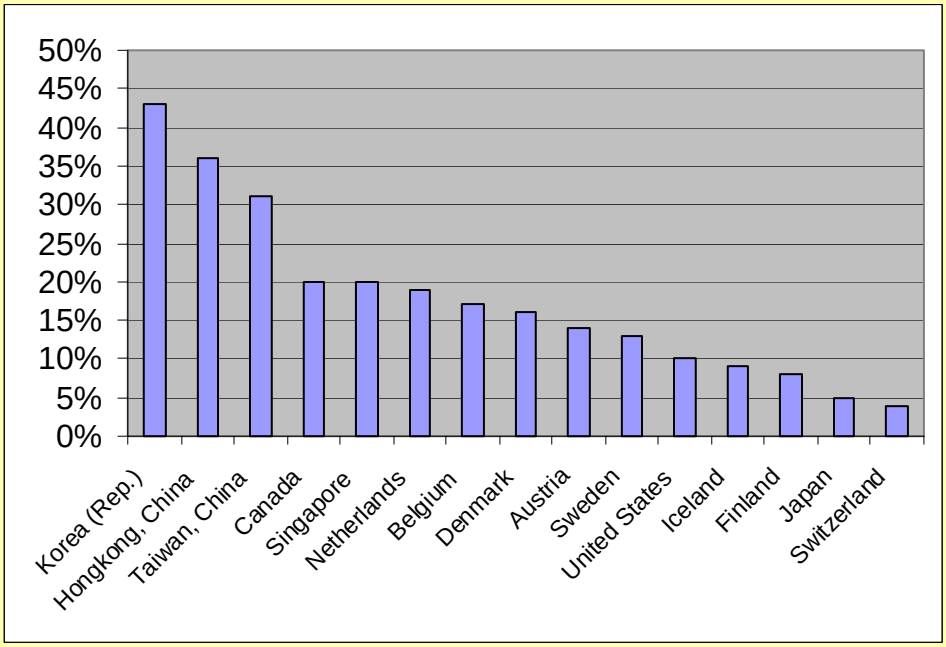
Source: Education Statistics and Indicators, Education at a Glance – 2002 Edition, OECD, Paris 2002.

Developing countries inevitably tend to have far fewer computers per student than richer countries do. In the United States, the ratio of students to computers dropped from 125 to one in 1983 to five to one in 2000. One assessment of computers in classrooms in developing countries found that Costa Rica had an average of between 53 and 73 students per computer in its schools, while Chile had 68 to 137 students per machine.[3]

Access to the Internet varies widely, even among countries of broadly comparable levels of income. In Asia, for example, Japan has 43.9 Internet users per 100 inhabitants; Australia has 37.1; and New Zealand 28.6. Among Asia's poorer countries, China has 2.6 users per 100; Indonesia 1.9; and India only 0.7.[4] So levels of income are not necessarily the main determinant of access.

High-speed access to the Internet also varies. The Republic of Korea has long been the leader in the percentage of households with high-speed access, and indeed overall Asia is the clear leader in broadband (see Figure 2). Canada is high on the list, but the United States is still surprisingly low. In 2003 Japan started making major strides to join the top countries by rapidly decreasing the cost of high-speed access.[5] Although high-speed access is poor in most developing countries, China, now fifth in number of DSL lines, is growing faster than any other large country and is likely to be the biggest broadband country in the world within a few years.

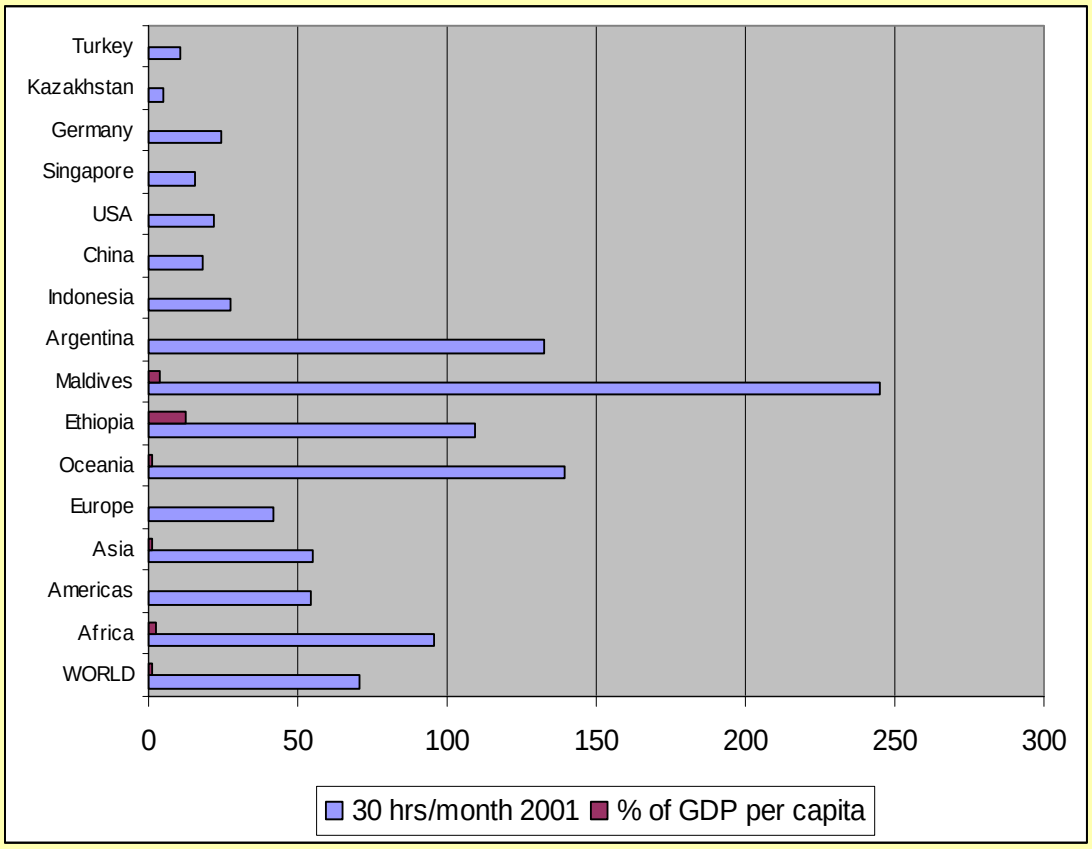
Figure 2: Top 15 economies by 2002 broadband penetration



Source: International Telecommunication Union (ITU) adapted from national reports.

The cost of Internet access and the structure of charges are important. Where telephone companies or Internet service providers (ISP) charge on a timed basis, the effect may be to deter students from using the Internet as a research tool. Countries that still have monopoly providers of local services (as is the case in many developing countries) often have more expensive and less flexible telephone services than countries with competition. For example, in Ethiopia the cost of 30 hours of Internet use in 2001 is US$ 109.57 (which is 12.40 per cent of gross domestic product (GDP) per head, the highest ratio in the world), in Maldives US$ 244.69 (3.85 per cent), and Argentina US$ 132.19 (0.21 per cent), whereas in the United States it is US$ 22.05 (0.01 per cent), Australia US$ 23.52 (0.01 per cent), Singapore US$15.83 (0.01 per cent) and in Germany US$24.13 (0.01 per cent). The world average is US$ 70.71, or 1.18 per cent of GDP per head. These variations demonstrate that there are wide variations even among developing countries. In Turkey, the cost is less than 0.05 per cent of GDP per head, and in Kazakhstan 0.06 per cent (see Figure 3).[6] Without relatively affordable Internet access, it is hard to see how ICTs can play more than a rudimentary role in education. Governments can—and should—influence this by providing cheap access to educational institutions, as is the case for example in Malaysia and Thailand. Again, the Asian countries have been doing a better job overall in providing cheap access for schools than most African countries have done.

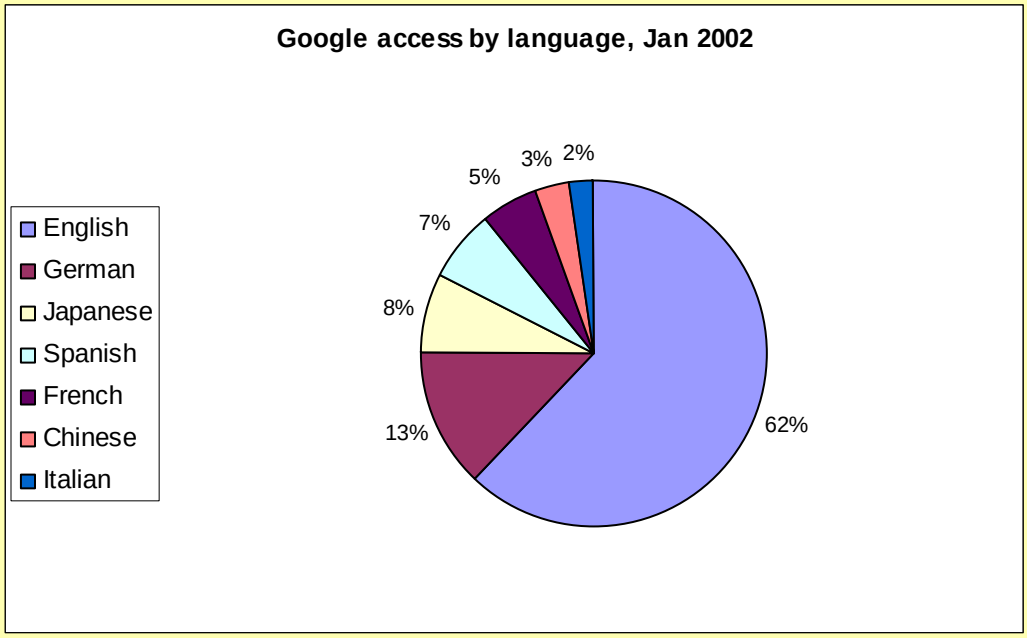
Figure 3: Cost of 30 hours of Internet access, 2001



Source: ITU.

The availability of educational software may also vary, and not just because of countries' differing ability to afford it. Most material is available in English. That will restrict the choice for schools and universities in countries where English is not widely used. Countries that want to use educational software in other languages may have to translate and adapt it, as China has already been doing on a huge scale. That will increase costs. Greater problems arise in countries with several languages, or even with several scripts. For example, Thailand has 75 spoken languages, China has 202, and India has 15 official and 1,683 spoken languages.[7]

Figure 4: Languages in the Internet, 2002



Source: OECD.

The importance of these challenges varies for developing countries, some of which are more ready to benefit from the effective use of ICTs than others. Compare, for instance, the situation in Indonesia with that in Ethiopia.

Indonesia has already made extensive use of ICTs to deliver distance learning. By the end of 2001, 1,800 of the country's 30,000 secondary schools were connected to the Internet. The country is building on a programme of distance learning established through Universitas Terbuka, established in 1984 as the country's first distance-teaching university, which now has over 350,000 students. The University of Indonesia estimates that, by 2005, 30 per cent of its 38,000 students will be involved in distance education.[8]

One reason for Indonesia's success may be its competitive market for Internet services. The country has more than 60 Internet-service providers and some 2,500 Internet cafés, known locally as "Warnets", scattered around the country and operated by private entrepreneurs. The Indonesian postal service also offers Internet access at over 100 post offices. The Indonesian Internet Kiosk Association (AWARI) also provides low-cost Internet access for distance education.

In Ethiopia, by contrast, a study by the International Telecommunication Union of ICTs in education in late 2001[9] found:

- Extremely low Internet use. This is hardly surprising, given that the country had a mere 0.48 lines per 100 inhabitants, and given the fact that Internet access is four times as expensive as in the United States (see above). Out of a population of 65m, there were perhaps at most 60,000 Internet users.
- Extremely low Internet access in schools: only nine of the country's 12,000 primary schools and ten of its 424 secondary schools had Internet access.
- Hardly any information technology (IT)-trained people. The country's six universities and three polytechnics produced 113 IT graduates in 2001.
- 25 official languages written in three different scripts.
- Monopoly provision of all telecommunication services by Ethiopia Telecomm.

- High telephone tariffs.

Although a British non-governmental group had installed a US$1.2m fibre-optic connection to the five campuses of the university of Addis Abeba, it was unused: Ethionet, the country's monopoly Internet-service provider, refused to supply a link because it would imply the resale of its services by the university.

All these factors suggest that ICTs will be introduced at differing speeds in different countries. However, the extent to which China has forged ahead of richer countries in terms of Internet access and the spread of high-speed connections suggests that income levels are not all that matters. By the start of this year, more than 800,000 computers had been installed in 70,000 primary and secondary schools. Over 10 million primary and secondary school students had learnt how to use computers to go online. The ministry of education has mandated that all schools be connected by 2010 to the China Education and Research Network, a national academic network. Universities are offering distance-learning courses on a rapidly growing scale, and the Government is investing in Internet access in remote regions with the specific aim of widening access to education.[10]

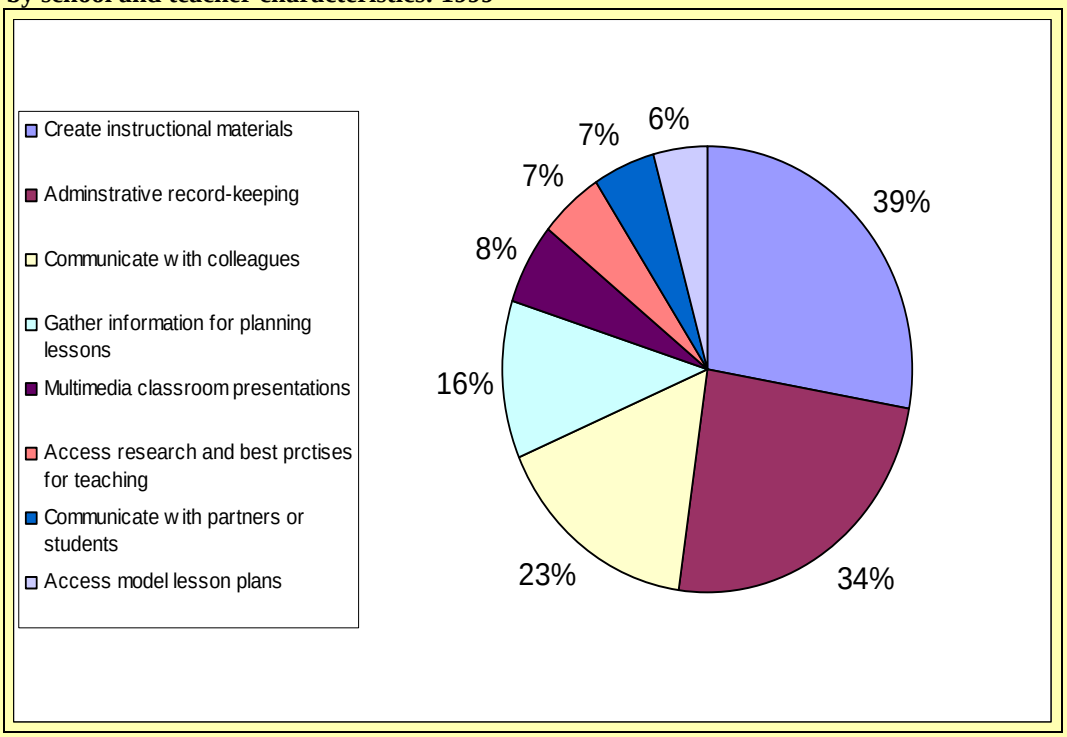
Public policy is important here. In general, developing countries with competitive providers of telecommunications and Internet service, and with governments that are eager to extend education, will find it easier to apply ICTs in education than those without these advantages.

3 ICTs in schools

Computers are spreading rapidly in schools not just in wealthy countries, but increasingly in developing ones as well. However, although schools have had computers in classrooms for almost two decades, ways to use them effectively have evolved slowly and patchily. Schools use ICTs in two main ways: for administration and routine tasks of classroom management, and for instruction. In the classroom, they have two main instructional roles: for teaching ICT skills and as a tool for teaching other subjects.

Probably the most incontrovertible benefit of computers in schools has been in easing administrative chores. For example, teachers no longer need to pass round bundles of end-of-term reports in paper envelopes, but can fill them in on screen (and often deliver them safely to parents online). Data on students' attendance and performance can be more easily recorded and analysed. The use of ICTs for administration and routine tasks of classroom management seems to have developed just as quickly, or quicker, than their use in instruction. A survey carried out in the United States by the National Center for Education Statistics[11], published in 2000, of the way that teachers in US public schools use the Internet, gave an invaluable picture of the factors shaping ICT use in schools. It found that administrative record-keeping was the second-largest use made of computers by teachers (34 per cent), after that of creating instructional materials (39 per cent). A second semi-administrative use was also common: using computers to communicate with colleagues. That was reported by 23 per cent of teachers, whereas only 7 per cent used the machines for another obvious task: to communicate with parents or students (see Figure 5).

Figure 5: Percent of teachers indicating they use computers or the Internet a lot at school to accomplish various objectives, by school and teacher characteristics: 1999



Source: US Department of Education, National Center for Education Statistics, Fast Response Survey System, "Survey on Public School Teachers Use of Computers and the Internet," FRSS 70, 1999

The use of ICTs to make administration more efficient may also raise the overall quality of education. For instance, if teachers spend less time on administrative tasks, they will have more time for teaching and for preparing materials. So using ICTs to improve administration may pay off rather well. This is a gain that evaluators rarely consider. However, it may well be the area on which schools should mainly concentrate, perhaps looking for inspiration to well-run corporations, rather than chasing the more elusive benefits of ICTs in teaching.

In the case of actual teaching, advance has been more hesitant. Indeed, in 2001, one acknowledged expert in the United Kingdom argued that there was a danger that the use of ICTs in the classroom would turn out to be a classic case of innovation failure. It might, he argued, turn out to be "A low-quality implementation of a not very powerful technology of practice produces poor or no improvement in outcomes, which in turn produces low commitment to the innovation."[12] Some studies in the United Kingdom suggest that perhaps 10 to15 per cent of teachers are non-users and a further 25-30 per cent are minimal users. One explanation may be demographic: in developed countries, teaching is frequently a profession with a high average age. (Another may be the uncomfortable certainty that a class of ten-year-olds knows far more about ICTs than the average middle-aged teacher.)

In spite of the sums so far invested in bringing ICTs to the classroom, many schools, and indeed teachers, still seem unclear how to make the best use of them. There is, say some observers, an absence of clear "teaching technologies of ICT usage" that tell teachers what might work with which children.[13] As a result, ICTs are often bolt-on devices, rather than an integrated part of lessons and of pedagogy. And those that are more adventurous may use ICTs mainly to search for existing information and knowledge, rather than as part of some new and

transforming way to teach and to learn. The survey mentioned above found that 86 per cent of teachers used the Internet for e-mail and to find instructional material.[14]

But increasingly, if tentatively, teachers are using ICTs to download material created by other teachers and made available to others through teachers' numerous discussion boards; to find material in different languages for language classes; to set drills and tests; and to set classroom research projects. Schools also use classroom management software, through which the teacher controls the computers on which students work: teachers can give students assignments to work on, and at the same time see what they are doing, which is important when class sizes grow. Tools such as these may allow teachers to communicate with larger classes, and so eventually be particularly useful in developing countries.

The survey[15] discussed above found that 66 per cent of American public-school teachers reported using computers or the Internet for instruction during class time. Moreover, 41 per cent of teachers assigned students work that involved computer applications such as word processing and spreadsheets; and 31 per cent said they assigned practice drills using computers; and 30 per cent assigned research using the Internet. Elementary school teachers were more likely than secondary-school teachers to assign practice drills; secondary-school teachers were more like than elementary teachers to assign research using the Internet.

From this survey, three factors emerge as having an important influence on the extent to which teachers use ICTs to teach. They are:

- Experience—which is probably a proxy for age. For example, 47 per cent of those who had been teaching for between four and nine years reported that they used computers or the Internet a lot to create instructional materials, compared with 35 per cent of those who had been teaching for 20 or more years. And, of teachers with three or fewer years of experience (the newest of all), 31 per cent reported feeling well prepared to use computers and the Internet, compared with only 19 per cent of those who had been teaching for 20 years or more.
- School poverty level (measured by the proportion of children eligible for subsidised lunches). In schools with the fewest poor children, teachers were much more likely to use computers for everything from administration to creating teaching materials, and to assign students work that called for computer use.
- Professional development. Teachers who had received more than 32 hours of professional training in the use of computers and the Internet in the previous three years were more likely to use computers both for tasks around the lesson and for teaching students. In addition, training had a marked impact on teachers' confidence. Thus 29 per cent of those who had had more than 32 hours of training reported feeling very well prepared compared with 6 per cent of those who had had eight hours' training or less (see Table 1).

Table 1: Teaching it to teachers

Percentage distribution of teachers in the United States with access to computers or the Internet at school according to the level of preparedness they feel to use computers and the Internet, by school and teacher characteristics, 1999

School and teacher characteristics	Not at all prepared	Somewhat prepared	Well prepared	Very well prepared
All public school teachers with access to computers or the Internet at school	**13**	**53**	**23**	**10**
School instructional level				
Elementary school	12	55	23	10
Secondary school	15	50	23	12
Percent of students eligible for free or reduced-price school lunch				
Less than 11 percent	10	53	25	12
11–30 percent	13	52	25	10
31–49 percent	14	51	24	10
50–70 percent	16	58	16	10
71 percent or more	13	55	22	10
Teaching experience				
3 or fewer years	10	46	31	13
4–9 years	10	49	28	13
10–19 years	14	55	21	10
20 or more years	16	58	19	8
Hours of professional development*				
0 hours	32	46	15	6
1–8 hours	19	55	20	6
9–32 hours	4	61	25	10
More than 32 hours	1	32	37	29
Type of work assigned to a moderate or large extent				
Use computer applications such as word processing, spreadsheets, etc.	4	45	33	19
Practice drills	4	54	27	14
Research using the Internet	4	43	34	19
Solve problems/analyze data	3	49	29	19
Research using CD-ROM	3	42	33	21
Produce multimedia reports/projects	5	38	33	24
Graphical presentation of materials	4	38	35	22
Demonstrations/simulations	2	34	37	28
Correspond with experts, authors, students from other schools, etc., via e-mail or Internet	4	32	34	30

Source: US Department of Education, National Center for Education Statistics, Fast Response Survey System, "Survey on Public School Teachers Use of Computers and the Internet", FRSS 70, 1999.

Other studies emphasize the importance of technical training and support, and of the reliability and ease of use of hardware and software. If teachers have to spend time dealing with unreliable equipment, ICTs will reduce their productivity, not increase it. Unreliability means that teachers risk losing an entire class of teaching time: a teacher in front of 30 students, trying to boot a system for 25 minutes, has only 20 minutes of the class left in which to use the on-screen material. One American education district with 155,000 school students estimated that, if every teacher spent on average an hour trying to fix computer problems, the cost would be the equivalent of 307 full-time teaching staff.[16]

Probably the most important lesson from studies of the use of ICTs in schools is the need for extensive training. Teachers need to learn to make the most of both hardware and software. The US Department of Education argues that, "If there is a single overarching lesson that can be culled from research about teacher professional development and technology, it is that it takes more time and effort than many anticipate."[17]

The US education department recommends that school districts set aside 30 per cent of their technology budgets simply to cover staff training and development.[18] Many US state departments of education require school districts to set aside between 20 per cent and 30 per cent of their state technology-grant money for staff development.[19] However, a 1993 survey of US schools found that only 15 per cent of the typical computer-system budget was devoted to staff instruction[20]. And one consultancy, Quality Education Data Inc, estimates that the average US school district spends a mere 6 per cent of its technology budget for teacher training.[21]

In developing countries, the share of project funds going to teacher training is also sometimes much lower than seems desirable. A study[22] financed by the World Bank, found that Turkey allocated rather over 1 per cent of total project costs for initial training, and rather less than 1 per cent for continuing staff development; while Barbados allocated 4 per cent of total costs for staff training. Chile and Egypt reported allocations for training as

a proportion of costs at school level, rather than a share of the budget for the entire system. In Chile's case, the allocation was 18 per cent of budget; in Egypt, 28 per cent.[23]

4 Costs of ICTs in schools

Estimating the true cost of ICTs is not easy. Public policy-makers often look merely at the costs of acquiring hardware and software. These, however, are likely to be only a small part of the total cost. Other costs can easily surpass the initial investment. For example, schools discover that they have budgeted for hardware but not for software, or not for ongoing maintenance. The failure to make provision for all costs from the start sometimes means that expensive hardware lies idle.

Even hardware costs may be greater than at first appears. They typically include not just computers, but auxiliary equipment such as printers and scanners. One 1995 study of eight high-tech US schools found that they spent between 30 per cent and 67 per cent of their budget for ICTs on hardware.[24] Schools elsewhere seem generally to spend a smaller proportion, notably in developing countries.

However, there are many other costs that are frequently overlooked. In the United States, a project run by the Consortium for School Networking, a non-profit organization backed by the computer industry, tries to educate schools about the "total cost of ownership": the costs not only of installing but also of running and efficiently using ICTs in schools. Among the "extras" that are easily forgotten, they include:

- Staff training and development. For example, a study by McKinsey, a big management consultancy, pointed out that a district planning to connect all its classrooms to the network would have to hire substitute teachers at a cost of US$100 a day to cover while permanent staff were being training, and also the equivalent of 1.5 full-time staff members to conduct training.[25]
- Technical support. A study[26] by the Milken Exchange on Education and Technology in 1998-99 found that 39.6 per cent of school districts "frequently" used teachers to provide support and 11.5 per cent frequently used students. Not only does using teachers mean pulling them away from other duties; it is also likely to be a second-best way of providing support. More than 29 per cent of respondents to the survey said that one reason why computers were unused in their schools was because they were waiting to be repaired.
- Software. In businesses, software frequently equals 20-25 per cent of hardware costs. However, in US schools the typical proportion is 10 per cent or less of budget. An official report in the United States in 1997 recommended that school systems allocated approximately US$100 a year per student for software.[27] In fact, Quality Education Data, a consultancy, reports that the average US school spent about US$11 per student on educational software in the 1998-99 schools year. That may not be unreasonable: many instructional materials available on the Internet are free.
- Replacement. US educational experts recommend replacing computers after between three and five years. Wear and tear apart, computer technology is evolving rapidly. And newer software applications may require newer hardware – even if they do not also provide commensurate improvements in instructional power. The frequency with which computers need replacing means that schools which build them into their pedagogy will find them a recurring item of expenditure, rather than a once-for-all capital outlay. But school budgets often do not allow money to be rolled forward over several years, and so may be badly structured to cope with the need to make such a large investment every few years.
- Retrofitting. Installing computers in both schools and universities may involve more extensive investment than the hardware alone. Buildings may have to be adapted, and electrical supplies upgraded. Some of these costs can be reduced by using wireless networks, although for the moment these are less likely to be used by most educational establishments than conventional connections.

Another influence on cost appears to be the way that computers are deployed through a school. Are they scattered among classrooms or concentrated in a special computer laboratory? A study in 1995 by McKinsey, a consultancy, compared the cost of putting computers into classrooms, with one for every five students and a high-speed connection, with that of putting them into a computer lab. Because costs such as maintenance and

security were higher in the classroom, the up-front investment was were about four times and the recurring cost per student three times higher than the laboratory installation.[28]

The bottom line is that schools (and, as discussed below, universities) easily underestimate the true costs of adopting ICTs. Of these, by far the most important is the cost of training and staff development. But few of the costs are once-and-for-all. The rapid pace of technological change means that computers need replacing, and software needs updating, and both require staff to leave the classroom and learn new techniques.

5 Do ICTs help children to learn better?

Evaluating technology projects is notoriously difficult. Even more so is the evaluation of educational interventions. School influence on pupils' academic or social outcomes explains only about 12 to 15 per cent of the variance, leaving 85 per cent or more to be explained by the influence of factors such as the child's family background, lifetime experience, natural ability and so forth.[29]

Many early experiments with ICTs in classrooms were based on nothing more than enthusiasm or hunch. However, the growing emphasis on the need to show concrete benefits has led to more attempts to evaluate the impact of computers in classrooms. But evaluating ICTs in education is particularly hard, for a number of reasons.

Even in schools that make extensive use of ICTs, the amount of time spent using them in class is still generally tiny in relation to the time spent using more traditional teaching tools, from blackboard and chalk to photocopied handouts. In Britain, children use ICTs for an average of 45 minutes a week in primary school, and for one hour and 15 minutes in secondary school.[30]

In addition, technologies and the way they are applied both vary greatly from one school or university to another. Many studies merely collect examples, rather than attempting to gauge teaching effectiveness. Many, too, attempt to measure the effectiveness of ICTs against quantity measures—how many computers, how much ICT software, and so forth—instead of attempting to assess quality, by looking at the ways ICTs is deployed in the classroom.

One of the most thorough attempts[31] to set out the measurement issues in the evaluation of ICTs in schools, published in April 2002, picked out three problems:

- "Terms such as 'technology' and 'technology integration' mean different things to different people."
- "Most of the measures used in evaluation are 'home grown'…measures that directly measure the effects of each grant."
- "There is a tendency to focus more on short-term outcomes and effects, rather than seeing the interventions as part of a total package designed to change how schools function."

"Evaluations", the authors add, "are more likely to look at whether students have specific knowledge (standardized tests) than whether students have acquired higher-order thinking and problem-solving skills that would allow them to gain and apply knowledge effectively." Moreover, "evaluations are more likely to look at whether teachers have mastered specific technology skills than to what extent they can effectively apply those skills to enhancing teaching and learning."

Few studies use random control groups of students. The result, not surprisingly, is that most studies suggest that the effectiveness of ICTs depends on how computers are used, in what context and with what expectations.

The most intensively studied application of computers in education, and one of the oldest, is that known as "computer-aided instruction": drill programs that repeatedly test a student's factual knowledge. The program poses a multiple-choice question; the student gets an immediate result. Most research suggests that, when such testing is the only basis of instruction, its result is mixed. But when it is combined with traditional instruction, in frequent and short sessions, it is more effective and speedy than traditional instruction alone. Few studies have explored whether such instruction is cost-effective. One that did, conducted in the 1980s, found it more cost-effective for improving maths scores than lengthening the school day or reducing class size, but less effective than peer tutoring.[32]

Such a use of computers is relatively simple and therefore easy to test. Much more complex to assess is the effect of ICTs when teachers use them to encourage a class to do independent research. Many such studies fall back on anecdotal evidence, or on largely subjective reports of changes in children's attitudes after ICTs became available.

A rare exception is a study by two economists of the introduction of computers into many of Israel's primary and middle schools in the mid-1990s.[33] The way in which computers were allocated among schools gave the authors something that most studies lack: comparable groups of children with and without access to computers.

The authors compared the test scores for maths and Hebrew achieved by children in the fourth and eight grades (i.e, aged about nine and 13) in schools with and without computers. They also asked the classes' teachers how they used various teaching materials, such as photocopied worksheets and computer programs. The researchers found that the Israeli scheme had much less effect on teaching methods in middle schools than in elementary schools. It also found no evidence that the use of computers improved children's test scores. Instead, it found the reverse. In the case of the maths scores of fourth graders, there was a consistently negative relationship between computer use and test scores.

The authors suggest three possible explanations for this disappointing outcome. First, the introduction of computers into classrooms might have used up cash that would otherwise have paid for other aspects of education. However, because the money for the computer programme came from the national lottery and not the main education budget, this is unlikely to have been the case. Nor did the study find any significant change in teaching resources, methods or training in schools that acquired computers through the scheme.

A second explanation is that effective adoption of computers in education takes time to have an effect. However, the schools surveyed had already been using computers for a full year. The third explanation is the simplest: that the use of computers in teaching is at the least no better than other methods and may be worse. As one of the authors concludes, "the costs are clear-cut and the benefits are murky."[34]

It may be difficult to produce incontrovertible evidence on the impact of classroom computers on children's learning. At the least, it would be helpful to have some properly randomized tests, set up with the precision that would be used to test an expensive new drug. Even then, it may be hard to reach enduring conclusions, just as it has proved hard to establish without doubt that children benefit from smaller class sizes. But at the very least, there are grounds for schools to hesitate before investing in computers in classrooms, if the aim of that investment is to improve the teaching of subjects other than computer literacy. Other investments, in teaching materials or in teacher development, may have more impact on educational outcomes.

Without effective evaluation of educational impact, it is hard to measure the cost-efficiency of the use of technology in classrooms. Yet this measure becomes increasingly important as the size of ICT investments increase, and as education budgets are more constrained. In the United States, the tightening economy has caused a greater emphasis on thinking about the real benefits of technology investment, compared with its cost. For instance, a technology planning guide released in January 2001 by the California Department of Education[35] said, "Technology planning needs to be comprehensive and include considerations of the long-term implications of the choices made … Hardware purchased should meet district needs and have the lowest cost of ownership over the long term."

This shift of emphasis from effectiveness to cost-effectiveness is not surprising, given the weaker economy. But it may slow down the application of ICTs in public education. ICTs are a more expensive policy intervention than most. Governments increasingly ask, not "Do ICTs have an impact on educational attainment?" but instead "Which policy interventions get the most bang for the buck?" One of the characteristics of much cost-effectiveness research is to find that very cheap interventions with relatively small effects are more cost effective than larger and more expensive interventions with larger effects. In addition, a greater emphasis on cost-effectiveness may well slow the pace of innovation. That is a process that requires a certain amount of wasteful experiments in order to succeed.

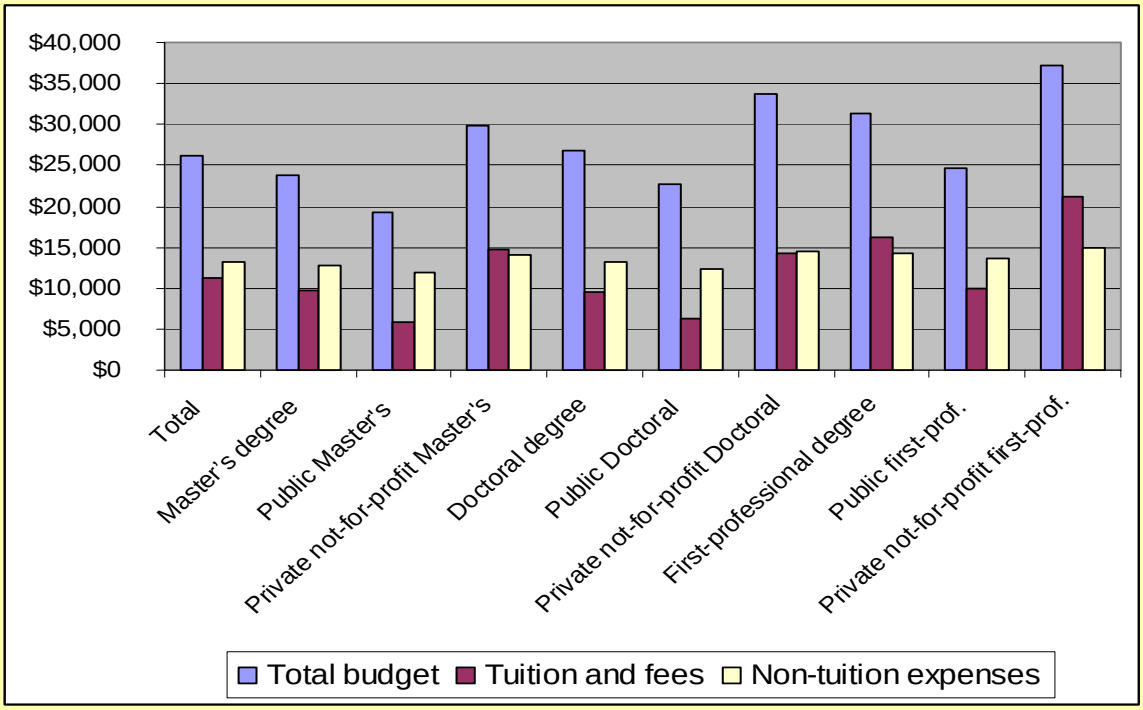
6 ICTs in universities

There are important differences between the use of ICTs in schools and in higher education and especially universities.

One is the context in which schools and universities typically use ICTs. While school teaching that makes use of ICTs generally occurs with a class that is physically present, this is not normally the case when ICTs are used to deliver university courses. Part of the challenge in introducing ICTs into schools is finding ways to combine the teacher's presence with that of the technology.

A more significant difference is that, whereas school education is generally free, students increasingly pay at least part of the cost of university education. This is especially true for students in the United States. There, average total tuition at top private universities increased in real terms from about $16,300 in 1992-93 to about US$19,700 in 1999-2000; and at top public universities, from about US$4,000 to US$4,800[36] (see Figure 6). So one of the driving forces behind the spread of distance learning in both schools and universities is the desire to cut costs. But the pressure tends to be stronger in universities, because it comes from the students as well as from the educational policy-makers.

Figure 6: Average expenses for graduate and first-professional students in the US, by attendance status, type of degree, and institution type: 1999-2000



Source: US Department of Education, National Center for Education Statistics, 1999-2000 National Postsecondary Student Aid Study (NPSAS:2000)

Even more important are the questions of time and of location. Whereas school students usually do most of their formal studying in school, that is not the case for students in higher education, a growing minority of whom may study only partly—or not at all—on the campus of the university that is running their course. In developed countries, this is often because students are working while studying; in poorer countries, because there is simply not the money to finance a traditional university education.

In terms of their use of ICTs as a teaching tool, universities fall into three broad categories. Many conventional universities in rich countries use computers in the ways that schools do—as a teaching tool or to improve the

efficiency of communicating with students and of administration. For developing countries, one of the most important uses of ICTs in universities may be one that also applies in schools: as an inexpensive way to gain access to teaching materials, which are expensive to create.

In rich countries, ICTs are now widely used in university classrooms. In the United States in particular, university students frequently have access to computers in class. Sometimes, the university provides personal computers (PC), but increasingly, the installation of wireless loops allows students to use their own laptops for access to the Internet anywhere in the university buildings, including in class. Although these are widely used for teaching scientific subjects, anecdotal evidence suggests that they are less useful for teaching other courses. Instead, lecturers are growing used to the idea that they have to compete with the Internet and e-mail for their class's attention.[37]

As an example of using ICTs to communicate with students and to manage more efficiently, take the example of the University of California, Los Angeles (UCLA).[38] Almost all the university's 3,000 or so undergraduate courses now have their own website, and about 55-60 per cent of these not only supply lecture notes, but allow students to take tests online and to see the results. And the university has, like many businesses, saved money by combining online its purchasing of everything from computers to pencils, thus giving it more buying power.

The two more widely discussed categories are the universities that offer degrees only at a distance; and the conventional universities that expand their reach by offering some courses at a distance, either to individuals or on satellite campuses.

Most of pure distance universities, such as the United Kingdom's Open University, build on older techniques of distance learning. Correspondence courses, after all, are more than a century old. A number of new virtual universities were launched in 1997-99, at the peak of the dotcom boom. Some were spun off as for-profit businesses by existing universities; others were private for-profit enterprises. Both tended to have a small core of full-time instructors and a larger group of contract faculty, to be called in as needed. Several have shut in the past couple of years, including Virtual Temple in the United States, the distance-learning initiative of Philadelphia's Temple University which was created to cater to the adult market for continuing education and to international students. Temple's president, David Adamany, said about online learning that "despite much discussion and no little hype this is still an uncharted sea. It is already apparent that no one has yet found a way for on-line learning to be economically viable".[39] Other closed ventures include NYUOnline and UMBCOnline, spin-offs of New York University and the University of Maryland/Baltimore County respectively.

In addition, many traditional universities offer a mix of delivery methods. Generally, the goal is to widen access and tap into markets that cannot easily be reached with more traditional approaches. Some offer the same course online and in a classroom; others use a hybrid mix of electronic and traditional methods of delivery. Some set up satellite campuses with broadband links on which students, young and mature, who live in small towns and who could not travel to a larger campus, can learn partly at a distance.

Sometimes, distance courses allow a university to reach students in remote parts of the country or abroad. Such courses are frequently run in partnerships to give students a base in the country where they are learning. For example, the Massachusetts Institute of Technology in the United States has a partnership with the National University of Singapore and Nanyang Technological University; and the University of Michigan at Ann Arbor has a joint programme with Shanghai Jiao Tong University to offer a master's degree in engineering manufacturing to Chinese students through distance learning.[40] The business school of Curtin University in Australia uses video-conferencing to offer courses jointly with the university of Singapore;[41] Curtin itself has plans to build a distance learning university in Africa. Some of these projects do not lead to degrees: Stanford, Yale and Oxford universities have a joint for-profit project called the Alliance for Lifelong Learning to offer non-credit courses in literature, classics and religion that last from several weeks to eight months.

The University of British Columbia in the United States developed an online Master's course in technology-based distributed learning in partnership with Mexico's Monterrey Institute of Technology (ITESM). Of the first students to enrol, 40 were UBC graduate students, registered for the conventional campus Masters of Education programme; 80 were registered with ITESM for a Masters in Educational Technology; and 30 were "non-credit" students, who paid the fees but did not take a full programme. That last group came from 17 different countries, including China, Australia and Japan.[42] Among them were six students who already had

PhDs and 12 who already had Masters degrees. Clearly, there is a need for educational opportunities for people who are already well qualified but who want to update or extend their knowledge—or earn a degree recognized in a different country.

Many developing countries have universities of the hybrid sort. For example, China has a long history of using satellite television to deliver distance education to its vast and remote population. The Government is well aware both of the thirst for university education and of the impossibility of accommodating everyone who wants to take a degree in the conventional way. In the mid-1990s, it began to build a high-speed network intended as a platform for distance education. In September 1998, the Ministry of Education launched a pilot project to experiment with distance college education in four universities (Beijing Communications University, and Tsinghua, Zhejiang and Hunan universities) with the recent addition of Peking University.

Often, the reason for offering distance courses is to help students who are at work at times when conventional classes take place. Kwantlen University College, a college in British Columbia offering two-year courses, was able to retain a programme that had found it hard to attract viable numbers on campus by offering it online. Many of the distance students said that they would not have been able to take the course on campus and that the online version gave them more flexibility.[43]

Indeed, the ability to combine study and work is frequently a reason why students, especially in the United States, turn to distance learning. Students who are continuing their education and are in full- or part-time jobs cannot afford to sit in a classroom at a certain time. Work commitments prevent it, and travelling to a class from a job or home takes time. For this growing group, distance learning makes it possible to combine work and study, instead of taking a sabbatical or dropping out.

Figures[44] from a study sponsored by the US Department of Education's National Center for Education Statistics show that, in 1999-2000, 80 per cent of undergraduates work while enrolled and 60 per cent attend on less than a full-time and full-year basis; and 30 per cent of undergraduates consider themselves primarily employees who are also taking classes. Of "employees who study", 80 per cent work 36 or more hours per week. "Students who work" have a more diverse employment pattern: 23 per cent work one to 15 hours a week, 34 per cent work 16 to 25 hours a week, 21 per cent work 26 to 35 hours a week, and 22 per cent spend 36 or more hours a week on the job. Most of those who have studied the question agree that students who work one to 15 hours a week, preferably in an on-campus job, also study harder. Students who work more than 15 hours per week tend to have weaker grades and a lower chance of completing a degree. In total, 50 per cent of undergraduates work and attend less than full time and full year. Among that group, the most common workload is 16 to 35 hours a week. Only 9 per cent of undergraduates fit the traditional pattern: attend full-time for a full year and work the recommended one to 15 hours a week.

The technology of distance education has become increasingly sophisticated. While many universities in developing countries rely on relatively simple technologies, such as satellite television, others use a wide variety of techniques for distance instruction. For example, some use techniques such as online discussion, allowing a degree of student interaction that is impossible in print-based distance learning. In the United States, live video instruction is now the most popular and fastest growing mode for delivering distance education.[45] Other popular technologies include WebCT or Blackboard, two web-based management systems for both course management (course content made available in web) and administration (for instance, student IDs, building access, and campus commerce).

However, for developing countries in particular, costs of distribution can still be a formidable obstacle. If distance learning is to achieve its potential in developing countries, inexpensive and efficient communications are essential. Technologies such as low-cost WiFi and VSAT will gradually bring down the cost of connections for rural areas. In addition to browsing material at their own pace, students can listen to lectures through voice-over-IP applications which require less bandwidth than videoconferencing. New mobile phones which allow the transmission of images and video will enable interactive communications, but they will certainly be used first in wealthier countries, just as personal digital assistants (PDA) are already being deployed in university teaching.

How many students participate in distance courses? The figures for China are enormous, even at the experimental stage. Tsinghua enrolled 1,740 Internet postgraduate students in business administration, computer technology and civil and business law in 1999; Zhejiang University enrolled nearly 3,000 Internet undergraduate

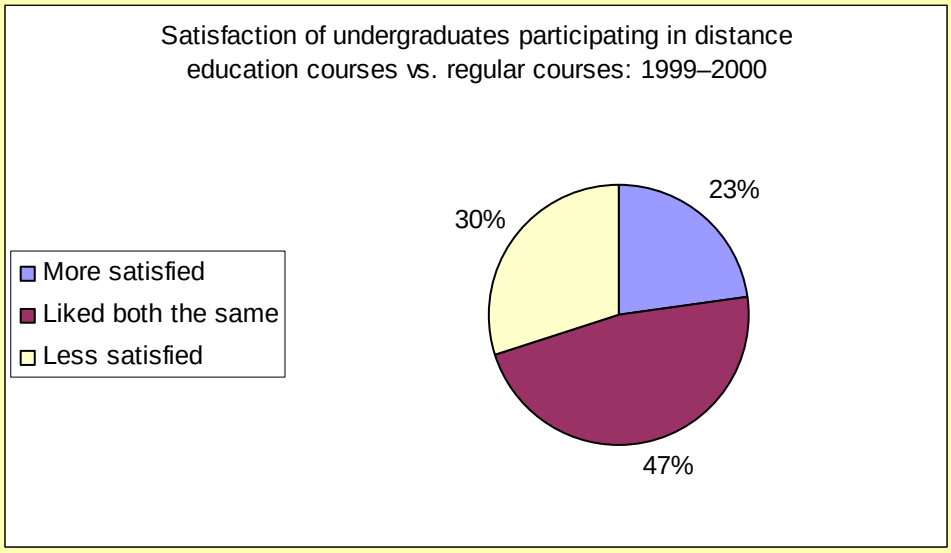
students and 420 postgraduate students in computer, English literature and business administration courses in 1998 and 1999; and Hunan University not only enrolled 3,500 Internet students in computer and English literature courses, but began to teach its undergraduates on campus online.

Where distance education is the only option available, such immense numbers are likely to be achievable. However, where students have a choice between distance courses and conventional campus-based college education, the pattern is more mixed. Overall, figures reported by NEDRC[46] show that 8.4 per cent of the United State's about 13 million undergraduate students took at least one course credit via distance education in 1999-2000. Of that total, 59 per cent took courses delivered over the Internet; 37 per cent took live, interactive courses delivered in other ways; and 39 per cent took pre-recorded courses. Among the study's other findings:

- Older, working undergraduates were more likely to participate in distance education than their younger counterparts. Thus 10 per cent of undergraduates aged 24 and older reported taking a course via distance education compared with 6 per cent of younger undergraduates.
- Undergraduates with family responsibilities also were more likely to participate in distance education. Married students, with or without dependents, were more likely than those who were unmarried, dependent or independent, to take courses via distance education (12.4 per cent and 10.7 per cent as against 6.3 per cent and 8.1 per cent respectively).
- Institutions offering associate's degrees are more likely than other types of institutions to offer distance education. Not surprisingly, undergraduates enrolled at public, two-year institutions were more likely than students enrolled at any other type of institution to take distance-education classes.
- Like undergraduates, graduate and professional students who attended part- time, full-year were more likely to participate in distance education than students who attended full-time, full-year (13 per cent versus 6 per cent).

These figures suggest that students still perceive distance learning as a second-best. It may offer enormous convenience and accessibility, especially when used in conjunction with face-to-face instruction, but where possible, students seem still to aspire to study on campus.

Figure 7: Getting satisfaction?
Percentage distribution of reported satisfaction among undergraduates who participated in distance education courses compared to regular classes, 1999–2000



Source: US Department of Education, National Center for Education Statistics, 1999–2000 National Postsecondary Student Aid Study (NPSAS:2000).

7 The challenges of university distance education

In setting up distance courses, universities, like schools, often run up against unexpected problems. These may include unexpectedly high start-up costs or low revenues, and the challenge of structuring a course to be delivered electronically.

Reaching distant students can pose difficulties that universities may not consider in advance. For instance, at UBC, mentioned above, the bookstore had no easy way to receive payment from abroad, and the library did not serve some distance students. And Kwantlen College initially required online students to install Lotus Notes Client on their home computers, which meant that students had to come to campus for a training session. Even where a university is delivering courses to a satellite site, it may not take account of the importance of delivering course materials and tests to its distant learners in good time.

Cost is the largest challenge. As an analysis of the costs of developing the course at British Columbia in the United States shows, a successful online course can make a small profit, although not immediately. However, initial development costs are typically higher, and often much higher, than those of conventional courses. The British Columbia course made no allowance for the cost of course planning or marketing, and hugely underestimated the cost of administration. Its development costs were a hair-raising 75 per cent over budget. When Southern Arkansas University-Magnolia decided to use compressed video as the basis for an online course, it found that the initial equipment cost US$80,000, and the acquisition of a permanent high-speed connection a further US$1,200 a month.[47] (Worse, the university later found compressed video a less effective way to deliver a course than had been hoped.)

While costs may be unexpectedly high, the revenues that universities often hope will cover their costs may turn out to be unexpectedly low. The School of Dentistry at UCLA invested an enormous sum in setting up a course to educate peridontists around the world.[48] It took US$750,000 and five years to design. It has been a

commercial failure, as has the extension courses that the university offers online in subjects such as hotel management.

Not only do the finances of online courses sometimes disappoint universities. Students may find that their cost is not significantly lower than an equivalent conventional course. Of course, students save money in terms of accommodation and earnings foregone, but the cost of tuition may not be substantially lower than a campus course of equivalent quality. Comparison is made harder by the fact that the online universities charge differently from conventional universities: a fee per credit hour. For example, Jacksonville University in the United States charges US$350 per credit hour for its nursing programme. An 11-18 hour plan therefore costs about US$6,300, whereas the tuition per semester for a campus-based course is US$8,270. And the University of Phoenix Online, which specializes in educating working adults and has over 45,000 online students, charges US$422 per credit hour. The university points out to would-be students that they can expect to pay for approximately one to two hours of online connect time a month. But it argues that this is less expensive than the petrol, parking fees, babysitters and meals that students would need to finance if they took a class on a traditional campus.

Case studies also suggest that instructing (and learning) online is time-consuming. Instructors may try to respond to most comments and communications from students; and students find it tedious to make in writing a point that would take a few seconds to say. More than half the students who took the UBC course reported that it took longer than a conventional course would have done. Because multimedia presentations are more complex than straight lectures, the preparation time increases. Those extra time demands may affect academic attitudes to distance learning if they take time away from writing for publication and thus hamper promotion.

Online university courses can be developed and revised very quickly, or even while the course is in progress. But that advantage is available only if the university has appropriate infrastructure to support online teaching; the right software; and a clear understanding of the difference between online and conventional instruction.

Simply posting lecture notes online is not a good way to teach. Feedback is less likely to come from the instructor alone and more likely to be collaborative, delivered by the students as well. In universities, as in schools, teachers trained in traditional methods are having to evolve new instructional techniques. Neither teacher nor student has the eye contact that is such an important part of much teaching. And there is still uncertainty about whether distance learning should strive to give a student an experience as close to that in the classroom as possible—or to improve instruction over what traditional methods can convey.

Instructors' control over the presentation of their course also has to be shared with a technician, whose role may make a large difference to the effectiveness of the course. "This role…can have a huge impact on the quality of the presentation, yet many times the instructor and the technician do not meet until the initial class meeting," notes one commentator.[49] And academics often have little guidance and even less structured training. Universities are typically not very good at training their academics in pedagogical techniques, and distance learning is no exception.

As in other areas of online education, reliability of technology is essential. One study noted a presentation during which the connection was lost twice before the students arrived and ten times during the actual session.[50]

Several studies, mainly in the United States, have sought to compare students' experience of traditional and distance university learning. A study[51] at the University of Alabama, for instance, offered an undergraduate introductory course in management information systems in three formats:

- Traditional, in which the course was a conventional mix of lecture and discussion
- Web-based, in which the class met briefly only once a week to go over assignments and take tests. All other teaching was delivered on WebCT, with lecture notes and tests all handled through the Web.
- Hybrid, in which the delivery of materials and class discussions took place online, but the class met for lectures and tests.

Student performance was much the same for each of the three groups of juniors who took part in the experiment. There was little difference in the groups' test scores. That was remarkable, given that the instructors involved had not taught a purely Web-based course before. However, the technicalities of delivering the course proved

difficult. Students had too little support to sort out problems. Tapping into streaming video proved particularly difficult. And students' understanding of the use of the Internet ranged from the rudimentary to the advanced. Some did not understand how to configure their computer systems properly. Perhaps not surprisingly, the students who took the Web-based course were much less satisfied with it than the students in the other two groups.

Among the lessons that the study's authors drew were:

- the difficulty of designing effective Web-based courses without access to high-speed Internet connections (a point of even greater importance to developing countries);
- the need for clear specifications for a student's hardware, software and telecommunications before the course starts;
- plenty of support for both students and instructors throughout the course.

In summary, distance learning delivered with ICTs seems to be especially helpful in several respects. It allows developing countries to offer university education to people who would otherwise be denied it. It offers a way for mature adults to balance the demands of work, family and study. Online learning is especially valuable as a way to give these older learners access to expertise and an opportunity to share their own experience and thinking with others. It is thus a good way to deliver lifelong learning, to students who are likely to have well defined goals and to be more motivated than the younger full-time campus student. And it offers access to international courses and the opportunity to work collaboratively with people in other parts of the world.

ICTs also offers universities, like schools, some clear gains as a tool for administration and management. And many students enjoy and draw value from courses offered in the form of distance learning, and benefit from the flexibility and wider access that they provide. But, most who have the choice and the resources still seem to prefer traditional campus courses to learning at a distance.

8 ICTs in training

The emphasis on the use of ICTs in corporate training appears to have grown among large companies since the terrorist attacks in the United States of 11 September, 2001 and the current recession, which has cut back business travel.[52] However, even in the United States, after several years of Internet hype, it is still relatively small. Training via the use of ICTs in some form or other accounts for 10.5% of all training time, compared with 9 per cent a year earlier. Among smaller companies, the use of e-learning levelled off between 1998 and 1999. And the share of corporate training budgets that companies across the board spent on learning technologies rose from 3.7 per cent in 2000 to only 4.6 per cent in 2001.

By far the widest use of ICTs in corporate training is, not surprisingly, to teach computer skills. That accounted for 55 per cent of all computer-delivered training in the corporate United States in 2000. However, 72 per cent of all training in computer skills is delivered not by ICTs but in a classroom, by a live instructor. And only 6 per cent of all formal corporate training is delivered by an instructor to a remote location.[53] Clearly companies have not yet found ICTs the best way to deliver training or to develop human capital.

This is particularly significant, given that many companies are well aware that their profitability depends on the quality of their workforce, and so have an interest in training them in the most efficient possible way. In addition, companies have a big interest in reducing the time their staff spend on training programmes rather than at their jobs, and so are constantly looking for ways to improve the productivity of training.

However, a number of big companies claim that distance learning has helped them to train staff who would otherwise be unable to take part in programmes. For example, one large US retailer has for some years been providing interactive training to satellite classrooms. The company, which says it could previously afford to train only 10 per cent of its managers and supervisors each year at its head office in Texas, claims that the result has been a cut in costs and an improvement in sales effectiveness.[54] And Unilever, a big British household goods firm, tracks the results of e-learning programmes in an attempt to evaluate them. The company argues that e-learning has helped its sales staff to produce more than US$ 20m of additional sales.[55]

The companies that are most enthusiastic about electronically delivered training claim that it has several benefits, many of which echo the arguments made for distance learning offered by universities:

- It allows employees to study material where they want and at their own pace.
- It allows easy access to experts: one good instructor can teach everyone.
- It is speedily and inexpensively updated.
- It allows the progress employees make and the courses they take to be readily monitored.
- It allows courses to be tailored to an employee's individual skills and requirements.
- It delivers the information when it is needed.

Like universities, some companies use live, interactive, two-way video conferencing to allow their staff to take courses in scattered locations. A far-flung group of employees can assemble for a class, watch a lecture or demonstration, ask questions online, and then debate the material locally.

More common, though, is the use of asynchronous, on-demand training that employees can participate in as their workload allows. Using the Internet to deliver training to employees' personal computers is particularly appropriate for the two groups that often pioneer online training in companies: sales personnel and information technology staff. With more sophisticated tools, companies can take advantage of inexpensive and extraordinarily realistic simulation techniques. For instance, one well-known giant manufacturer of aircraft engines has developed a simulation of a running Boeing 777 engine. Students who fly through it, using virtual reality, have been found to learn ten times better than they do from an instructor using audiovisual equipment.[56]

One potential strength of online delivery is that it can be provided to workers at any time and in any place. Exploiting that requires careful thought. With ICTs, as with traditional media, production costs stay high or even rise while distribution costs sharply fall. So the economics of electronic training will depend largely on the relative costs of production and distribution.

Online training programmes have to be designed to cope with irregular sessions. At clearly marked points along the road, employees need regular checkpoints—tests to measure what they have absorbed. Training may also have to be sliced into small bits. Conscious that mobile learning may eventually come to mean learning from a cell phone or a personal digital assistant, researchers at Stanford University's Learning Lab have studied the possibility of teaching people anything useful in sessions as short as a few minutes at a time. Among the first-cut answers are that it is easier to practice the already familiar than to learn something new, and that the learning must be delivered in extremely simple, intuitively obvious ways.[57]

A further benefit of online delivery is the speed with which it can be updated. Material available online can be updated much faster and more cheaply than can paper manuals or CD-ROMs. People must also have information on hand: technical data, say, or knowledge of formal constraints, such as regulations.

Indeed, companies are beginning to see that electronic delivery may change the thinking behind many concepts of training. Given the availability of online help, dedicating time to make people retain things is sometimes a waste of time. It may be speedier to teach people how to use online help.

One important possibility will be to use the "anywhere, any time" nature of online training to provide what might be called "just-in-time learning." Because the information is online, it is quick to update and easy to search. As information is updated more and more rapidly, it will be impossible to have people "study" in the traditional way. Instead, they should have access to the latest information whenever it is needed.

Some companies are already developing ways to provide this. For example, one aircraft manufacturer has designed a wireless-based, voice-activated device through which a mechanic can swipe the bar code on a new part when fitting it to an aircraft. The computer dictates installation and repair instructions into the mechanic's earpiece and can simultaneously track the part's history.[58] United Airlines has been designing a system that both monitors what its employees do as they work on an aircraft, and also supplies the relevant technical data they need.[59] This brings an interesting new paradigm: instead of learning facts, people will need skills for finding and analyzing constantly updating information, so the emphasis will be more on teaching methods.

Overall, the main lesson for public educators from corporate experience is that the expected benefits of ICTs in training may be harder to capture than they initially appear. At the very least, they underline a familiar theme: the importance of preparing training staff to use ICTs effectively. Some studies suggest that companies use as much money for staff training as they spend on hardware.[60] But they also suggest that, even in companies driven by strong financials pressures to cut costs and increase the productivity of training sessions, looking at several options and taking all aspects into account is necessary to make really effective use of ICTs.

9 Conclusions

Undoubtedly, ICTs are potentially a useful tool both for managing education and for teaching. Use in managing educational institutions should be encouraged, as should use by instructors to gain access to educational materials. And, by teaching computer skills to youngsters, they may influence inward investment. For instance, Costa Rica argues that its success in attracting job-rich employment from ICT companies such as Intel is a result of its national strategy to put computers into secondary schools.[61]

But getting the best from ICTs depends on several variables, including the appropriate design of software and hardware; the training and attitude of instructors; and the realization that different students have different requirements. It also requires a willingness to experiment: effective use of ICTs in education and training is likely to require quite different pedagogical techniques from traditional classroom teaching. These will probably take a long time to devise and disseminate. Moreover, the new emphasis on cost-effectiveness may discourage innovation.[62]

Well-designed ICTs can allow educators to reach new groups of potential students, particularly mature students, lifelong learners, students with physical disabilities, students in employment and students who are far from education centres. Most of these groups are composed mainly of older and well-motivated students. In developing countries, electronically delivered courses may make the difference between some education and none at all for people in remote rural areas. For aid donors, it is thus especially worthwhile to invest in opportunities for remote learning.

ICTs are most likely to be cost-effective when used to reach very large numbers of students (a common problem in developing countries); when used for research; and when used by administrators. In most other situations, they are unlikely to save money. They involve both heavy initial costs to prepare teaching materials, and recurrent costs to replace hardware and software. Many education policy-makers seriously underestimate the total costs of operating ICT-based learning.

Finally, technology is never a substitute for good teaching. Without skilled instructors, no electronic delivery can achieve good results. But neither can traditional classroom teaching, come to that.

[1] Assessing the Impact of Technology in Teaching and Learning: A Sourcebook for Evaluators (edited by Jerome Johnston, University of Michigan, and Linda Toms Barker, Berkeley Policy Associates), Institute for Social Research at the University of Michigan, April 2002, http://www.dlrn.org/star/sourcebook.html.

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[62] Indeed, from now on innovation is less likely to come from within education than from industry and especially from the defence industry.