

# Chapter 2

## New directions in education

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### CHALLENGES IN EDUCATION

Information and communications technologies (ICTs) are a diverse set of technological tools and resources used to communicate and to create, disseminate, store, and manage information. These processes lie at the very heart of education. In recent years, educational access to digital ICT tools, applications, networks, and media worldwide has grown dramatically. As noted in the *World Education Report* (UNESCO, 1998), education is facing a significant challenge in preparing students and teachers for 'our future "knowledge-based" society' at a time when most teachers are not trained to use ICTs and 'the majority of existing school buildings, even in the most developed countries, are not equipped to integrate the new information and communication technologies.'

Digital ICTs are quickly becoming more accessible, but it is important to note that earlier technologies continue to play a critical role in education worldwide. Access to films, videotapes, telephones, television or radio is still far more commonplace than access to a computer or to the Internet and the World Wide Web. For example, the Telesecundaria Project in Mexico, which began in 1965 as a closed-circuit television pilot project, today delivers classes designed for lower secondary school level to over 12,000 rural communities, enrolling more than 800,000 students.

In this chapter, the focus is on the 'newer' digital ICTs with special emphasis on educational uses of the Internet and the World Wide Web. The new digital ICTs are not single technologies, but combinations of hardware, software, media, and delivery systems. As will be seen, ICTs in education today encompass a wide range of rapidly evolving technologies, including hardware, software and applications.

New ICTs differ in several important dimensions from older technologies: they can integrate multiple media into single educational applications; they are interactive and include the capacity to control, manipulate, and contribute to the information environment; they are flexible, offering freedom from

rigid scheduling and from barriers of time and location; through connectivity, they provide access to every other person on the planet who has an Internet account, to hundreds of thousands of information archives, and to millions of Web pages. These four dimensions – integration of multiple media, interactivity, flexibility of use, and connectivity – distinguish digital ICTs from previous technologies. Because of these differences, educators are finding powerful new ways to integrate digital ICTs into the curricula.

The introduction of new ICTs has always raised difficult debates among specialists in education, but the purpose of this chapter is not to reopen them in relation to modern informations and communication technologies. Their impact on education is so recent and the situation is evolving so fast, that it would be hazardous at this point in time to attempt any assessment of the 'state of the art' on the matter, let alone an evaluation. In the present context, the main purpose is to show that a wide range of initiatives are taking place all over the world, at all levels of education, showing a potential for further developments which looks almost unlimited. However, it is important to discuss the various issues in a realistic way. For this reason the chapter is presented in four parts. Firstly, typical examples from across the five continents will be given, thus confirming that the impact of ICTs is real everywhere in the world. Secondly, the effectiveness of ICTs will be examined, showing how they can improve normal teaching assignments or introduce new methods. Thirdly, some general problems raised by the use of ICTs will be discussed more particularly in relation to the creations of content and teacher training. Lastly, the main aspects of national planning will be presented briefly.

## WORLDWIDE EXAMPLES

Although there is apparently no comprehensive data on ICTs in schools worldwide, it is clear from many national examples that schools are increasingly being

equipped with them. It is also apparent that ICT equipment and Internet connectivity is still much more widespread in North American schools than elsewhere. For example, in the United States, the ratio of students per computer dropped from 63:1 in 1985 to 6:1 in 1997 while the number of schools with Internet access has grown from 35% in 1994 to 72% in 1997.

In Europe, more than 80% of schools in Slovenia have access to the Internet – 93% of secondary schools and 80% of primary schools – which is similar to the percentages of developed countries. The Government of the United Kingdom plans to connect all schools, colleges, universities, libraries, and as many community centres as possible to the Internet by 2002. The German Government will connect 10,000 schools to the Internet by mid-1999. In Italy, plans were announced in 1998 for the installation of computer and multimedia facilities in 15,000 Italian schools to be completed by the year 2000.

In Asia, similar developments are taking place. In Japan, as of 1997, over 94% of public schools were computer-equipped and 10% were connected to the Internet. The Government plans to achieve a pupil-to-computer ratio of 2:1 in middle schools and 1:1 in high schools by 1999. All of the public schools in Japan will be connected to the Internet by 2003. In the People's Republic of China, the central government will increase funding for basic, vocational and higher education projects over the next two years. These plans include strategies to make increasing use of Internet-based educational programmes. In New Zealand, 83% of primary schools and 94% of secondary schools have Internet access.

In Latin America, the Chilean government established the Enlaces (Links) project to connect schools and related institutions to Chile's national computer network. By 1996, over 180 primary schools and 62 secondary schools had been connected and, by the year 2000, the Chilean government plans to connect 50% of the 8,250 primary schools and 100% of the 1,700 secondary schools.

In Africa, the Creating Learning Networks for African Teachers Initiative aims to contribute to educational change by encouraging educational institutions to become information and learning resource centres for their communities. It also hopes to contribute to attitudinal change among teachers with a view to stimulating ongoing professional development by creating electronic learning networks among teacher training institutions and their partners in education at local, national and international levels. These networks will allow for exchange of information, experiences and expertise, for collaborative action and for new patterns of communication. Pilot projects were initiated in Zimbabwe by connecting five teacher training centres (TTC) and their partner institutions to the Internet. Currently the project is carried out in close collaboration with the World Bank's WorldLinks for Development programme. A project in Senegal is structured in a similar way, while in Kenya and Uganda the Initiative is being introduced as part of a collaborative learning project in the area of science/mathematics teaching, linking teachers, students and researchers in Zimbabwe, Kenya and Uganda.

In the Middle East, as part of a programme sponsored by the World Bank to improve basic education, the Turkish Government will be installing computer laboratories in over 15,000 schools and training over 200,000 teachers in computer literacy and computer-aided instruction techniques.

Informal and non-formal education institutions are also increasingly being equipped with ICTs and connected to the Internet. At present, about 20% of libraries in the United Kingdom are connected to the Internet. The government's National Grid for Learning initiative will connect all libraries and museums in the United Kingdom to the Internet. In the United States, a 1998 survey found that 73% of the nation's public libraries offered basic Internet access to the public. Many public and privately-funded museums are offering ICT-based learning opportunities. For

example, in a joint project with the Fraunhofer Institute for Software and Systems Engineering, the German Historical Museum in Berlin and the Haus der Geschichte of the Federal Republic of Germany in Bonn are developing a virtual exhibition of German history for the Internet.

Community schools are also making more use of ICTs. The Lighthouse Project in Thailand is offering non-formal educational programmes at five locations in Thailand ([lcs.www.media.mit.edu/groups/el/thai/Lighthouse/Lampang/lp\\_index.html](http://lcs.www.media.mit.edu/groups/el/thai/Lighthouse/Lampang/lp_index.html)).

In part, efforts to connect educational organizations to the Internet are being driven by societal pressure. This does not eliminate, however, the need to check whether there will be positive consequences for such a move. One aspect of this question is how effective the ICTs are in education.

## EFFECTIVENESS

To answer this question three aspects must be considered. The first deals with the comparison between traditional teaching techniques and those which make use of ICTs; here the term ICT-mediated instruction will be used. The second covers teaching activities which would not be possible without modern ICTs, hence the expression ICT-enabled instruction. The third concerns all the techniques, whether ICT-mediated or enabled, and raises the question as to whether they are worth their costs.

### ICT-mediated instruction

The first question to be considered about the effectiveness of ICT in education is what impact, if any, ICT-mediated instruction has on student performance. ICT-mediated instruction refers to instruction delivered through a technological channel such as television, radio, or a computer network.

Evidence has consistently shown that ICT-mediated instruction using conventional teaching methods is as effective as traditional face-to-face instruction (see, for example, [www2.ncsu.edu/oit/](http://www2.ncsu.edu/oit/)

nsdsplit.htm) and, in the case of computer-based instruction, may in certain instances improve student learning and attitudes to learning (Kulik 1994, as cited in Glennan and Melmed, chap. 2, 1995). However, the picture is less clear – but promising – for more sophisticated uses of ICTs in the classroom, especially for the host of applications and methods that support ‘constructivist’ learning, in which students are encouraged to work in rich environments of information and experience to build their own understanding of them (Apple Computer, Inc., 1995; Bertelsmann Foundation, 1998). Research into the effectiveness of ICT-mediated instruction is continuing worldwide, and should provide a clearer picture of the effectiveness of ICTs in supporting constructivist teaching. For example, as part of the Helsinki 2000 project, Finnish researchers are conducting a five-year, multi-disciplinary study focused on analyzing innovative teaching practices through intensive case studies on computer-supported collaborative learning.

#### ICT-enabled education

A second way to assess the merit of ITC-use in education is to consider what, if anything, they enable students and teachers to do that they would not otherwise be able to do. To explore this question, five aspects of the educational use of ICTs will be considered: supporting new teaching methods, accessing remote resources, enabling collaboration, extending educational programmes and information literacy.

#### Supporting new teaching methods

Modern constructivist educational theory emphasizes critical thinking, problem solving, ‘authentic’ learning experiences, social negotiation of knowledge, and collaboration. The teaching methods concerned change the role of the teacher from a disseminator of information to a learning facilitator, helping students as they actively engage with information and materials to construct their own understanding. ICTs

have the potential to be used in support of these new educational methods, enabling students to learn by doing. ICTs can make it possible for teachers to provide students with self-paced, self-directed problem-based or constructivist learning experiences, as well as to test student learning in new, interactive, and attractive ways that may better assess the depth of their understanding of content and processes.

One example may help illustrate how ICTs can support constructivist teaching methods. Computer Supported Intentional Learning Environments (CSILE, [csile.oise.utoronto.ca/intro.html](http://csile.oise.utoronto.ca/intro.html)), developed at the Ontario Institute for Studies in Education, is a network system that provides support for collaborative learning and inquiry within a school. CSILE promotes student interaction through referencing, connecting ideas, sharing authorship, and ‘building on’ the work of others to advance knowledge. The central feature of CSILE is a ‘communal’ database into which students can enter text and graphics, and can read, add to, and comment on the work of others.

#### Accessing remote resources

As previously mentioned, connectivity is one of the main differences between older and newer ICTs. The first aspect of connectivity concerns access to material resources.

Digital library initiatives that will provide collections that are electronically accessible on the Internet, including printed works (e.g. textbooks, journals, illustrations, maps, charts and graphs), photographs, films and videotapes, paintings, 3D models, graphics, animations, software, reference materials, audio files, and so forth are being undertaken in countries around the world.

Thousands of websites that contain collections of high quality curriculum guides, lesson plans, and instructional activities now exist. For example, the United Nations CyberSchoolBus website ([www.un.org/Pubs/CyberSchoolBus](http://www.un.org/Pubs/CyberSchoolBus)) contains teaching units on urbanization, health, the environment, and women

and politics, as well as interactive games, maps, databases, and quizzes.

In addition to efforts to digitize existing physical resources, many new information resources (e.g. websites, digital images, electronic journals and newsletters) are being created which can **only** be accessed electronically. As digital representations of physical resources are created, and as more information resources are distributed in digital format only, it will be critical that students and teachers have ICT access.

### Enabling collaboration

Since not all resources are inanimate, a second important aspect of connectivity deals with human resources. ICT enables educational collaboration between individuals and groups of people. E-mail, computer-mediated conferencing, and desktop videoconferencing are all being used to support collaboration among individuals and groups. Collaboration is also taking place by means of real-time chat systems ([www.idiom.co.uk/intchat.htm](http://www.idiom.co.uk/intchat.htm)); whiteboards ([www.sisweb.com/math/whiteboard/](http://www.sisweb.com/math/whiteboard/)); newsgroups ([www.peg.apc.org/~iearn/works.htm](http://www.peg.apc.org/~iearn/works.htm)); computer-mediated conferencing (CMC) ([www.ascusc.org/jcmc/](http://www.ascusc.org/jcmc/)); and specialized software like **CaMILE: Collaborative and Multimedia Interactive Learning Environment** ([www.cc.gatech.edu/gvu/edtech/CaMILE.html](http://www.cc.gatech.edu/gvu/edtech/CaMILE.html)) and **The Knowledge Integration Environment** ([www.kie.berkeley.edu/KIE.html](http://www.kie.berkeley.edu/KIE.html)). Other applications include MUDs (Multi-User Domains) MOOs (Multi-user Object Oriented domains), and MUSHs (Multi-User Shared Hallucinations). Such applications are Internet-accessible, text-mediated virtual environments in which participants can both interact with others and help construct the common virtual space.

ICTs make it possible for people in widely dispersed locations to participate in 'virtual learning communities.' Virtual learning communities are learning groups based on shared purpose, rather than on distinctions of location or age. Through the ICTs,

learners can be drawn together from almost anywhere in the world, and can construct their own formal or informal learning groups. Such communities may cross barriers of time, geography, age, ability, culture and social status. Virtual education allows students to study at their own time, place and pace. In essence, a virtual education means having educational transactions accessible from the home, the workplace or anywhere that the student chooses to be.

Virtual Design Studios, begun in 1993, are a form of collaboration among teams of architecture students in universities worldwide ([arch.hku.hk/projects/vds/](http://arch.hku.hk/projects/vds/)). Teachers and students, on different continents and in different time zones, work on common design projects using computer-aided design systems, e-mail, a central database, and video-conferencing. Participants use the World Wide Web to display their designs and a virtual international jury of architects and teachers judges the relative merit of the work. Virtual Design Studio techniques are also being utilized by other disciplines, such as engineering.

The SIMULAB Project, supported by the European Union, involves web-based communication among language students across national boundaries. Using specialized software, teachers can create Internet-based simulations for role-playing activities in language learning. The simulations, incorporating e-mail, chat, and online creation and editing of documents, are thought to motivate oral and written communication among the participating groups, while students are guided through scenarios relevant to the country of their chosen language ([www2.echo.lu/telematics/education/en/projects/files/simulab.html](http://www2.echo.lu/telematics/education/en/projects/files/simulab.html)).

### Extending educational programmes

ICTs make it possible to extend the reach of educational programmes in two important ways. First, educational programmes can be delivered anywhere in the world. Second, ICTs can help individuals learn throughout their lifetime.

Distance education programmes, also known as 'distributed' education programmes, are those in which the teacher and students are physically separated, and teaching and learning takes place by means of single technologies or combinations of ICTs. In the past, such programmes made use of print, radio, and television (see box 2.1.). Today, new ICTs are leading to changes in these traditional 'open' or distance education programmes. For example, the International Francophone Consortium of Distance and Open Learning Institutions (CIEFFAD), a consortium of open and distance learning institutions spread over 49 countries, of which 80% are in developing nations, has recently entered into a phase of re-engineering to make use of new ICTs. The group aims to provide at least one hundred access points to the Internet per year in member establishments with the major part of the consortium having access to the network by the end of 1998. In the Pacific region, the University of the South Pacific has been using Intelsat for several years.

The Western Governors University ([www.wgu.edu](http://www.wgu.edu)) is an example of a 'virtual university', or university with no physical campus. WGU, initiated in 1996 by 18 governors in the western United States, offers more than 300 college-level distance learning courses from 30 affiliated universities and education providers. WGU has forged international alliances with the China Internet Education Center, Tokai University in Japan ([www.u-tokai.ac.jp](http://www.u-tokai.ac.jp)), the University of British Columbia in Canada ([www.ubc.ca](http://www.ubc.ca)), the Open University in the United Kingdom ([www.open.ac.uk](http://www.open.ac.uk)) and the Virtual University of the Monterrey Institute of Technology in Mexico ([www.sistema.itesm.mx/english/uv.htm](http://www.sistema.itesm.mx/english/uv.htm)). The principal aim is to collaborate on the development and delivery of distance learning programmes.

In Germany, the four Baden universities, namely, Freiburg, Karlsruhe, Mannheim and Heidelberg, recently announced the establishment of that country's first virtual university. The objective is to establish individual distance learning via e-mail

Integrated Services Digital Networks (ISDN) or digital television. In Africa, the World Bank is funding the development of the African Virtual University (AVU). AVU ([www.avu.org](http://www.avu.org)) completed a pilot phase in 1996–98 and is now moving into an operational phase when it will begin delivering full-fledged undergraduate degree programmes in science and engineering in January 1999. The AVU's programmes will be delivered by a combination of ICTs including interactive television and the Internet. The programme is developing a digital library of scientific engineering as a resource for students and teachers.

The Hanoi Summit (November 1997) entrusted the creation of a francophone virtual university to the Agence Universitaire de la Francophonie for a budget of 4 million French francs. As a beginning, six digitized campuses have been opened in Bulgaria, Cameroon, Haiti, Madagascar, Senegal and Viet Nam ([www.aupelf-uref.org/UVF/](http://www.aupelf-uref.org/UVF/)).

Virtual educational programmes are not limited to postsecondary education. The United States Department of Education has funded the Virtual High School (VHS) project ([vhs.concord.org](http://vhs.concord.org)). During the 1997/98 school year, VHS offered 29 Internet-based, credit-bearing courses to about 500 students in 27 schools located in 10 states. This approach is thought to be particularly useful as many of the participating schools either have no qualified teacher or insufficient enrollment to justify individually offering some of the courses which are available through this collaborative scheme.

In addition to educational institutions using ICTs to enhance or create distance learning programmes, commercial companies are offering ICT-based distance education programmes. Although alternate and distance education providers currently make up less than 2% of the postsecondary education market, almost \$2 billion dollars has been raised on Wall Street since 1996 to finance such new ventures.

Establishing lifelong learning habits among citizens and providing lifelong learning opportunities

### Box 2.1 → The use of electronic media in open learning and distance education

This is a worldwide study based on data from 147 institutions involved in distance education.

39 countries are represented; 72% of the institutions are located in developed and 28% in developing countries.

Educational level of the programmes included Training levels	Programmes (%)
Pre-primary	2
Primary	6
Secondary	14
Tertiary	60
Vocational	26
Continuing education	46
Life enrichment, civic education, etc.	13

Use of learning materials	Programmes in:	
	Developed countries (%)	Developing countries (%)
Documents	99	100
Audio	67	86
Video	82	77
Computer assisted learning	50	43
Multimedia	30	7

Distance education is by no means a new phenomenon, but the means of distribution are changing and increasing rapidly with recent technological developments. The study provides some insight into the use of electronic media in terms of the types and means of interaction that takes place in the course of the educational programmes. The most noticeable result is that electronic media are used mainly to support traditional learning methods. Only a few cases could be identified where media were used to change the characteristics of learning to better serve the needs of the learners.

Use of communication tools	Programmes in:	
	Developed countries (%)	Developing countries (%)
Telephone/fax	84	84
Audio-conferences	34	27
Video-conferences	24	18
Computer conferences	28	5
E-mail	64	30
Database access	15	11

Some selected results concerning:

- types of learning materials
- types of communication tools
- types of communication channels

Audio-based materials have a significantly higher usage in developing countries than in developed countries. Production of audio materials is relatively inexpensive and requires less technical sophistication than other electronic learning materials. The requirements at the user-end are also lower than for other electronic learning materials.

Use of communication channels	Programmes in:	
	Developed countries (%)	Developing countries (%)
Mail/physical delivery	87	86
Public service telephone network	83	57
Radio	6	29
Direct Broadcast TV	9	16
Terrestr. Broadcast TV	13	11
Integrated Services Digital Network	20	7
Specialized links (unspecified)	17	2
Digital spec. links	11	5
Public data network	12	2
Cable	11	2

Concerning the tools used to facilitate the interaction during the learning process, all forms except the use of telephone/fax are more highly represented in the developed countries. Consequently the channel most used for communication (apart from mail) is the public service telephone network; radio is used on a larger scale in the developing countries than in the developed countries.

Compiled from *The Use of Electronic Media in Open and Distance Education*, prepared by My von Euler and David Berg, Paris, UNESCO, 1998.

has become a major goal of governments and non-governmental organizations worldwide. For example, UNESCO's Learning Without Frontiers (LWF) initiative ([www.unesco.org/education/lwf/](http://www.unesco.org/education/lwf/)), 'is geared towards stimulating innovation and exploring alternative pathways/partners/technologies for the provision of lifelong and lifewide learning opportunities, particularly, to those who are currently unreached by or excluded from conventional modes of educational delivery' (UNESCO, 1996). In addition to this initiative, UNESCO has recently set up an Institute for Information Technologies in Education (IITE) ([www.info/iite.ru](http://www.info/iite.ru)), located in Moscow and designed to act as an international clearing-house for the collection and dissemination of best practices and models in the field of application of information and communication technologies in education. It will also offer assistance in the pre- and in-service training of the teachers in the use of information technology, particularly in the developing countries, countries in transition and countries of the Commonwealth of Independent States.

The European Lifelong Learning Initiative ([www.ellinet.org/elli/home.html](http://www.ellinet.org/elli/home.html)) makes use of ICTs, 'to initiate the dissemination of information, the co-ordination of projects and studies, the mobilization of actions, people and organizations to bring Europe into the Lifelong Learning Age. It covers all sectors and all countries' (European Lifelong Learning Initiative, 1997). The Asia Pacific Economic Cooperation (APEC) Forum has established three mechanisms to assist countries in the region to establish lifelong learning projects: the creation of a database of scholars, researchers and practitioners in the region involved with lifelong learning issues and programming for the region; the development and publication of a book of papers on lifelong learning policies, practices and programmes in the Asia Pacific region; and a lifelong learning conference for APEC members to discuss issues identified in the book ([www.apec-hurdit.org/lifelong-learning-project.html](http://www.apec-hurdit.org/lifelong-learning-project.html)).

### Information literacy

In the light of changing perceptions about what constitutes appropriate skills for the modern era, some organizations are promulgating educational standards that attempt to define what all students should know about ICTs. For example, the National Educational Technology Standards (NETS) project ([cnets.iste.org](http://cnets.iste.org)) in the United States has released an initial set of national educational technology standards for pre-college students.

However, although it may be assumed that students will have to acquire new skills in order to compete and contribute in an increasingly ICT-dominated global economy, it is not clear what skills will be necessary: 'Unlike the more stable content and goals we have for other areas of school study, technology continues to change and evolve; with these changes come ever-new goals for how technology should serve learning, and what students should know about technology' (Fulton, 1998).

There does seem to be a growing consensus that all students must achieve 'information literacy': 'It is the task of general education to provide every girl and boy with the versatile basic skills in acquiring, managing and communicating information which are necessary in the information society and essential for successful further study' (Ministry of Education, Finland, 1995). Focusing on concepts such as 'information literacy', rather than on specific technologies or applications, may be essential in planning and developing new curricula.

### Cost-effectiveness

The third issue when assessing the effectiveness of ICT in education is the question of cost-effectiveness. Information is of critical importance, especially to developing countries with fewer resources to invest. However, assessing the cost-effectiveness of ICTs in education is difficult, if not impossible, for at least four reasons: lack of meaningful data, variability in

the use of ICTs, difficulty of generalizing from specific programmes, and difficulty of assessing the value of qualitative educational differences. In addition, traditional cost-analyses cannot take into account the societal and economic consequences of **not** investing in ICTs for education.

### Cost comparisons

Nonetheless, even in the face of such obstacles, attempts to establish the relative costs of ICTs in education have been reported. In general, these studies find that the use of new ICTs is more expensive than instruction delivered by older technologies like print and radio, but less expensive than instruction delivered by television (see Potashnik and Capper, 1998).

In a World Bank report (1998a) on education and ICTs in Latin America and the Caribbean, the costs of using a computer with an Internet connection in a school was much less expensive per pupil than broadcast television, but substantially more expensive than radio.

M. Potashnik and D. Adkins (1996), in spite of severe lack of data, were able to compare the per pupil costs of setting up a computer laboratory in a school for computer-assisted instruction in Belize (\$78), Jamaica (\$89), and Chile (\$104) (pp. 13–15). A similar analysis of the costs of equipping a classroom, not a laboratory, with computers in the United States for computer-assisted instruction yielded a figure of \$453.

L. Osin (1998), in a paper on ICTs in developing countries, assessed the annual per-student cost of providing computers for instruction in developing countries at \$84. This finding is in close agreement with the study by Potashnik and Adkins mentioned above. On the same basis, if 30 computers were used 300 days per year, 10 hours per day, as a resource to raise the skills and education levels of all members of the community, not just students, Osin estimates the cost would decrease to \$0.34 per hour of interaction. He concludes, 'There is no alternative system

known that may provide the benefits possible by integrating computers in the education system, while at the same time serving the whole community' (1998, p. 9).

### Costs of alternatives

Another factor that must be considered when calculating the cost-effectiveness of ICT use is the question of alternatives. The costs of building sufficient campuses to handle the rising demand for education may be prohibitive. Virtual educational institutions do not require the same campus infrastructure and related costs incurred by campus-based institutions.

In Taipei (Taiwan, China), the distance education-based National Open University, with its budget of NT\$800 million, accommodates approximately 30,000 adult students each year. By comparison, the National Taiwan University, one of the larger universities in Taipei, has an annual budget of \$NT3,500 million for its 21,000 students (Ministry of Education, 1996). Though gross numbers of this sort beg some level of refinement, the differential costs remain substantial and manifest (Huang, 1997).

### Costs to society

Lastly, when discussing cost-effectiveness, the societal costs to developing countries of not preparing their citizens to participate in an information-based global society must be considered. **The World Development Report 1998/99** (World Bank, 1998b) warns that the global explosion of knowledge may either lift hundreds of millions of the world's poor out of poverty or it may create a widening knowledge gap, in which poor countries lag further and further behind. As Potashnik and Adkins (1996) have pointed out, 'even in countries which do not believe in the cost-effectiveness of information technology as a tool for mass education, it is important that they begin acquiring experience using this technology for educational purposes. Otherwise, educators in

developing countries will be marginalized in the international dialogue on education' (p. 3).

## CREATING AN ICT-ENABLED LEARNING ENVIRONMENT

In this section, the focus will be on the development of ICT-enabled learning environments, specifically on infrastructure, content, teacher education and training, and technical support.

### Infrastructure

In order to make use of digital ICTs, schools must be equipped with computers. In order to access the Internet from a computer, schools, homes, libraries, and other educational venues must be equipped with an Internet connection, either by means of the telephone or cable network and a modem or a direct connection. Many creative means of providing computers and building the necessary Internet infrastructure are being explored in countries throughout the world.

### Education/business collaboration

Collaboration, including cost sharing, between education and industry to build ICT infrastructure is becoming commonplace. For example, the Bristol Education Online Network (BEON) project ([www.education.bt.com/ednews/43beon.htm](http://www.education.bt.com/ednews/43beon.htm)) and the follow-on Merseyside Education Online Network (MEON) ([meon.eonic.net](http://meon.eonic.net)) are co-operative efforts of the commercial companies British Telecom (BT) and International Computers Limited (ICL), local schools and the University of Exeter School of Education. ICL is supplying multimedia computers and BT is providing access to remote services and to the Internet to a number of schools in the area. Another promising approach to equipping schools with computers inexpensively is to transfer the technology from government organizations and businesses to schools. For example, the Computers for Schools programme in Canada ([www.schoolnet.ca/cfs-ope/welcome\\_e.html](http://www.schoolnet.ca/cfs-ope/welcome_e.html)), is soliciting donations of 'obsolete' or redundant computers from business, industry, and individuals, and refurbishing them before donating them to schools.

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### Netdays

Netday (see [www.netday.org](http://www.netday.org)) initiatives, which began in 1995, are characterized as 'high-tech barn-raising,' in other words, efforts by community volunteers to wire classrooms, libraries, and computer laboratories so that they may connect to the Internet. Organizers of such efforts typically help schools to develop a technical plan that includes instructional goals, network and wiring architecture, network management and technical support, training, and an operating budget. On a specific day, volunteers from the local community do the physical work necessary to set up the network, greatly reducing the costs of providing Internet access within the schools. Netdays now take place in many countries including Australia ([www.netdayoz.edu.au](http://www.netdayoz.edu.au)), New Zealand ([www.netday.net.nz](http://www.netday.net.nz)), European countries, ([www.netdays.org/en/projects/country.html](http://www.netdays.org/en/projects/country.html)), Israel ([www.netdays.org.il](http://www.netdays.org.il)), Japan ([www.netday.or.jp/index-e.html](http://www.netday.or.jp/index-e.html)), and South Africa ([www.netday.org.za](http://www.netday.org.za)). In Latin American and the Caribbean, UNESCO is sponsoring a netday initiative ([www.unesco.org/events/latin/euro\\_america.html](http://www.unesco.org/events/latin/euro_america.html)).

### Community networking

Many community networking initiatives have educational components and are worthy of mention. In an interesting example of how community networking can benefit educational institutions, the International Telecomputing Consortium ([www.itc.org](http://www.itc.org)) is working with schools and universities in China to create school-based community networks. In these projects, schools establish computer centres with Internet access for use by students and teachers in class ([www.itc.org/chinaprojects.html](http://www.itc.org/chinaprojects.html)). After hours, the centre remains open and training by teachers and students is made available to parents and other members of

the community who may not have Internet access. The school thus provides Internet access for the community with some revenue returning to the school.

### Content

Beyond equipment and software, appropriate content is necessary to make use of ICTs for educational purposes. In this section, a few of the many initiatives related to the creation and standards of educational content will be considered.

#### Content creation

Although some online content is specifically designed for educational purposes, most is not. One approach to facilitating access to appropriate educational content is the creation of a 'Schoolnet'. Schoolnets, also known as 'national education grids', are local, national or regional projects that may include efforts to wire schools physically to information services, but the fundamental aim is to provide access to appropriate educational content.

For example, the United Kingdom's National Grid for Learning (NGfL) 'is both an architecture (or structure) of educationally valuable content on the Internet, and a programme for developing the means to access that content in schools, libraries, colleges, universities, workplaces, homes and elsewhere' (*ICT in Education News*, 1998). Schoolnets now exist in France ([www.educnet.education.fr/](http://www.educnet.education.fr/)), Ireland ([www.scoilnet.ie](http://www.scoilnet.ie)), Japan ([www.schoolnet.or.jp/schoolnet/index-e.html](http://www.schoolnet.or.jp/schoolnet/index-e.html)), South Africa ([www.gp.school.za/gnsite.htm](http://www.gp.school.za/gnsite.htm)), Thailand ([www.school.net.th](http://www.school.net.th)), and other countries (cf. European Schoolnet ([www.eun.org/index.html](http://www.eun.org/index.html))).

One of the advantages of new ICTs is that they empower users not only to consume information, but also to produce it. With a computer, printer, and desktop publishing software, any local educational group can produce high quality printed materials. With an Internet connection and a website, any educational organization can 'publish' content derived

from local knowledge and experience. For example, the Summer Institute of Linguistics (SIL) has helped set-up Literacy and Awareness Publication (LAMP) centres in each of the twenty provinces of Papua New Guinea to promote literacy in approximately 850 local languages. At these centres, literacy texts are produced that can be shared between the centres; they cover a wide variety of subjects including healthcare, hygiene and preservation of the environment.

#### Content standards

Although many tools exist to help teachers and students locate information (see [Alexia.lis.uiuc.edu/Irl/links/search.html](http://Alexia.lis.uiuc.edu/Irl/links/search.html)), at present finding specific educational materials on the World Wide Web can be likened to a scavenger hunt, often resulting in wasted time and unexpected results. A teacher or student may find it difficult to locate specific information or materials that might be useful within the curriculum at a particular grade level. The results of indiscriminate searches also raise the issue of the validity and reliability of the information let alone legality and harmfulness (see box 8.3). Because of varying technical standards, materials created with one ICT-based learning system may not be usable in a different technical environment once they have been found.

Several efforts to bring order to the chaos of the Internet and World Wide Web are underway. To this end, the European Commission has initiated a Memorandum of Understanding: Multimedia Access to Education and Training in Europe. By December 1998, over 160 educational organizations, government agencies, and commercial companies had signed the MoU ([www2.echo.lu/telematics/education/en/news/mou1198/nov1998mou.html](http://www2.echo.lu/telematics/education/en/news/mou1198/nov1998mou.html)).

Projects like the Dublin Core Metadata Initiative ([purl.oclc.org/dc](http://purl.oclc.org/dc)) and the Instructional Management Systems (IMS) project ([www.imsproject.org](http://www.imsproject.org)) which create technical standards, may 'help transform the end-user experience of the Web from the unstructured tangle it is today into something more like a digital

library or virtual learning centre' (Sithers, 1998). If international agreement can be reached on an acceptable set of technical standards, teachers and students may be able to search for educational materials with common descriptors and be assured that the materials, once found, will be compatible with local ICT applications.

### Teacher training

As noted in a Finnish government report, 'how computers are used in education depends on the pedagogical competence and technical skills of the teaching staff who must know how to exploit these modern technologies in pedagogically meaningful ways' (Finnish National Fund for Research and Development, 1998). In some countries, for example the United Kingdom, training in ICT use is a requirement for a teaching certificate. As educational applications of ICT continue to evolve, apart from preparatory training, refresher courses for experienced teachers will also be necessary. Furthermore, it may not be sufficient simply to provide training for teachers. For instance, Murphy and Gunter (1997) advocate that ICT training be extended to educational administrators.

ICT training for teachers must deal with at least two aspects. First, teachers need technical training to learn how to use and maintain ICT equipment and software. Such technical training is being offered to teachers in a wide variety of ways. Pre-service university-based courses, in-service workshops, commercial training programmes, and other opportunities abound, many of which make use of ICTs to deliver the training. Second, since 'integration of technologies into curricula requires changes of huge magnitude' (Foa et al., 1998, p. 1), training in how to integrate ICT use into the curriculum is necessary. Such training should include effective ICT teaching methods and the use of discipline-specific applications.

In one possible framework for organizing ICT

training for teachers, McDougall and Squires (1997) identify five areas: skills with particular applications; integration into existing curricula; ICT-related changes in curricula; changes in teachers' roles; and underpinning theories of education. The authors note that most ICT teacher training mistakenly focuses entirely on the first issue.

Many innovative approaches are being developed to provide support for university staff. For example, several universities have established 'expert partners' programmes. As reported by Guernsey, 'people who fill the jobs have one thing in common: a hybrid expertise that blends academic computing with college teaching' (1998, p. A35). Staff who are both qualified academics within a discipline and who have expertise using ICTs for instruction are hired 'to provide faculty on-site, intradepartmental consulting and support in information and instructional technology for academic purposes to foster their awareness and use of technological resources, both within and without the University' ([rits.stanford.edu/atss/atp/index.html](http://rits.stanford.edu/atss/atp/index.html)). In another innovative but more costly approach, students are being enlisted to provide ICT support and training for teachers. At Wake Forest University (North Carolina) in the United States, first-year students are hired and trained to work as Student Technology AdvisoRS (STARS). STARS are assigned to faculty members to help implement ICT-based projects ([www.wfu.edu/Computer-information/STARS/index1.html](http://www.wfu.edu/Computer-information/STARS/index1.html)).

Training methodologies vary, but 'training of trainers' models are common and in most instances may be more cost-effective than on-site, small group or individual ICT training. In such programmes, 'teacher-leaders' are selected using a variety of criteria such as prior experience with ICTs in education, staff development expertise, and the commitment to the programme by school and district administration. These individuals receive intensive training courses to master technical details and approaches to integrating ICTs into the curricula. Once

trained, they return to their educational institutions and provide ICT training and support for their peers. Such programmes may also include ongoing, long-term support for the trainers, including site visits, computer-based conferences, and e-mail advice. In large geographical areas, the responsibility for such training and continuing support may be delegated to regional ICT consortia co-ordinated by a central administrative body (cf. [www.rtec.org](http://www.rtec.org)).

#### Technical support

The provision of on-site, technical support as needed is critical to the success of an ICT-based educational programme. Although standard service agreements, purchased separately or included in the purchase of ICT equipment and software, typically cover regular maintenance and repair costs, and may even include e-mail or telephone support, such arrangements may fall short of what is necessary in educational settings. Without adequate technical support, schools have experienced 'large workloads for existing staff, maintenance backlogs, and reduced computer use because computers were out of service' (U.S. Government Accounting Office, 1998).

In universities, such support may take the form of technical staff assigned to a 'computer centre', 'media centre', or 'distance learning centre'. In schools, knowledgeable peers, students, volunteers and specialized computer teachers are generally providing such support; less frequently, trained technical staff, located either within the school or district office, are employed.

## NATIONAL PLANNING

The use of ICTs in education is a difficult, expensive and complex undertaking and a host of issues, including infrastructure, curricula changes, teacher training, technical support, and so on must be considered. Such an undertaking, especially on a national level, requires careful planning.

As noted in a World Bank report, 'Many governments stand at the threshold of the twenty-first century without clearly-defined plans and strategies about the use of educational technology – but they are making major new investments anyway' (1998a, p. 31). The report identifies generic issues for planners to consider when developing national ICT education strategies. These are broadly grouped into three categories: educational policy and goals setting, teaching and learning, and institutional development and capacity building. The report also itemizes several successful strategies, implemented in varying degrees, including developing a national or regional plan for country-wide deployment of technologies; implementing experimental projects to gain experience for country-wide deployment; undertaking small-scale demonstration projects; using technology to address educational equity issues; using broadcast technologies, including computer networks, to reach learners in remote areas; investing in preparing students and teachers for technology-based jobs; and creating schools using ICT as their core educational delivery system (*ibid.*, p. 5).

Claeys, Lowych, and Van der Perre (1997), in an article based on interviews with a sample of 65 experts from across Europe about introducing ICTs into education, summarize the respondents' view of the role of government as that of developing a clear vision on reforming the educational system through ICTs, enacting adequate funding measures, and establishing partnerships with education and industry for the development of educational software. In addition:

... interviewees expect: (1) the development of a special cell in the department of education to support the introduction of ICT in education, (2) the development of incentives/projects, (3) the development of an advisory council to help the government promoting the introduction of ICT in education and, (2) the re-creation of the curriculum, in which information technology is embedded and an equivalent adaptation of the rules for examination (Claeys et al., p. 151).

Osin (1998), summarizing the experiences of projects in developed countries, warns against beginning a project by purchasing computers. He advocates an eight-step planning process beginning with gathering together the necessary expertise in an Advisory Committee that will define and implement a plan which starts by the careful implementation of pilot projects. Osin also recommends training a cadre of instructors for teacher training, introducing computers into teacher-training colleges, and conducting both formative and summary evaluations of the pilot projects before attempting large-scale ICT implementation.

Apart from planning, national governments have a role to play in helping to remove political and economic roadblocks that prevent the sharing of educational resources among countries. Mclsacc and Blocher (1998), in a discussion of distance education, advocate: 'Courses offered globally should encourage broad international participation and have sliding scale tuition policies. Sharing in developing educational materials and courses saves the duplication of time and effort and conserves valuable national resources' (p. 46). Potashnik and Capper, in their article, note:

Employers and universities are now drawing both staff members and students from all corners of the globe. Consequently, they face new challenges in evaluating course work done at, and degrees earned from, unknown institutions in other countries. While accreditation has typically been controlled by individual countries, the globalization of distance education has created a whole new challenge in accreditation and certification of learning (op. cit., p. 45).

These authors continue, citing the Global Alliance for Transnational Education (GATE) ([www.edugate.org](http://www.edugate.org)), an international alliance of higher education, government and business, as one effort 'to carry out the formidable task of creating a global certification and review process for education delivered across borders' (id.).

Government intervention may also help assure affordable ICT access for education. For example, telecommunications rates may be regulated to assure economical ICT access to educational institutions. In late 1996, the United States Congress enacted the Telecommunications Act of 1996 ([www.technologylaw.com/techlaw/act\\_index.html](http://www.technologylaw.com/techlaw/act_index.html)). The universal service section of the law, Section 254, will help schools and libraries obtain access to telecommunications services and technologies at discounted rates. Tax incentives, such as the 21st Century Classrooms Act for Private Technology Investment (P.L. 105-34, Title II B, Sec. 224) ([hillsource.house.gov/IssueFocus/SpecialProjects/ALearner/ALMain/tech.pdf](http://hillsource.house.gov/IssueFocus/SpecialProjects/ALearner/ALMain/tech.pdf)), enacted by the United States Congress in 1997, are one way of encouraging corporate ICT-equipment donations to educational institutions. The Act allows companies to deduct the full price of a computer which is donated to a school within two years of purchase from their taxes.

ICTs are evolving rapidly and, once established, national educational policies on ICT 'have to be regularly updated if they are to respond adequately to the challenge of effectively exploiting these constant changes to the technologies and their applications' (Byron and Gagliardi, 1996).

## CONCLUSION

Because of their ability to integrate multiple media, interactivity, flexibility of use and connectivity, the newer digital ICTs are bringing about remarkable changes in education around the world. Those changes affect both the pedagogical and the institutional aspects of education. As far as teaching is concerned, in our view, the two changes which are worth recalling, are first, the interactivity of ICTs, which creates an environment where the learners have a much more active role; and second, the immense information resource base which can be used to support teaching activities at all levels. From the institutional point of view, ICTs are introducing a completely new setting for teaching that might be

characterized by two keywords: **flexibility**, in the sense that constraints of time and place are less stringent, and **opening**, meaning that contacts and co-operation can be established anywhere in the world with a wide range of individuals both within and outside the educational community. The focus here has been on existing, widespread uses of ICTs in education, but advances in wireless telecommunications, virtual reality, pervasive computing, artificial intelligence, speech recognition, and 'next-generation' networking technologies promise to transform today's ICT educational applications as comprehensively as the computer revolutionized those of yesterday. The pressure for institutional changes which may result should not be underestimated. However, if ICTs are to cross the threshold from promise to practice in education worldwide, certain minimal conditions must be met. These include funding mechanisms to address inequities of access; agreements on technical standards and academic certification; sound implementation strategies; comprehensive regional, national, and local plans; appropriate educational pedagogy and content; networking infrastructure; and sufficient equipment, training and technical support. The costs of fulfilling these conditions will be high, but the alternatives may present even higher costs in terms of the loss of educational opportunities and in increasing the gap between rich and poor.

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