

ICT in *Education*

by Victoria L. Tinio

Foreword

This set of E-Primers on the application of Information and Communication Technologies (ICTs) to development, is presented by UNDP for the benefit of participants to the World Summit on the Information Society.

These E-Primers have been produced by UNDP's regional project, the Asia-Pacific Development Information Programme (APDIP), in association with the secretariat of the Association of Southeast Asian Nations (ASEAN). They cover a range of key topics of special interest to the ICT for Development field. Although produced mainly within and for the Asia-Pacific region, the Primers contain information and examples which pertain universally.

- The Information Age
- Nets, Webs and the Information Infrastructure
- E-commerce and E-business
- Legal and Regulatory Issues for the Information Economy
- E-government
- ICT and Education
- ICT for Poverty Alleviation

Additional titles will be added, and all can be found at <http://www.eprimers.org> and <http://www.apdip.net>.

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Preface

One of the many challenges facing developing countries today is preparing their societies and governments for globalization and the information and communication revolution. Policy-makers, business executives, NGO activists, academics, and ordinary citizens are increasingly concerned with the need to make their societies competitive in the emergent information economy.

The e-ASEAN Task Force and the UNDP Asia Pacific Development Information Programme (UNDP-APDIP) share the belief that with enabling information and communication technologies (ICTs), countries can face the challenge of the information age. With ICTs they can leap forth to higher levels of social, economic and political development. We hope that in making this leap, policy and decision-makers, planners, researchers, development practitioners, opinion-makers, and others will find this series of e-primers on the information economy, society, and polity useful.

The e-primer aims to provide readers with a clear understanding of the various terminologies, definitions, trends, and issues associated with the information age. It is written in simple, easy-to-understand language. It provides examples, case studies, lessons learned, and best practices that will help planners and decision makers in addressing pertinent issues and crafting policies and strategies appropriate for the information economy.

This e-primer is also available online at www.eprimers.org and www.apdip.net.

This e-primer is brought to you by UNDP- APDIP, which seeks to create an ICT enabling environment through advocacy and policy reform in the Asia-Pacific region, and the e-ASEAN Task Force, an ICT for development initiative of the 10-member Association of Southeast Asian Nations. We welcome your views on new topics and issues on which the e-primers may be useful.

Finally, we thank all who have been involved with this series of e-primers-writers, researchers, peer reviewers and the production team.

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Introduction

Globalization and technological change—processes that have accelerated in tandem over the past fifteen years—have created a new global economy “powered by technology, fueled by information and driven by knowledge.”¹ The emergence of this new global economy has serious implications for the nature and purpose of educational institutions. As the half-life of information continues to shrink and access to information continues to grow exponentially, schools cannot remain mere venues for the transmission of a prescribed set of information from teacher to student over a fixed period of time. Rather, schools must promote “learning to learn,” i.e., the acquisition of knowledge and skills that make possible continuous learning over the lifetime.² “The illiterate of the 21st century,” according to futurist Alvin Toffler, “will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn.”

Concerns over educational relevance and quality coexist with the imperative of expanding educational opportunities to those made most vulnerable by globalization—developing countries in general; low-income groups, girls and women, and low-skilled workers in particular. Global changes also put pressure on all groups to constantly acquire and apply new skills. The International Labour Organization defines the requirements for education and training in the new global economy simply as “Basic Education for All,” “Core Work Skills for All” and “Lifelong Learning for All.”³

Information and communication technologies (ICTs)—which include radio and television, as well as newer digital technologies such as computers and the Internet—have been touted as potentially powerful enabling tools for educational change and reform. When used appropriately, different ICTs are said to help expand access to education, strengthen the relevance of education to the increasingly digital workplace, and raise educational quality by, among others, helping make teaching and learning into an engaging, active process connected to real life.

However, the experience of introducing different ICTs in the classroom and other educational settings all over the world over the past several decades suggests that the full realization of the potential educational benefits of ICTs is not automatic. The effective integration of ICTs into the educational system is a complex, multifaceted process that involves not just technology—indeed, given enough initial capital, getting the technology is the easiest part!—but also curriculum and pedagogy, institutional readiness, teacher competencies, and long-term financing, among others.

This primer is intended to help policymakers in developing countries define a framework for the appropriate and effective use of ICTs in their educational systems by first providing a brief overview of the potential benefits of ICT use in education and the ways by which different ICTs have been used in education thus far. Second, it addresses the four broad issues in the use of ICTs in education—effectiveness, cost, equity, and sustainability. The primer concludes with a discussion of five key challenges that policymakers in developing countries must reckon with when making decisions about the integration of ICTs in education, namely, educational policy and planning, infrastructure, capacity building, language and content, and financing.

(1) Definition of *Terms*

What are ICTs and what types of ICTs are commonly used in education?

ICTs stand for *information and communication technologies* and are defined, for the purposes of this primer, as a “diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information.”⁴ These technologies include *computers, the Internet, broadcasting technologies (radio and television), and telephony.*

In recent years there has been a groundswell of interest in how computers and the Internet can best be harnessed to improve the efficiency and effectiveness of education at all levels and in both formal and non-formal settings. But ICTs are more than just these technologies; older technologies such as the telephone, radio and television, although now given less attention, have a longer and richer history as instructional tools.⁵ For instance, radio and television have for over forty years been used for open and distance learning, although print remains the cheapest, most accessible and therefore most dominant delivery mechanism in both developed and developing countries.⁶ The use of computers and the Internet is still in its infancy in developing countries, if these are used at all, due to limited infrastructure and the attendant high costs of access.

Moreover, different technologies are typically used in combination rather than as the sole delivery mechanism. For instance, the Kothmale Community Radio Internet uses both radio broadcasts and computer and Internet technologies to facilitate the sharing of information and provide educational opportunities in a rural community in Sri Lanka.⁷ The Open University of the United Kingdom (UKOU), established in 1969 as the first educational institution in the world wholly dedicated to open and distance learning, still relies heavily on print-based materials supplemented by radio, television and, in recent years, online programming.⁸ Similarly, the Indira Gandhi National Open University in India combines the use of print, recorded audio and video, broadcast radio and television, and audioconferencing technologies.⁹

What is e-learning?

Although most commonly associated with higher education and corporate training, e-learning encompasses learning at all levels, both formal and non-formal, that uses an information network—the Internet, an intranet (LAN) or extranet (WAN)—whether wholly or in part, for course delivery, interaction and/or facilitation. Others prefer the term *online learning*. *Web-based learning* is a subset of e-learning and refers to learning using an Internet browser (such as Netscape or Internet Explorer).

What is blended learning?

Another term that is gaining currency is blended learning. This refers to learning models that combine traditional classroom practice with e-learning solutions. For example, students in a traditional class can be assigned both print-based and online materials, have online mentoring sessions with their teacher through chat, and are subscribed to a class email list. Or a Web-based training course can be enhanced by periodic face-to-face instruction. “Blending” was prompted by the recognition that not all learning is best achieved in an electronically-mediated environment, particularly one that dispenses with a live instructor altogether. Instead, consideration must be given to the subject matter, the learning objectives and outcomes, the characteristics of the learners, and the learning context in order to arrive at the optimum mix of instructional and delivery methods.

What is open and distance learning?

Open and distance learning is defined by the Commonwealth of Learning as “a way of providing learning opportunities that is characterized by the separation of teacher and learner in time or place, or both time and place; learning that is certified in some way by an institution or agency; the use of a variety of media, including print and electronic; two-way communications that allow learners and tutors to interact; the possibility of occasional face-to-face meetings; and a specialized division of labour in the production and delivery of courses.”¹⁰

What is meant by a learner-centered environment?

The National Research Council of the U.S. defines learner-centered environments as those that “pay careful attention to the knowledge, skills, attitudes, and beliefs that learners bring with them to the classroom.”¹¹ The impetus for learner-centredness derives from a theory of learning called constructivism, which views learning as a process in which individuals “construct” meaning based on prior knowledge and experience. Experience enables individuals to build mental models or schemas, which in turn provide meaning and organization to subsequent experience. Thus knowledge is not “out there”, independent of the learner and which the learner passively receives; rather, knowledge is created through an active process in which the learner transforms information, constructs hypothesis, and makes decisions using his/her mental models. A form of constructivism called social constructivism also emphasizes the role of the teacher, parents, peers and other community members in helping learners to master concepts that they would not be able to understand on their own. For social constructivists, learning must be active, contextual and social. It is best done in a group setting with the teacher as facilitator or guide.

(2) The *Promise* of ICTs in Education

For developing countries ICTs have the potential for increasing access to and improving the relevance and quality of education. It thus represents a potentially equalizing strategy for developing countries.

[ICTs] greatly facilitate the acquisition and absorption of knowledge, offering developing countries unprecedented opportunities to enhance educational systems, improve policy formulation and execution, and widen the range of opportunities for business and the poor. One of the greatest hardships endured by the poor, and by many others who live in the poorest countries, is their sense of isolation. The new communications technologies promise to reduce that sense of isolation, and to open access to knowledge in ways unimaginable not long ago.¹²

However, the reality of the Digital Divide—the gap between those who have access to and control of technology and those who do not—means that the introduction and integration of ICTs at different levels and in various types of education will be a most challenging undertaking. Failure to meet the challenge would mean a further widening of the knowledge gap and the deepening of existing economic and social inequalities.

How can ICTs help expand access to education?

ICTs are a potentially powerful tool for extending educational opportunities, both formal and non-formal, to previously underserved constituencies—scattered and rural populations, groups traditionally excluded from education due to cultural or social reasons such as ethnic minorities, girls and women, persons with disabilities, and the elderly, as well as all others who for reasons of cost or because of time constraints are unable to enroll on campus.

- **Anytime, anywhere.** One defining feature of ICTs is their ability to transcend time and space. ICTs make possible asynchronous learning, or learning characterized by a time lag between the delivery of instruction and its reception by learners. Online course materials, for example, may be accessed 24 hours a day, 7 days a week. ICT-based educational delivery (e.g., educational programming broadcast over radio or television) also dispenses with the need for all learners and the instructor to be in one physical location. Additionally, certain types of ICTs, such as teleconferencing technologies, enable instruction to be received simultaneously by multiple, geographically dispersed learners (i.e., synchronous learning).
- **Access to remote learning resources.** Teachers and learners no longer have to rely solely on printed books and other materials in physical media housed in libraries (and available in limited quantities) for their educational needs. With the Internet and the World Wide Web, a wealth of learning materials in almost every subject and in a variety of media can now be accessed from anywhere at anytime of the day and by an unlimited number of people. This is particularly significant for many schools in developing countries, and even some in developed countries, that have limited and outdated library resources. ICTs also facilitate access to resource persons—mentors, experts, researchers, professionals, business leaders, and peers—all over the world.

How does the use of ICTs help prepare individuals for the workplace?

One of the most commonly cited reasons for using ICTs in the classroom has been to better prepare the current generation of students for a workplace where ICTs, particularly computers, the Internet and related technologies, are becoming more and more ubiquitous. Technological literacy, or the ability to use ICTs effectively and efficiently, is thus seen as representing a competitive edge in an increasingly globalizing job market. Technological literacy, however, is not the only skill well-paying jobs in the new global economy will require. EnGauge of the North Central Regional Educational Laboratory (U.S.) has identified what it calls “21st Century Skills,” which includes digital age literacy (consisting of functional literacy, visual literacy, scientific literacy, technological literacy, information literacy, cultural literacy, and global awareness), inventive thinking, higher-order thinking and sound reasoning, effective communication, and high productivity.¹³ (See Table 1 for a brief explanation of each skill.)

Table 1. Skills Needed in the Workplace of the Future

Digital Age Literacy	
Functional literacy	Ability to decipher meaning and express ideas in a range of media; this includes the use of images, graphics, video, charts and graphs or visual literacy
Scientific literacy	Understanding of both the theoretical and applied aspects of science and mathematics
Technological literacy	Competence in the use of information and communication technologies
Information literacy	Ability to find, evaluate and make appropriate use of information, including via the use of ICTs
Cultural literacy	Appreciation of the diversity of cultures
Global awareness	Understanding of how nations, corporations, and communities all over the world are interrelated

Inventive Thinking	
Adaptability	Ability to adapt and manage in a complex, interdependent world
Curiosity	Desire to know
Creativity	Ability to use imagination to create new things
Risk-taking	Ability to take risks

Higher-Order Thinking	
Creative problem-solving and logical thinking that result in sound judgments	

Effective Communication	
Teaming	Ability to work in a team
Collaboration and interpersonal skills	Ability to interact smoothly and work effectively with others
Personal and social responsibility	Be accountable for the way they use ICTs and to learn to use ICTs for the public good
Interactive communication	Competence in conveying, transmitting, accessing and understanding information
High Productivity	Ability to prioritize, plan, and manage programs and projects to achieve the desired results Ability to apply what they learn in the classroom to real-life contexts to create relevant, high-quality products

Source: Adapted from EnGauge. North Central Regional Educational Laboratory. Available Online at <http://www.ncrel.org/engage/skills/21skills.htm>. Accessed 31 May 2002.

The potential of ICTs to promote the acquisition of these skills is tied to its use as a tool for raising educational quality, including promoting the shift to a learner-centered environment.

How can the use of ICTs help improve the quality of education?

Improving the quality of education and training is a critical issue, particularly at a time of educational expansion. ICTs can enhance the quality of education in several ways: by increasing learner motivation and engagement, by facilitating the acquisition of basic skills, and by enhancing teacher training.¹⁴ ICTs are also transformational tools which, when used appropriately, can promote the shift to a learner-centered environment.

Motivating to learn. ICTs such as videos, television and multimedia computer software that combine text, sound, and colorful, moving images can be used to provide challenging and authentic content that will engage the student in the learning process. Interactive radio likewise makes use of sound effects, songs, dramatizations, comic skits, and other performance conventions to compel the students

to listen and become involved in the lessons being delivered. More so than any other type of ICT, networked computers with Internet connectivity can increase learner motivation as it combines the media richness and interactivity of other ICTs with the opportunity to connect with real people and to participate in real world events.

Facilitating the acquisition of basic skills. The transmission of basic skills and concepts that are the foundation of higher order thinking skills and creativity can be facilitated by ICTs through drill and practice. Educational television programs such as *Sesame Street* use repetition and reinforcement to teach the alphabet, numbers, colors, shapes and other basic concepts. Most of the early uses of computers were for computer-based learning (also called computer-assisted instruction) that focused on mastery of skills and content through repetition and reinforcement. (See section below on *Computer-Based Learning*.)

Enhancing teacher training. ICTs have also been used to improve access to and the quality of teacher training. For example, institutions like the Cyber Teacher Training Center (CTTC) in South Korea are taking advantage of the Internet to provide better teacher professional development opportunities to in-service teachers. The government-funded CTTC, established in 1997, offers self-directed, self-paced Web-based courses for primary and secondary school teachers. Courses include “Computers in the Information Society,” “Education Reform,” and “Future Society and Education.” Online tutorials are also offered, with some courses requiring occasional face-to-face meetings.¹⁵ In China, large-scale radio- and television-based teacher education has for many years been conducted by the China Central Radio and TV University,¹⁶ the Shanghai Radio and TV University and many other RTVUs in the country. At Indira Gandhi National Open University, satellite-based one-way video- and two-way audio-conferencing was held in 1996, supplemented by print-materials and recorded video, to train 910 primary school teachers and facilitators from 20 district training institutes in Karnataka State. The teachers interacted with remote lecturers by telephone and fax.¹⁷

Box 1. Electronic Tutorials to Enhance Learner Support at Universitas Terbuka, Indonesia

Since its establishment in 1984 as the first distance and open learning institution in Indonesia, the Universitas Terbuka (Indonesian Open Learning University) has made great strides in making higher education available to Indonesians, having served more than 400,000 students nationwide in its 14 years of existence. The mandate of Universitas Terbuka, however, is not only to expand educational opportunity but also to “improv[e] the quality of education and make it more relevant to national development needs.”¹⁸ In its effort to address issues of quality in instruction, it has recently introduced the use of the Internet and a combination of facsimile and Internet technologies for student tutorials in 40 of its more than 700 courses on offer. These electronic tutorials are a supplement to more traditional tutorial models—including face-to-face, regular mail, radio and television—already employed by the university.

Two electronic tutorial models are being used: tutorials via email lists, and tutorials via a combination of email and fax messages. In the latter, tutors send email messages to a “fax gateway” which are then received by students as fax messages while student’s messages are sent by fax and then converted to email messages to the tutors. While both models allow tutor-student and student-student interaction, the fax/Internet model is the more accessible of the two since fax services in Indonesia are cheaper than Internet access, and do not require students to have basic computing and emailing skills.

These two models were initially piloted over a two-semester period and results revealed low participation rates for both students and tutors. This was due partly to the lack of familiarity and comfort with using the technology and partly to more basic confusion over the purpose of the tutorials. Tutors also claimed that the limited availability of computers, lack of time and low student participation dampened their initial interest in electronic tutorials.

Thus, while Internet and fax technologies have the potential to enhance learning support at Universitas Terbuka, practical steps must be taken to improve tutor-to-computer ratios, upgrade the computing and emailing skills of both academic staff and students, more aggressively promote the electronic tutorial model, and not least, collaborate with external institutions to create more Internet access points throughout Indonesia.

Source: Tian Belawati, et al. Electronic Tutorials: Indonesian Experience; available from http://www.irrodl.org/content/v3.1/belawati_rn.html; Internet; accessed 7 August 2002.

How can ICTs help transform the learning environment into one that is learner-centered?

Research has shown that the appropriate use of ICTs can catalyze the paradigmatic shift in both content and pedagogy that is at the heart of education reform in the 21st century.¹⁹ If designed and implemented properly, ICT-supported education can promote the acquisition of the knowledge and skills that will empower students for lifelong learning.

When used appropriately, ICTs—especially computers and Internet technologies—enable new ways of teaching and learning rather than simply allow teachers and students to do what they have done before in a better way. These new ways of teaching and learning are underpinned by constructivist theories of learning and constitute a shift from a teacher-centered pedagogy—in its worst form characterized by memorization and rote learning—to one that is learner-centered. (See Table 2 for a comparison of a traditional pedagogy and an emerging pedagogy enabled by ICTs.)

- **Active learning.** ICT-enhanced learning mobilizes tools for examination, calculation and analysis of information, thus providing a platform for student inquiry, analysis and construction of new information. Learners therefore learn as they do and, whenever appropriate, work on real-life problems in-depth, making learning less abstract and more relevant to the learner's life situation. In this way, and in contrast to memorization-based or rote learning, ICT-enhanced learning promotes increased learner engagement. ICT-enhanced learning is also “just-in-time” learning in which learners can choose what to learn when they need to learn it.
- **Collaborative learning.** ICT-supported learning encourages interaction and cooperation among students, teachers, and experts regardless of where they are. Apart from modeling real-world interactions, ICT-supported learning provides learners the opportunity to work with people from different cultures, thereby helping to enhance learners' teaming and communicative skills as well as their global awareness. It models learning done throughout the learner's lifetime by expanding the learning space to include not just peers but also mentors and experts from different fields.

Table 2. Overview of Pedagogy in the Industrial versus the Information Society

Aspect	Less (‘traditional pedagogy’)	More (‘emerging pedagogy’ for the information society)
Active	<ul style="list-style-type: none"> • Activities prescribed by teacher • Whole class instruction • Little variation in activities • Pace determined by the programme 	<ul style="list-style-type: none"> • Activities determined by learners • Small groups • Many different activities • Pace determined by learners
Collaborative	<ul style="list-style-type: none"> • Individual • Homogenous groups • Everyone for him/herself 	<ul style="list-style-type: none"> • Working in teams • Heterogeneous groups • Supporting each other
Creative	<ul style="list-style-type: none"> • Reproductive learning • Apply known solutions to problems 	<ul style="list-style-type: none"> • Productive learning • Find new solutions to problems
Integrative	<ul style="list-style-type: none"> • No link between theory and practice • Separate subjects • Discipline-based • Individual teachers 	<ul style="list-style-type: none"> • Integrating theory and practice • Relations between subjects • Thematic • Teams of teachers
Evaluative	<ul style="list-style-type: none"> • Teacher-directed • Summative 	<ul style="list-style-type: none"> • Student-directed • Diagnostic

Source: Thijs, A., et al. Learning Through the Web Available Online http://www.decidenet.nl/Publications/Web_Based_Learning.pdf Accessed 31 May 2002.

- **Creative Learning.** ICT-supported learning promotes the manipulation of existing information and the creation of real-world products rather than the regurgitation of received information.
- **Integrative learning.** ICT-enhanced learning promotes a thematic, integrative approach to teaching and learning. This approach eliminates the artificial separation between the different disciplines and between theory and practice that characterizes the traditional classroom approach.
- **Evaluative learning.** ICT-enhanced learning is student-directed and diagnostic. Unlike static, text- or print-based educational technologies, ICT-enhanced learning recognizes that there are many different learning pathways and many different articulations of knowledge. ICTs allow learners to explore and discover rather than merely listen and remember.

(3) The Uses of ICTs in Education

Education policymakers and planners must first of all be clear about what educational outcomes (as discussed above) are being targeted. These broad goals should guide the choice of technologies to be used and their modalities of use.

The potential of each technology varies according to how it is used. Haddad and Draxler identify at least five levels of technology use in education: presentation, demonstration, drill and practice, interaction, and collaboration.²⁰

Each of the different ICTs—print, audio/video cassettes, radio and TV broadcasts, computers or the Internet—may be used for presentation and demonstration, the most basic of the five levels. Except for video technologies, drill and practice may likewise be performed using the whole range of technologies. On the other hand, networked computers and the Internet are the ICTs that enable interactive and collaborative learning best; their full potential as educational tools will remain unrealized if they are used merely for presentation or demonstration.

How have radio and TV broadcasting been used in education?

Radio and television have been used widely as educational tools since the 1920s and the 1950s, respectively. There are three general approaches to the use of radio and TV broadcasting in education:²¹

- 1) **direct class teaching**, where broadcast programming substitutes for teachers on a temporary basis;
- 2) **school broadcasting**, where broadcast programming provides complementary teaching and learning resources not otherwise available; and
- 3) **general educational programming over community**, national and international stations which provide general and informal educational opportunities.

The most notable and best documented example of the *direct class teaching* approach is Interactive Radio Instruction (IRI). This consists of “ready-made 20-30 minute direct teaching and learning exercises to the classroom on a daily basis. The radio lessons, developed around specific learning objectives at particular levels of maths, science, health and languages in national curricula, are intended to improve the quality of classroom teaching and to act as a regular, structured aid to poorly trained classroom teachers in under-resourced schools.”²² IRI projects have been implemented in Latin America and Africa. In Asia, IRI was first implemented in Thailand in 1980; Indonesia, Pakistan, Bangladesh and Nepal rolled out their own IRI projects in the 1990s.²³ What differentiates IRI from most other distance education programs is that its primary objective is to raise the quality of learning—and not merely to expand educational access—and it has had much success in both formal and non-formal settings.²⁴ Extensive research around the world has shown that many IRI projects have had a positive impact on learning outcomes and on educational equity. And with its economies of scale, it has proven to be a cost-effective strategy relative to other interventions.²⁵

Mexico’s *Telesecundaria* is another notable example of direct class teaching, this time using broadcast television. The programme was launched in Mexico in 1968 as a cost-effective strategy for expanding lower secondary schooling in small and remote communities. Perraton describes the programme thus:

Centrally produced television programs are beamed via satellite throughout the country on a scheduled basis (8 am to 2 pm and 2 pm to 8 pm) to Telesecundaria schools, covering the same secondary curriculum as that offered in ordinary schools. Each hour focuses on a different subject area and typically follows the same routine—15 minutes of television, then book-led and teacher-led activities. Students are exposed to a variety of teachers on television but have one home teacher at the school for all disciplines in each grade.²⁶

The design of the programme has undergone many changes through the years, shifting from a “talking heads” approach to more interactive and dynamic programming that “link[s] the community to the programme around the teaching method. The strategy meant combining community issues into the programs, offering children an integrated education, involving the community at large in the organization and management of the school and stimulating students to carry out community activities.”²⁷

Assessments of Telesecundaria have been encouraging: drop out rates are slightly better than those of general secondary schools and significantly better than in technical schools.²⁸

In Asia, the 44 radio and TV universities in China (including the China Central Radio and Television University), Universitas Terbuka in Indonesia, and Indira Ghandi National Open University have made extensive use of radio and television, both for direct class teaching and for school broadcasting, to reach more of their respective large populations. For these institutions, broadcasts are often accompanied by printed materials and audio cassettes.

Japan's University of the Air was broadcasting 160 television and 160 radio courses in 2000. Each course consists of 15 45-minute lectures broadcast nationwide once a week for 15 weeks. Courses are aired over University-owned stations from 6 am to 12 noon. Students are also given supplemental print materials, face-to-face instruction, and online tutorials.²⁹

Often deployed with print materials, cassettes and CD-ROMS, school broadcasting, like *direct class teaching*, is geared to national curricula and developed for a range of subject areas. But unlike direct class instruction, school broadcasting is not intended to substitute for the teacher but merely as an enrichment of traditional classroom instruction. School broadcasting is more flexible than IRI since teachers decide how they will integrate the broadcast materials into their classes. Large broadcasting corporations that provide school broadcasts include the British Broadcasting Corporation Education Radio TV in the United Kingdom and the NHK Japanese Broadcasting Station. In developing countries, school broadcasts are often a result of a partnership between the Ministry of Education and the Ministry of Information.

General educational programming consists of a broad range of programme types—news programs, documentary programs, quiz shows, educational cartoons, etc.—that afford non-formal educational opportunities for all types of learners. In a sense, any radio or TV programming with informational and educational value can be considered under this type. Some notable examples that have a global reach are the United States-based television show *Sesame Street*, the all-information television channels *National Geographic* and *Discovery*, and the radio programme *Voice of America*. The *Farm Radio Forum*, which began in Canada in the 1940s and which has since served as a model for radio discussion programs worldwide, is another example of non-formal educational programming.³⁰

What is teleconferencing and what have been its educational uses?

Teleconferencing refers to “interactive electronic communication among people located at two or more different places.”³¹ There are four types of teleconferencing based on the nature and extent of interactivity and the sophistication of the technology: 1) audioconferencing; 2) audio-graphic conferencing, 3) videoconferencing; and 4) Web-based conferencing.

Audioconferencing involves the live (real-time) exchange of voice messages over a telephone network. When low-bandwidth text and still images such as graphs, diagrams or pictures can also be exchanged along with voice messages, then this type of conferencing is called audiographic. Non-moving visuals are added using a computer keyboard or by drawing/writing on a graphics tablet or whiteboard. *Videoconferencing* allows the exchange not just of voice and graphics but also of moving images. Videoconferencing technology does not use telephone lines but either a satellite link or television network (broadcast/cable). *Web-based conferencing*, as the name implies, involves the transmission of text, and graphic, audio and visual media via the Internet; it requires the use of a computer with a browser and communication can be both synchronous and asynchronous.

Teleconferencing is used in both formal and non-formal learning contexts to facilitate teacher-learner and learner-learner discussions, as well as to access experts and other resource persons remotely. In open and distance learning, teleconferencing is a useful tool for providing direct instruction and learner support, minimizing learner isolation. For instance, an audiographic teleconferencing network between Tianjin Medical University in China and four outlying Tianjin municipalities was piloted in 1999 as part of a multi-year collaboration between Tianjin Medical University and the University of Ottawa School of Nursing funded by the Canadian International Development Agency. The audiographic teleconferencing network aims to provide continuing education and academic upgrading to nurses in parts of Tianjin municipality where access to nursing education has been extremely limited.³² Other higher education institutions using teleconferencing in their online learning programs include the Open University of the United Kingdom, Uнитар (Universiti Tun Abdul Ruzak) in Malaysia, Open University of Hong Kong, and Indira Gandhi National Open University.

Box 2. Promoting Learner-Centered Pedagogy through Computers

Project CHILD (Computers Helping Instruction and Learning Development) is a computer-integrated instruction programme developed in 1988 by the University of Florida for grades K-5 (pre-school and primary school). The programme focuses on three subject areas—reading, writing and mathematics. Each Project CHILD classroom has a learning station with between three to six computers. Butzin describes a typical Project CHILD classroom scenario thus:

- A class period begins with the teacher conducting a whole group lesson—let’s say an introduction to fractions. After about 10 minutes of direct instruction, the students fan out to their first assigned learning station. Each station will have an activity related to fractions. Some stations will focus on skill practice, while others will focus on concept development. The station activities encompass kinesthetic (hands-on) learning as well as auditory and visual modalities. The teacher assigns instructional software at each computer station to tie in with the lesson objectives.
- As student groups work at their stations, the teacher circulates to help, probe, assess, and encourage students as they work on their assigned tasks. When a student finishes an activity . . . [s/he] moves on [to the next station] as needed. At the end of the period, the teacher gathers the class together for reflection and discussion on the day’s activities.
- Teachers form cross grade subject-specific clusters (K-2 or 3-5) and work with children over three years, the better to judge what software is appropriate for the subject and to allow students to learn at their own pace. Teachers are also given one year training on integration and are provided with research-based materials for lesson planning and technology integration.

Over a decade’s worth of research on Project CHILD students have shown that they have scored consistently higher on standardized tests than their counterparts in traditional classrooms, and that the positive effects of the programme have increased over time. Project CHILD students also exhibited better attitudes toward school and learning, and better discipline as well. Project CHILD has been recognized as an effective programme by the U.S. Department of Education’s National Diffusion Network and has received funding for nationwide expansion.

Source: Butzin, S., “Project CHILD: A Decade of Success for Young Children”. Available Online <http://www.thejournal.com/magazine/vault/A2882.cfm> Accessed 22 June 2002.

How have computers and the Internet been used for teaching and learning?

There are three general approaches to the instructional use of computers and the Internet, namely:

- 1) Learning about computers and the Internet, in which technological literacy is the end goal;
- 2) Learning with computers and the Internet, in which the technology facilitates learning across the curriculum; and
- 3) Learning through computers and the Internet, integrating technological skills development with curriculum applications.³³

What does it mean to learn about computers and the Internet?

Learning about computers and the Internet focuses on developing technological literacy. It typically includes:

- Fundamentals: basic terms, concepts and operations
- Use of the keyboard and mouse
- Use of productivity tools such as word processing, spreadsheets, data base and graphics programs
- Use of research and collaboration tools such as search engines and email
- Basic skills in using programming and authoring applications such as Logo or HyperStudio
- Developing an awareness of the social impact of technological change.³⁴

Box 3. South Korean Universities Go Virtual

South Korea has one of the most advanced ICT infrastructures in the world—computer penetration is extensive, and broadband Internet access is one of the best globally. The pervasiveness of ICT use in South Korean society has spilled over to the higher educational system.

South Korea currently has 15 single-mode virtual universities that offer only ICT-based courses. Among these are the Korea Cyber University, the Korea Digital University, and the Open Cyber University. These universities specialize in lifelong learning and vocational education—a deliberate strategy to prevent unnecessary competition with more established campus-based universities—and have a combined projected enrolment of 17,200 in 2002. Courses offered cover a wide range of fields, including technology, management, law, languages, social sciences, education, and theology.

Online courses are also offered by over 100 of South Korea's dual-mode universities. Ewha Woman's University, for instance, offers Internet-based courses in language, e-learning, drug prevention, in-service teacher training, and Korean and Women's studies for local and foreign students as well as working adults.

The accelerated adoption of virtual education in South Korea was a result of deliberate planning by government. It began in 1998 with the launch of the Virtual University Trial Project (VUTP). With 65 universities and five companies participating, the VUTP was designed to:

- 1) create a cost-effective virtual education system without diminishing quality;
- 2) develop and implement Web-based or other types of distance education courses;
- 3) identify appropriate policies and standards for running a virtual university; and
- 4) share experiences during the trial period.

Participating institutions experimented with various technologies: satellite broadcasting, videoconferencing, video-on-demand, intranets, and the Internet. Based on the VUTP experience, detailed criteria for establishing virtual universities in South Korea were added to the Lifelong Education Law.

Two years after the VUTP, however, policymakers and educators in South Korea continue to grapple with issues of quality management, capacity building, cost-savings, open access, and the appropriateness of the instructional model for adult learners.

Source: Jung, In Sung, "Virtual Education at the Tertiary Level: The Experience of Korea." Available Online <http://www.TechKnowLogia.org...> Accessed 4 July 2002.

What about learning with computers and the Internet?

Learning with the technology means focusing on how the technology can be the means to learning ends across the curriculum. It includes:

- Presentation, demonstration, and the manipulation of data using productivity tools
- Use of curriculum-specific applications types such as educational games, drill and practice, simulations, tutorials, virtual laboratories, visualizations and graphical representations of abstract concepts, musical composition, and expert systems
- Use of information and resources on CD-ROM or online such as encyclopedia, interactive maps and atlases, electronic journals and other references³⁵

Technological literacy is required for learning with technologies to be possible, implying a two-step process in which students learn about the technologies before they can actually use them to learn. However, there have been attempts to integrate the two approaches.

What does learning through computers and the Internet mean?

Learning through computers and the Internet combines learning about them with learning with them. It involves learning the technological skills "just-in-time" or when the learner needs to learn them as he or she engages in a curriculum-related activity. For example, secondary school students who must present a report on the impact on their community of an increase in the price of oil for an

Economics class may start doing research online, using spreadsheet and database programs to help organize and analyze the data they have collected, as well using a word processing application to prepare their written report.

How are computers and the Internet used in distance education?

Many higher educational institutions offering distance education courses have started to leverage the Internet to improve their programme's reach and quality. The Virtual University of the Monterrey Institute of Technology in Mexico uses a combination of print, live and recorded broadcasts, and the Internet to deliver courses to students throughout Mexico and in several Latin American countries. Similarly, the African Virtual University, initiated in 1997 with funding support from the World Bank, uses satellite and Internet technologies to provide distance learning opportunities to individuals in various English-speaking and French-speaking countries throughout Africa.

At the University of the Philippines Open University, course materials are still predominantly print-based but online tutorials are becoming a convenient alternative to face-to-face tutorials especially for students unwilling or unable to go to UPOU's various physical learning centres. About 70-90% of UPOU's degree courses offer online tutorials as an option, while in several of its non-degree courses tutorials are conducted only online.

But even in Korea, where infrastructure is among the best in the world, and government has put considerable financial and other resources behind an ambitious ICT-based re-tooling of its educational system, challenges to online education persist. (See Box 3.)

Internet- and Web-based initiatives have also been developed at the secondary education level. The Virtual High School is a result of efforts of a nationwide consortium of school districts in the United States to promote the development and sharing of Web-based courses. In Canada, Open School offers a wide range of courses and resources to grades K-12 teachers and students that meet the requirements of the British Columbia curriculum. Course delivery is done through a mix of broadcast and video, while some courses are delivered totally online.³⁶

The biggest movers in e-learning, however, are not found within academe but in the private sector. John Chambers, CEO of Cisco, famously predicted that e-learning would be the next big killer application, and corporations are moving aggressively to fulfill this prediction. Merrill Lynch estimates that the combined higher education and corporate e-learning markets in the US will grow from \$US2.3 billion in 2000 to US\$18 billion in 2003, with corporate training accounting for almost two thirds of that growth.³⁷ Indeed, the number of corporate universities have grown from 400 to 1,800 over the last 13 years. Corporate universities are primarily in-house organizations in large multinational companies that make use of videoconferencing and the Internet for employee training.³⁸ If this rate of growth continues, the number of corporate universities will exceed the number of traditional universities by 2010.³⁹ A parallel development in business is the growth of a new breed of companies that offer online training services to small- and medium-sized enterprises.⁴⁰

What is telecollaboration?

Online learning involving students logging in to formal courses online is perhaps the most commonly thought of application of the Internet in education. However, it is by no means the only application. Web-based collaboration tools, such as email, listservs, message boards, real-time chat, and Web-based conferencing, connect learners to other learners, teachers, educators, scholars and researchers, scientists and artists, industry leaders and politicians—in short, to any individual with access to the Internet who can enrich the learning process.

The organized use of Web resources and collaboration tools for curriculum appropriate purposes is called telecollaboration. Judi Harris defines *telecollaboration* as "an educational endeavor that involves people in different locations using Internet tools and resources to work together. Much educational telecollaboration is curriculum-based, teacher-designed, and teacher-coordinated. Most use e-mail to help participants communicate with each other. Many telecollaborative activities and projects have Web sites to support them."⁴¹ The best telecollaborative projects are those that are fully integrated into the curriculum and not just extra-curricular activities, those in which technology use enables activities that would not have been possible without it, and those that empower students to become active, collaborative, creative, integrative, and evaluative learners (see Table 1). There are currently hun-

dreds of telecollaborative projects being implemented worldwide and many more that have either been completed or are in development.

One example is the Voices of Youth⁴² project developed by UNICEF. It encourages students to share their views on global issues, such as HIV/AIDS and child labour, with other youth and adults around the world through an electronic discussion forum. The Voices of Youth website also provides background information on the different discussion topics as well as resource materials to help teachers integrate the Voice of Youth discussions in their other classroom activities.

The International Telementor Program (ITP)⁴³ links students with mentor-experts through email and discussion forums. Founded in 1995 with support from Hewlett Packard, ITP provides project-based online mentoring support to 5th to 12th grade and university students, especially from at-risk communities. The ITP telementor typically meets online with the student at least once every two weeks to answer questions, discuss key issues, recommend useful resources, and comment on student output. The teacher's role, on the other hand, is to provide support to both student and telementor, monitor the telementoring process, and track the student's progress.

Perhaps the most widely cited telecollaborative project is the Global Learning and Observations to Benefit the Environment (GLOBE) Program.⁴⁴ GLOBE is a U.S. Government-sponsored programme launched in 1994 that links primary and secondary students and teachers from over 10,000 schools in more than 95 countries to the scientific research community. GLOBE gives students the opportunity to collaborate with scientists in conducting earth science research. Participating students periodically take measurements of the atmosphere, water, soils, and land cover at or near their schools, following strict protocols designed by GLOBE scientists. They then enter this data to a central Web-based database. The database may be accessed by scientists, researchers and the general public. GLOBE also provides teachers with guidelines and materials for structured learning activities that take off from the students' hands-on experience. Students can also go to the GLOBE website for visualizations of the data they and other students have collected.

(4) *Issues in the Use of ICTs in Education*

Effectiveness, cost, equity, and sustainability are four broad intertwined issues which must be addressed when considering the overall impact of the use of ICTs in education.

Does ICT-enhanced learning really work?

The educational effectiveness of ICTs depends on how they are used and for what purpose. And like any other educational tool or mode of educational delivery, ICTs do not work for everyone, everywhere in the same way.

Enhancing access. It is difficult to quantify the degree to which ICTs have helped expand access to basic education since most of the interventions for this purpose have been small-scale and under-reported. One exception is the television-based project Telesecundaria (discussed in a previous section), which in 1997-98 was serving over 750,000 junior secondary students in 12,000 centres in Mexico. In Asia and Africa, assessments of distance learning projects at the junior secondary level using a combination of print, taped, and broadcast technologies have been less conclusive, while at the primary level there is little evidence that ICT-based models have thrived.⁴⁵ In higher education and adult training, there is some evidence that educational opportunities are being opened to individuals and groups who are constrained from attending traditional universities. Each of the 11 so-called mega-universities, the biggest and most well-established open and distance institutions in the world (which include the Open University of the United Kingdom, the Indira Gandhi National Open University of India, the China TV University System, the Universitas Terbuka of Indonesia, and the University of South Africa, among others) has an annual enrollment of more than 100,000, and together they serve approximately 2.8 million. Compare that with the 14 million combined enrollment of the 3,500 colleges and universities in the United States.⁴⁶

Raising quality. The impact of educational radio and television broadcasts on the quality of basic education remains an under-researched area, but what little research there is suggests that these interventions are as effective as traditional classroom instruction.⁴⁷ Of the many educational broadcast projects, the Interactive Radio Instruction project has been the most comprehensively analyzed. Findings provide strong evidence of the project's effectiveness in raising the quality of education as demonstrated by increased scores on standardized tests as well as improved attendance.⁴⁸

In contrast, assessments of the use of computers, the Internet and related technologies for distance learning have been equivocal. Russell, in his comprehensive review of research, claims that there is "no significant difference" between the test scores of learners taking ICT-based distance learning courses and those receiving face-to-face instruction.⁴⁹ However, others claim that such generalizations are inconclusive, pointing out that the large number of articles on ICT-based distance learning does not include original experimental research or case studies.⁵⁰ Other critics argue that dropout rates are much higher when instruction is delivered at a distance via ICTs.

There have also been many studies that seem to support the claim that the use of computers enhances and amplifies existing curricula, as measured through standardized testing. Specifically, research shows that the use of computers as tutors, for drill and practice, and for instructional delivery, combined with traditional instruction, results in increases in learning in the traditional curriculum and basic skills areas, as well as higher test scores in some subjects compared to traditional instruction alone. Students also learn more quickly, demonstrate greater retention, and are better motivated to learn when they work with computers.⁵¹ But there are those who claim that these represent modest gains and, in any case, much of the research on which these claims are based are methodologically flawed.

Research likewise suggests that the use of computers, the Internet, and related technologies, given adequate teacher training and support, can indeed facilitate the transformation of the learning environment into a learner-centered one. But these studies are criticized for being mostly exploratory and descriptive in nature and lacking in empirical rigor. There is as yet no strong evidence that this new learning environment fosters improved learning outcomes. What does exist are qualitative data

based on observations and analysis of student and teacher perceptions that suggest a positive impact on learning.⁵²

One of the most critical problems in trying to assess the effectiveness of computers and the Internet as transformational tools is that standardized tests cannot capture the kinds of benefits that are expected to be gained in a learner-centered environment. Moreover, since technology use is fully integrated into the larger learning system, it is very difficult to isolate the technology variable and determine whether any observed gains are due to technology use or to some other factor or combination of factors.

How much does it cost?

Broadly speaking, educational television broadcasts and computer-based and online learning are more expensive than radio broadcasts.⁵³ There is disagreement, however, over whether television broadcasts are cheaper than computer-based and online learning.⁵⁴ That said, categorical assessments of cost-effectiveness are difficult to make because of lack of data, differences in programs, problems of generalization, and problems of quantification of educational outcomes and opportunity costs.⁵⁵ Speaking specifically of computers and the Internet, Blurton argues that “[w]hen considering whether ICT is “cost-effective” in educational settings, a definitive conclusion may not be possible for a variety of reasons. However, when considering the alternative of building more physical infrastructure, the cost savings to be realized from sharing resources, and the societal price of not providing access, ICT as a means of enabling teaching and learning appears to be an attractive and necessary alternative.”⁵⁶

A common mistake in estimating the cost of a particular ICT educational application is to focus too much on initial fixed costs—purchase of equipment, construction or retrofitting of physical facilities, initial materials production, and the like. But studies of the use of computers in classrooms, for example, show that installation of hardware and retrofitting of physical facilities account for only between 40% to 60% of the full cost of using the computers over their lifetime, or its *total cost of ownership*.⁵⁷ In fact, while at first glance it may seem that the initial purchase of hardware and software is the costliest part of the process, the bulk of the total cost of ownership is spread out over time, with annual maintenance and support costs (known as variable or recurrent costs) constituting between 30% to 50% of the total cost of hardware and software. The cost of professional development, another variable cost, also accumulates over time. For computer-based approaches the total cost of ownership therefore includes:

FIXED COSTS

- Retrofitting of physical facilities
- Hardware and networking
- Software
- Upgrades and replacement (in about five years)

VARIABLE OR RECURRENT COSTS

- Professional development
- Connectivity, including Internet access and telephone time
- Maintenance and support, including utilities and supplies

In order to determine cost efficiencies, fixed costs must be distinguished from variable costs, and the balance between the two understood. If the fixed costs of a technology project are high and its variable costs are low, then there will be cost advantages to scaling up. This is the case with general educational radio and television broadcasting. Programs such as Sesame Street and Discovery are more cost-efficient the larger their audience since the high cost of production is distributed over a larger viewer base while no staff expenditures are made for learner support.

On the other hand, the case of Telesecundaria in Mexico demonstrates that the impact of higher variable costs related to learner support may be offset if the scale of the project is sufficiently large to the point where per student costs compare favorably with those of traditional schools. Similarly, with the Interactive Radio Instruction project annual cost per student is estimated to fall from US\$8.25 with 100,000 students to US\$3.12 with 1,000,000.⁵⁸ Obviously, these economies of scale may be achieved only in countries with large populations.

Open and distance learning institutions have also achieved cost-effectiveness through economies of scale. Per student costs of the 11 mega-universities range from only 5% to 50% of the average of the traditional universities in their respective countries.⁵⁹

The introduction of computers represents additional costs for schools but without short-term cost advantages. Data on cost of computer use per student in both primary and secondary schools in fact suggest cost-ineffectiveness. In Chile, for example, cost per primary school student is between US\$22 and US\$83, with expenditures for computer use requiring 10% to 37% of the national primary school budget.⁶⁰ In the U.S., computer investments accounted for 1.3% of total expenditure on schools, with annual cost per student at US\$70.⁶¹

Perraton and Creed suggest that these levels of cost support the argument against putting computers in every classroom, particularly in primary schools where there are no strong curricular arguments for investment in computers. In secondary schools, spending money on computers may be justified by the curriculum but this will come with significant increases in total school expenditure.⁶²

Another dimension of cost is location, or who will pay for what. In projects that involve computers connected to the Internet, either the school or student or both bear the variable costs related to operations such as maintenance, Internet service charges, and telephone line charges. In contrast, with radio programming the learner has to pay only for a radio and a set of batteries.

Is there equity of access to ICTs in education?

Given the wide disparities in access to ICTs between rich and poor countries and between different groups within countries, there are serious concerns that the use of ICTs in education will widen existing divisions drawn along economic, social, cultural, geographic, and gender lines.

Ideally, one wishes for equal opportunity to participate. But access for different actors—both as users and producers—is weighted by their resources. Hence, initial differences are often reproduced, reinforced, and even magnified....A formidable challenge, therefore, continues to face planners of international education: how to define the problem and provide assistance for development.⁶³

The introduction of ICTs in education, when done without careful deliberation, can result in the further marginalization of those who are already underserved and/or disadvantaged. For example, women have less access to ICTs and fewer opportunities for ICT-related training compared to men because of illiteracy and lack of education, lack of time, lack of mobility, and poverty.⁶⁴ Boys are more likely than girls to have access to computers in school and at home. Not surprisingly, boys tend to enjoy working with computers more than girls.⁶⁵ As the American Association of University Women reports, "Girls have narrowed some significant gender gaps, but technology is now the new 'boys' club' in our nation's public schools. While boys programme and problem solve with computers, girls use computers for word processing..."⁶⁶

In an evaluation of its programme in four African countries, Worldlinks,⁶⁷ an organization that promotes project-based, international telecollaboration activities among secondary school teachers and students from developing countries, it was found that despite efforts to make the programme gender neutral, gender inequalities in access persist in Uganda and Ghana. Furthermore, while girls benefited more from the programme in terms of improved academic performance and communication skills, boys were able to hone their technological skills more. A complex of economic, organizational, and sociocultural factors account for these differences: "High student-to-computer ratios and first come-first serve policies do not favour girls (typically heavily outnumbered by boys at the secondary level), girls have earlier curfew hours and domestic chore responsibilities which limit their access time, and local patriarchal beliefs tend to allow boys to dominate the computer lab environment."⁶⁸ Measures proposed to address this gender bias include encouraging schools to develop "fair use" policies in computer labs, conducting gender sensitivity sessions, and advocating for reducing the after-school duties of girls to give them more time to use the computer lab.⁶⁹ Girls also need to have female role models to inspire them to participate in technology-related activities.⁷⁰

Providing access to ICTs is only one facet of efforts to address equity issues. Equal attention must be paid to ensuring that the technology is actually being used by the target learners and in ways that truly serve their needs. An ICT-supported educational programme that illustrates this wholistic approach is the *Enlace Quiché*: Bilingual Education in Guatemala Through Teacher Training programme.⁷¹ The programme seeks to establish and maintain bilingual education technology centres for educators, students, teachers, parents, and community members in Quiché and neighboring areas. The technical

teams for each centre are composed of three students, two teachers, and the centre administrator, with at least one female student and one female teacher. Another objective of *Enlace Quiché* is the creation of multimedia bilingual educational materials that are anchored on the Mayan culture and that reflect a constructivist approach to learning. As the project website notes, this “demonstrate[s] that the technology can be used to know, to conserve, to disclose and to value local knowledge.” The project thus illustrates a model for bridging the digital divide arising from the monopoly in Internet content provision by Western and English-speaking groups and from uneven capacities to make purposeful, relevant and critical use of digital resources (see section on language and content below).

Another example of a wholistic approach to ICT integration in education is a radio instruction project in Mongolia called the Gobi Women’s Project. It seeks to provide literacy and numeracy instruction built around lessons of interest to around 15,000 nomadic women, and to create income opportunities for them. Among the programme topics are livestock rearing techniques; family care (family planning, health, nutrition and hygiene); income generation using locally available raw materials; and basic business skills for a new market economy.⁷²

Are ICT-enhanced educational projects sustainable?

One aspect of development programs that is often neglected is sustainability. The long history of development aid has shown that too many projects and programs start with a bang but all too soon fade out with a whimper, to be quickly forgotten. This is true for many ICT-based educational projects as well. In many instances, these projects are initiated by third party donors—such as international aid agencies or corporations—and not enough attention is paid to establishing a mechanism by which the educational institution or community involved can pursue the project on its own or in partnership with other stakeholders after the initiating donor exits. But cost and financing are not the only barriers to sustainability. According to Cisler, the sustainability of ICT-enabled programs has four components: social, political, technological, and economic.⁷³

Economic sustainability refers to the ability of a school and community to finance an ICT-enabled programme over the long term. Cost-effectiveness is key, as technology investments typically run high and in many cases divert funds from other equally pressing needs. Planners should look to the total cost of ownership (*see preceding discussion on cost*) and build lucrative partnerships with the community to be able to defray all expenses over the long term. The need to develop multiple channels of financing through community participation ties economic sustainability closely to social and political sustainability.

Social sustainability is a function of community involvement. The school does not exist in a vacuum, and for an ICT-enabled project to succeed the buy-in of parents, political leaders, business leaders and other stakeholders is essential. Innovation can happen only when all those who will be affected by it, whether directly or indirectly, know exactly why such an innovation is being introduced, what the implications are on their lives, and what part they can play in ensuring its success. ICT-enabled programs must ultimately serve the needs of the community. Thus community-wide consultation and mobilization are processes critical to sustainability. In short, a sense of ownership for the project must be developed among all stakeholders for sustainability to be achieved.

Political sustainability refers to issues of policy and leadership. One of the biggest threats to ICT-enabled projects is resistance to change. If, for instance, teachers refuse to use ICTs in their classrooms, then use of ICTs can hardly take off, much less be sustained over the long term. Because of the innovative nature of ICT-enabled projects, leaders must have a keen understanding of the innovation process, identify the corresponding requirements for successful adoption, and harmonize plans and actions accordingly.

Technological sustainability involves choosing technology that will be effective over the long term. In a rapidly changing technology environment, this becomes a particularly tricky issue as planners must contend with the threat of technological obsolescence. At the same time, there is the tendency to acquire only the latest technologies (which is understandable in part because these are the models which vendors are likely to push aggressively) Generally, however, planners should go with tried and tested systems; stability issues plague many of the latest technologies. Again, the rule of thumb is to let the learning objectives drive the technology choice and not vice versa—the latest technologies may not be the most appropriate tools for achieving the desired educational goals. When making technology decisions, planners should also factor in not just costs but also the availability of spare parts and technical support.

(5) Key Challenges in *Integrating ICTs in Education*

Although valuable lessons may be learned from best practices around the world, there is no one formula for determining the optimal level of ICT integration in the educational system. Significant challenges that policymakers and planners, educators, education administrators, and other stakeholders need to consider include educational policy and planning, infrastructure, language and content, capacity building, and financing.

What are the implications of ICT-enhanced education for educational policy and planning?

Attempts to enhance and reform education through ICTs require clear and specific objectives, guidelines and time-bound targets, the mobilization of required resources, and the political commitment at all levels to see the initiative through. Some essential elements of planning for ICT are listed below.

- a. A rigorous analysis of the present state of the educational system. ICT-based interventions must take into account current institutional practices and arrangements. Specifically, drivers and barriers to ICT use need to be identified, including those related to curriculum and pedagogy, infrastructure, capacity-building, language and content, and financing.
- b. The specification of educational goals at different education and training levels as well as the different modalities of use of ICTs that can best be employed in pursuit of these goals. This requires of the policymaker an understanding of the potentials of different ICTs when applied in different contexts for different purposes, and an awareness of priority education needs and financial and human resource capacity and constraints within the country or locality, as well as best practices around the world and how these practices can be adapted for specific country requirements.
- c. The identification of stakeholders and the harmonizing of efforts across different interest groups.
- d. The piloting of the chosen ICT-based model. Even the best designed models or those that have already been proven to work in other contexts need to be tested on a small scale. Such pilots are essential to identify, and correct, potential glitches in instructional design, implementability, effectiveness, and the like.
- e. The specification of existing sources of financing and the development of strategies for generating financial resources to support ICT use over the long term.

What are the infrastructure-related challenges in ICT-enhanced education?

A country's educational technology infrastructure sits on top of the national telecommunications and information infrastructure. Before any ICT-based programme is launched, policymakers and planners must carefully consider the following:

- In the first place, are appropriate rooms or buildings available to house the technology? In countries where there are many old school buildings, extensive retrofitting to ensure proper electrical wiring, heating/cooling and ventilation, and safety and security would be needed.
- Another basic requirement is the availability of electricity and telephony. In developing countries large areas are still without a reliable supply of electricity and the nearest telephones are miles away. Experience in some countries in Africa point to wireless technologies (such as VSAT or Very Small Aperture Terminal) as possible levers for leapfrogging.⁷⁴ Although this is currently an extremely costly approach, other developing countries with very poor telecommunications infrastructure should study this option.
- Policymakers should also look at the ubiquity of different types of ICT in the country in general, and in the educational system (at all levels) in particular. For instance, a basic requirement for

computer-based or online learning is access to computers in schools, communities, and households, as well as affordable Internet service.

In general, ICT use in education should follow use in society, not lead it. Education programs that use cutting-edge technologies rarely achieve long term success:

It is cheaper, and easier, to introduce a form of technology into education, and keep it working, where education is riding on the back of large-scale developments by governments or the private sector. Television works for education when it follows rather than precedes television for entertainment; computers in schools can be maintained once commercial and private use has expanded to the point where there is an established service industry.⁷⁵

What are the challenges with respect to capacity-building?

Various competencies must be developed throughout the educational system for ICT integration to be successful.

Teachers. Teacher professional development should have five foci: 1) skills with particular applications; 2) integration into existing curricula; 3) curricular changes related to the use of IT (including changes in instructional design); 4) changes in teacher role; and 5) underpinning educational theories.⁷⁶ Ideally, these should be addressed in pre-service teacher training and built on and enhanced in-service. In some countries, like Singapore, Malaysia, and the United Kingdom, teaching accreditation requirements include training in ICT use. ICTs are swiftly evol-

Box 4. Will ICTs Replace the Teacher?

The answer is a resounding NO! In fact, with the introduction of ICTs in the classroom, the teacher's role in the learning process becomes even more critical. What can and should change is the kind of role that the teacher plays. The role of students, in turn, also expands. And since ICTs can open up the classroom to the outside world, the community can also play a new role in the classroom.

As learning shifts from the "teacher-centered model" to a "learner-centered model," the teacher becomes less the sole voice of authority and more the facilitator, mentor and coach—from "sage on stage" to "guide on the side." The teacher's primary task becomes to teach the students how to ask questions and pose problems, formulate hypotheses, locate information and then critically assess the information found in relation to the problems posed. And since ICT-enhanced learning is a new experience even for the teachers, the teachers become co-learners and discover new things along with their students.⁷⁷

Additionally, it is not uncommon to see students in an ICT-enabled classroom assume both formal and informal roles as teachers of their peers and younger students, sometimes even of their own teachers. Teachers and students from different schools, subject-matter experts, parents, community and business leaders, politicians, and other interested parties also become involved in the learning process—as resource persons, critics, mentors, and cheerleaders. They also comprise a public, and hopefully critical, audience for students' work published on the Web or through other media.⁷⁸

Yet many teachers are reluctant to use ICTs, especially computers and the Internet. Hannafin and Savenye identify some of the reasons for this reluctance: poor software design, skepticism about the effectiveness of computers in improving learning outcomes, lack of administrative support, increased time and effort needed to learn the technology and how to use it for teaching, and the fear of losing their authority in the classroom as it becomes more learner-centered.⁷⁹ These are all issues that must be addressed by both pre-service teacher education and in-service teacher professional development programs if schools and other educational institutions are to fully exploit the potential of computers and the Internet as educational tools.

At the in-service level, ICT teacher professional development (TPD) should be long-term, teacher-directed, and as flexible as possible. For many under-qualified, overworked, and underpaid teachers in developing countries, effective adoption of ICTs hinges on being given continuous opportunities to learn what they need to learn based on their specific circumstances and experience, when they have the time to learn it. Institutionalized incentives and support for teachers to pursue ICT TPD are also critical. This may take the form of promotions for teachers who innovate with (as opposed to merely using) ICTs in the classroom, or simply making sure that teachers have adequate access to technology after training.

Box 5. WorLD: Teacher Professional Development as the Cornerstone of Educational ICT Use

The World Links for Development (WorLD) Program began in Uganda in 1997 under the auspices of the World Bank Institute. Its goal was to help government to bring the benefits of the Internet and the World Wide Web to the country's secondary schools. The WorLD Program has three components: Connectivity, Training, and Monitoring and Evaluation. While many international and local organizations have focused on providing technology to schools, WorLD has, over the years, built an impressive reputation as one of the world's leading providers of professional development services to teachers, school administrators and policymakers in developing countries around the world. WorLD's Professional Development Program for Teachers, which is delivered primarily face-to-face by international and local trainers, with follow-ups online, are in five phases:

Phase 0. Computer Literacy

Objective: To introduce the fundamentals of computer technology and help participants acquire basic computer literacy knowledge and skills.

Phase 1. Introduction to the Internet for Teaching and Learning

Objective: introduce fundamental concepts, technologies, and skills necessary for introducing networked technology and the Internet to teaching and learning; initiate discussion of new possibilities, generate basic email projects.

Phase 3. Introduction to Telecollaborative Learning Projects

Objective: Introduction to educational telecollaboration—from activity structures to the creation, design, implementation and dissemination of original projects.

Phase 4: Curriculum and Technology Integration

Objective: Develop skills and understanding of how to create, incorporate and facilitate innovative classroom practices that integrate networked technology and curricula.

Phase 4. Innovations: Pedagogy, Technology & Professional Development

Objective: Develop skills and understanding of how to evaluate and diffuse innovative classroom practices while addressing social and ethical concerns.

WorLD has also developed training models for policymakers on educational ICT management and on telecenters. WorLD is currently active in over 20 countries in Africa, Latin America and South Asia. It is set to roll out its programme in Southeast Asia—in Cambodia, Laos, Vietnam, Indonesia and the Philippines—in 2003.

Source: WorLD. Program Profile. 2001.

ing technologies, however, and so even the most ICT fluent teachers need to continuously upgrade their skills and keep abreast of the latest developments and best practices.

While the first focus—skills with particular applications—is self-evident, the four other foci are of equal, if not ultimately greater, importance. Research on the use of ICTs in different educational settings over the years invariably identify as a barrier to success the inability of teachers to understand why they should use ICTs and how exactly they can use ICTs to help them teach better. Unfortunately, most teacher professional development in ICTs are heavy on “teaching the tools” and light on “using the tools to teach.”

Teacher anxiety over being replaced by technology or losing their authority in the classroom as the learning process becomes more learner-centered—an acknowledged barrier to ICT adoption—can be alleviated only if teachers have a keen understanding and appreciation of their changing role.

Education administrators. Leadership plays a key role in ICT integration in education. Many teacher- or student-initiated ICT projects have been undermined by lack of support from above. For ICT integration programs to be effective and sustainable, administrators themselves must be competent in the use of the technology, and they must have a broad understanding of the technical, curricular, administrative, financial, and social dimensions of ICT use in education.

Technical support specialists. Whether provided by in-school staff or external service providers, or both, technical support specialists are essential to the continued viability of ICT use in a given school. While the technical support requirements of an institution depend ulti-

mately on what and how technology is deployed and used, general competencies that are required would be in the installation, operation, and maintenance of technical equipment (including software), network administration, and network security. Without on-site technical support, much time and money may be lost due to technical breakdowns.

In the Philippines, for example, one of the major obstacles to optimizing computer use in high schools has been the lack of timely technical support. In some extreme cases involving schools in remote areas, disabled computers take months to be repaired since no technician is available in the immediate vicinity and so the computers have to be sent to the nearest city hundreds of kilometers away.⁸⁰

Content developers. Content development is a critical area that is too often overlooked. The bulk of existing ICT-based educational material is likely to be in English (see section on language and content below) or of little relevance to education in developing countries (especially at the primary and secondary levels). There is a need to develop original educational content (e.g., radio programs, interactive multimedia learning materials on CD-ROM or DVD, Web-based courses, etc.), adapt existing content, and convert print-based content to digital media. These are tasks for which content development specialists such as instructional designers, scriptwriters, audio and video production specialists, programmers, multimedia course authors, and web-developers are needed. Like technical support specialists, content developers are highly skilled professionals and are not, with the exception of instructional designers, historically employed by primary and secondary schools. Many universities with distance education programs, and those who otherwise make use of ICTs, have dedicated technical support and content development units.

What challenges need to be addressed in the areas of language and content?

English is the dominant language of the Internet. An estimated 80% of online content is in English.⁸¹ A large proportion of the educational software produced in the world market is in English. For developing countries in the Asia-Pacific where English language proficiency is not high, especially outside metropolitan areas, this represents a serious barrier to maximizing the educational benefits of the World Wide Web.

Even in countries where English is a second language (such as Singapore, Malaysia, the Philippines, and India) it is imperative that teaching and learning materials that match national curriculum requirements and have locally meaningful content, preferably in the local languages, be developed. (See Box 6.) This would ensure that the Web is a genuinely multicultural space and that peoples of different cultures have an equal stake and voice in the global communities of learning and practice online. Particularly vulnerable to exclusion of this sort are isolated, rural populations, cultural minorities, and women in general. Thus attention must be paid to their special needs.

One encouraging trend has been the emergence of national and regional school networks, or SchoolNets, that facilitate the sharing of content and information—curriculum guides, teaching and learning resources, telecollaborative project registries, school and teacher directories, training curricula and materials, research and policy papers, technology management guides, and start-up toolkits, among others. Countries like Australia, France, Finland, Japan, Canada, Thailand, Ghana, South Africa, and Zimbabwe, to name a few, all have national SchoolNets. The Enlaces programme in Latin America has linked schools from Spanish-speaking countries like Chile, Paraguay, Costa Rica, Colombia, and Peru. In Southeast Asia, efforts are currently underway to pilot SchoolNets in the Philippines, Indonesia, Cambodia, Laos, Myanmar and Vietnam, and to link these to existing national SchoolNets to create a region-wide ASEAN SchoolNet.

In Web-based learning, technical standardization of content has also become a pressing issue. Standardization allows different applications to share content and learning systems. Specifications in content, structure, and test formats are proposed so that interoperability may exist between different management systems, resulting in some cost-efficiencies. Standards must be general enough to support all kinds of learning systems and content. Worth mentioning are initiatives conducted by the Instructional Management System (IMS), the Advanced Distributed Learning /Shareable Courseware Object Reference Model (ADL/SCORM) initiative, the Aviation Industry Computer Based Training Committee (AICC), and the European ARIADNE project, since some of the standards they have proposed are already being widely applied.

Box 6. Content is King: Lessons from Thailand

Three years after its inception in 1995, SchoolNet Thailand, a joint project of the National Electronics and Computer Technology Center (NECTEC), the Telephone Organization of Thailand, the Communications Authority of Thailand, and the Ministry of Education, found itself facing a challenge it had not entirely expected. Having built a network infrastructure for education in Thailand that connected 152 local secondary schools to the Internet, it discovered that schools hardly used the Internet as a tool for teaching and learning. It soon became apparent that the lack of quality educational online resources in the local language, Thai, was discouraging Internet use among teachers and students. SchoolNetThailand thus had to expand what had largely been a “universal access” programme to include content development—complemented by training—in the Thai language.

In September 1998, SchoolNet Thailand commissioned Kasetstart University and the Institute for the Promotion of Teaching Science and Technology to create Thai language websites on secondary school-level Mathematics, Physics, Chemistry, Biology, Engineering, the Environment, and Computer Science. Collectively called the “Digital Library”, these websites were launched a little over a year later. SchoolNet Thailand also developed an easy-to-use web authoring application called the “Digital Library Tool Kit” that allowed teachers to create Web-based lessons in Thai. Teachers and students were also given instruction on web page development. By May 2001, the Digital Library already contained 1,113 lessons, created mostly by classroom teachers. Complementing the “Digital Library” project was the production of multimedia professional development materials called “Thai Teacher 2000” which included a printed manual, a video tape, and a CD-ROM.

SchoolNet Thailand’s content development efforts also benefited from a national documentation project spearheaded by the Office of the National Cultural Commission called “Thai Cultural Information System.” This programme was intended to, among others, collect information on Thai culture and disseminate this information through CD-ROMs and the Internet.

At present, SchoolNet Thailand boasts of approximately 4,000 schools in its network, with over 900 of these with their own web pages in Thai. It expects to extend Internet service provision to the estimated 34,000 schools nationwide in the coming years and to continue to lead in local content development in Thailand.

Source: NECTEC. (July 2002). ICT for Poverty Reduction: Examples of Programmes/Projects in Thailand, pp. 6-13.

The ease by which Web-based educational content can be stored, transmitted, duplicated, and modified has also raised concerns about the protection of intellectual property rights. For instance, are intellectual property rights violated when lectures broadcast over the television or on the Web incorporate pre-existing materials, or when students record educational broadcast on tape for later viewing?

While schools and universities may already have agreements that expressly authorize the use of certain materials for classroom purposes, these agreements may not be broad enough to accommodate telecommunications transmission, videotape recording, or the distribution of course-related materials beyond the classroom setting.⁸²

The United Nations International World Intellectual Property Organization is leading international efforts in setting global standards for the protection of intellectual property rights that would not at the same time unduly curtail the accessing and sharing of information. For teachers and students, each of whom are potential publishers of multimedia materials that incorporate the works of others, information and training about the ethical use of intellectual property should be an important component of ICT-based programs.⁸³

What are the challenges related to financing the cost of ICT use?

One of the greatest challenges in ICT use in education is balancing educational goals with economic realities. ICTs in education programs require large capital investments and developing countries need to be prudent in making decisions about what models of ICT use will be introduced and to be conscious of maintaining economies of scale. Ultimately it is an issue of whether the value added of ICT use offsets the cost, relative to the cost of alternatives. Put another way, is ICT-based learning the most effective strategy for achieving the desired educational goals, and if so what is the modality and scale of implementation that can be supported given existing financial, human and other resources?

Whyte suggests the following potential sources of money and resources for ICT use programs:

1. Grants
2. Public subsidies
3. Private donations, fund-raising events
4. In-kind support (e.g., equipment, volunteers)
5. Community support (e.g. rent-free building)
6. Membership fees
7. Revenues earned from core business:
 - Connectivity (phone, fax, Internet, web pages)
 - Direct computer access to users
 - Office services (photocopying, scanning, audiovisual aids)
8. Revenues earned from ancillary activities:
 - Business services (word-processing, spreadsheets, budget preparation, printing, reception services)
 - Educational services (distant education, training courses)
 - Community services (meeting rooms, social events, local information, remittances from migrant workers)
 - Telework and consulting
 - Specialized activities (telemedicine)
 - Sales (stationary, stamps, refreshments, etc.)⁸⁴

Private sector-public sector partnerships to either pilot or fast track ICT-based projects is a strategy that has gained currency among Ministries of Education in developing countries. These partnerships take many forms, including private sector grants with government counterpart contributions, donations of equipment and education-related content by corporations to state-run schools, and the provision of technical assistance for planning, management, and strengthening human resources at the grassroots level. Multilateral organizations and international aid agencies have also driven many of the most significant ICT in education efforts in the developing world.

But the financial litmus test of ICT-based programs is survival after donor money has run out. Many ICT-based education programs funded by aid agencies or by corporations could not be sustained because government failed to step in with the necessary financing; nor were the local communities in a position to generate the resources needed to continue these programs. This was the case with some of the Interactive Radio Instruction projects initiated by USAID. Therefore, a two-fold strategy is key: government support and local community mobilization.

Will ICT use be the silver bullet that will rid a developing country of all of its educational problems?

If there is one truism that has emerged in the relatively brief history of ICT use in education, it is this: It is not the technology but how you use it! Put another way: "How you use technology is more important than if you use it at all...[and] unless our thinking about schooling changes along with the continuing expansion of [ICTs] in the classroom then our technology investment will fail to live up to its potential."⁸⁵

Technology then should not drive education; rather, educational goals and needs, and careful economics, must drive technology use. Only in this way can educational institutions in developing countries effectively and equitably address the key needs of the population, to help the population as a whole respond to new challenges and opportunities created by an increasingly global economy. ICTs, therefore, cannot by themselves resolve educational problems in the developing world, as such problems are rooted in well entrenched issues of poverty, social inequality, and uneven development. What ICTs as educational tools can do, if they are used prudently, is enable developing countries to expand access to and raise the quality of education. Prudence requires careful consideration of the interacting issues that underpin ICT use in the school—policy and politics, infrastructure development, human capacity, language and content, culture, equity, cost, and not least, curriculum and pedagogy.

Box 7. Coke is IT: Corporate Social Responsibility in the Information Age

The Coca-Cola Company's ICT in Education partnerships with governments, multilateral organizations, non-governmental organizations and educators in the Asia Pacific began in 1997 with the establishment of the first Coca-Cola Learning Center in Ho Chi Minh City, Vietnam. Coca-Cola has since expanded the approach to four other countries in the region—the Philippines, China, Malaysia and Australia—bringing e-learning opportunities and resources to tens of thousands of young people and their communities.

Vietnam

Partners: Coca-Cola, Ministry of Education & Training and the National Youth Union

Funding: US\$375,000

Programme Highlights: Forty Learning Centres set up in secondary schools and youth centres in 33 cities and provinces. Programme provides Internet access, educational software and textbooks to students and teachers.

Australia

Partners: Coca-Cola, Microsoft Australia and the Inspire Foundation

Funding: US\$184,000

Programme Highlights: Launched in March 2001. Ten "Beanbag Net Centres" for disadvantaged youth in urban areas. Programme provides Internet access, IT training and dedicated local websites for young people.

Philippines

Partners: Coca-Cola, Department of Education and the Foundation for IT Education and Development

Funding: US\$450,000

Programme Highlights: Launched in April 2001. Fifteen "ed.venture" centres set up in secondary schools in six provinces. Programme provides Internet access and technology-based educational resources and training for teachers, students, and school administrators. Centres are used for teaching ICT skills, Math, Science, Languages, and History. Centres are open for community use.

China

Partners: Coca-Cola and the China Youth Development Foundation

Funding: US\$400,000

Programme Highlights: Launched in May 2001. Twenty "e-learning for life" centres set up in remote Project Hope primary schools across the country. Programme provides Internet access, educational content and training on ICT skills for teachers, students and local communities. Centres are used for the teaching of Math, Chinese, English and History.

Malaysia

Partners: Coca-Cola, Ministry of Education and the United Nations Development Programme

Funding: US\$360,000

Programme Highlights: Launched in March 2002. Six ICT "hubs" set up in secondary schools in peri-urban and rural areas. Programme provides wireless Internet access, educational software and training for students and teachers. Participating schools are integrating computer lab-based training into existing curricula. ICT "hubs" also double as community access centres.

"This is an exciting, 21st century extension of our support of youth education in Asia. We know that finding sustainable ways to bridge the digital divide is a real priority for many countries in Asia and we're committed to doing our part in helping. We do this through partnerships that take their cue from local leaders and experts. We've been focused on building local community ownership into each of these initiatives from the get-go. This helps ensure sustainability over time," explains Coca-Cola Asia's Stuart Hawkins.

It remains to be seen whether each of these country-level projects will indeed have a future without Coca-Cola. Prospects for the Malaysia project seem good—built into the programme design is the transfer of ownership and operational responsibility to the Malaysian government after one year. In the Philippines, the 15 school-based e-learning centres are making some inroads towards sustainability through community involvement and capacity building, although prospects for institutionalization remain unclear.

Source: Coca-Cola Asia. Project Fact Sheets, August 2002.

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