Technologies FOR EDUCATION

POTENTIALS, PARAMETERS, AND PROSPECTS

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Prepared for UNESCO by
Knowledge Enterprise, Inc.
www.KnowledgeEnterprise.org

UNESCO
United Nations Educational,
Scientific and Cultural Organization
Paris

AED
Academy for Educational Development
Washington, DC

The contents of the chapters of this book reflect the views of the respective authors and do not necessarily represent the policies or views of UNESCO, the Academy for Educational Development, or Knowledge Enterprise, Inc.

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ISBN 0-89492-112-6

Printed in the United States of America

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Preface

The right to education means that educational opportunity must be both equal and universal. Throughout its existence, UNESCO has sought to expand the reach of educational services and improve their quality. Its commitment to innovation, notably through the use of technologies, is equally long-standing. Since the 1960s, UNESCO has supported a variety of specific projects and conducted studies on a range of topics, including use of technologies for primary education in developing countries, expansion of higher education at a distance, and use of technologies in classroom instruction at all levels.

Educational progress in many developing countries faces a severe double bind. While all now accept the notion of the right to education and the expansion of demand at all levels this right implies, widespread economic stagnation or decline prevents action. These opposing trends put intolerable pressures on many countries' educational systems. Traditional expansion of education systems in many parts of the world will be impossible, so new resources and methods must be found. Impressive advances in technology over the past few years provide new hope that technological solutions, intelligently applied, can allow greater access, higher quality, and lower cost per learner. To achieve massive improvements through technologies will require learning from past mistakes and careful analysis of how to innovate broadly and durably.

UNESCO's current program has a strong emphasis on the use of technologies in and for education. This monograph is intended to help educational decision makers survey the technological landscape and its relevance to educational reform. This monograph is firmly rooted in a vision of education that begins with the learner and attempts to understand how technological tools can better contribute to educational goals. It looks at how technology can promote improvements in reach and delivery, content, learning outcomes, management of systems, teaching, and pertinence. In short, it is a contribution to global reflection on how to make learning throughout life a reality.

John Daniel
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Foreword

For 40 years, the Academy for Educational Development (AED) has devoted itself to fostering worldwide development in education, health, environment, family planning, and the economy, often introducing technology as a means to achieve development goals.

Today the demand for educational technology is high, and when technology is used thoughtfully and is learner centered, the results are gratifying. Again and again, we have witnessed the power of technology to enable people to learn and to interact, even in the most remote areas of the developing world. Through increased outreach we are helping to build the IT capacity of underserved populations such as people in rural areas, women, those with disabilities, and speakers of minority languages.

Lower costs and more flexible, adaptable, and user-friendly hardware are making this possible. So, too, is a new generation of teachers, planners, and administrators who understand the value and utility of the technologies. In its first international ed-tech project—evaluation of El Salvador's educational TV program—AED witnessed the impact that such thinkers can have on an educational system. In El Salvador a forward-looking minister of education viewed cutting-edge technology not only as an opportunity to deliver innovative programs to school children—the original purpose of the project being evaluated—but also as a means to achieve broader reform of a complex educational system. More than 25 years ago, he demonstrated technology's potential for educational change.

Long ago we learned that technology is not the answer unless it reflects learners' needs and suits their environment. Technologists then become their partners, and the new technologies help learners learn, conduct business, advocate for causes, receive information, and participate in the marketplace. AED is one such partner that provides assistance in planning, training, assessment, and hands-on support to ministries, communities, schools, and international donor agencies to help spread the effective use and application of the technologies.

It is imperative for decision makers and practitioners to share their experiences with educational technologies. Thus this book is an attempt to organize what is known in terms of research, thinking, and experience. It captures much of the progress in the field. It also identifies the challenges we still face.

AED, an independent, private, nonprofit organization, is delighted to co-publish this important book with UNESCO. Together we hope to further the dialogue about the promise of the new technologies for learning and development.

Stephen F. Moseley
President and CEO
Academy for Educational Development

Acronyms

ACOT	Apple Classrooms of Tomorrow
AVU	African Virtual University
BBC	British Broadcasting Company
CAGR	compound annual growth rate
CAI	computer-aided instruction
CAL	computer-assisted learning
CATT	Computer-Assisted Teacher Training project
CAUA	China Association of Universities for the Aged
CBT	computer-based training
CFI	*Centre de Formation des Instituteurs*
CIED	*Centro Internacional de Educacion y Desarrollo* (Venezuela)
CLN	Cisco Learning Network
CMC	computer-mediated communications
CODECS	Center for Open Distance Education for Civil Society (Romania)
COHCIT	*Consejo Hondureño de Ciencia y Tecnologia* (Honduras)
COL	Commonwealth of Learning
COLME	Commonwealth of Learning Media Empowerment
CONNECT-ED	Connectivity for Educator Development, Uganda
COW	computer-on-wheels
CRM	customer management relationship
CSCW	computer-supported collaborative work
DANIDA	Danish International Development Assistance
DC	direct current
DECT	digital European cordless telephone
DHTML	Dynamic Hypertext Markup Language
DOS	disc operating system
DSL	digital subscriber line
DVD	digital video disc
EBS	Educational Broadcast Services
EDC	Education Development Center
EdTech R&D	educational technology research and development
EOE	Educational Object Economy
ePOW	electronic Problem of the Week
ERIC	Educational Resource Information center
ERP	enterprise resource planning
ESCOT	Educational Software Objects of Tomorrow
FQEL	Fundamental Quality and Equity Levels project
FRM	Roberto Marinha Foundation
GDP	gross domestic product
GNP	gross national product
GLOBE	Global Learning and Observations to Benefit the Environment
GLS	Global Learning Solutions
GMI	General Motors Engineering and Management Institute
GPL	General Public License
ICT	information and communication technology
IDB	Inter-American Development Bank
IDG	International Development Goal
IESA	*Instituto de Estudios Superiores para la Administracion*
ILCE	*Instituto Latinoamericano de la Comunicación Educativa*
ILO	International Labor Organization
IMS	Instructional Management System
IP	Internet Protocol
IRI	Interactive Radio Instruction
ISDN	integrated services digital network
ISP	Internet service provider
ISTE	International Source for Technology in Education
IT	information technology
ITEK	Institute of Education Kyambogo (Uganda)
ITESM	Technological Institute of Monterrey (Mexico)
ITS	intelligent tutoring system
IVEN	International Virtual Education Network
JBTE	Joint Board of Teacher Education
KRDL	Kent Ridge Development Laboratory
LAN	local area network
LGPL	Lesser General Public License
LTNet	Learning Technologies Network (United States-Brazil)
LTSC	Learning Technology Standards Committee
LVI	LucentVision Interactive
MBEC	Ministry of Basic Education and Culture (Namibia)
MECC	Minnesota Educational Computing Corporation
MERLOT	Multimedia Educational Resource for Learning and Online Teaching
MONE	Ministry of National Education (Turkey)
NASA	National Aeronautics and Space Administration
NGO	nongovernmental organization
NIED	National Institute for Development (Namibia)
NOAA	National Oceanic and Atmospheric Administration

NOS	National Open School (India)
NSF	National Science Foundation
NSU	Nova Southeastern University
OECD	Organisation for Economic Co-operation and Development
OLA	Open Learning Agency (B.C., Canada)
OLI	Open Learning Institute of Hong Kong
OSS	open system software
OUHK	Open University of Hong Kong
PC	personal computer
PC3	Public Computer and Communication Center program
PLN	power line networking
POP	point of pressure post office protocol
PSA	public service announcement
PTA	parent-teacher association
PTC	Primary Teacher Training College (Uganda)
QOLN	Queensland Open Learning Network
RADECO	Radio-Assisted Community Basic Education
RAM	random access memory
RASCOM	Regional African Satellite Communications
REDUC	*Red Latinoamericano de Informacion y Documentacion en Educacion*
RIVED	*Red International Virtual de Educacion*
SEP	*Secretaría de Educación*
TCP	transmission control protocol
TCO	total cost of ownership
TECSUP	Higher Technological Institute (Peru)
TIMSS	Third International Mathematics and Science Study
TRIPS	Trade-Related Intellectual Property Rights
TVRO	television receive only
UHI	University of the Highlands and Islands (Scotland)
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UP	University of Phoenix
UPS	uninterruptible power supply
URL	Uniform Resource Locator
USAID	United States Agency for International Development
USB	universal serial bus
UTA	Universities of the Third Age (China)
UUCP	UNIX to UNIX copy
VEE	Virtual Exchange Environment
VHS	virtual high school
VITA	Volunteers in Technical Assistance
VSAT	very small aperture terminal
WHO	World Health Organization
WTO	World Trade Organization
XML	Extensible Markup Language

INTRODUCTION

1

THE DYNAMICS OF TECHNOLOGIES FOR EDUCATION

Wadi D. Haddad
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INTRODUCTION

Education has always lived a tension between two functions. On the one hand education is a matter of assuring continuity, that is, passing on what is known. On the other, it is a matter of fostering creativity and change, that is, propelling learners into the unknown. Both of these functions relate equally to knowledge and attitudes, to understanding and behavior. They are simultaneously complementary and conflictive. They touch the essence of the teaching/learning process. We want creativity, but we want it to emerge from what is known and understood. We want continuity, but when the result is lack of ability to solve problems or devise ways to improve the human condition, we are dismayed.

Since education has, fortunately, come to be considered as a human right, the main instrument of delivery of basic education is the school, and the right to education is, with exceptions, perceived as a right to schooling. So the tension between continuity and change is played out in an important way in the classroom. Thus it is extended to the need to simultaneously expand access, guarantee uniform quality, and leave room for diversity of results.

In the educational process, people are central. The role of teachers is always crucial. But, in each of the elements described above, the human element has limits, and other interventions need to be brought to bear strongly into the process of delivery and transformation of knowledge, and verification of results. It is the potential and role of technologies in contributing to improvement in the effectiveness and efficiency of this profoundly human exercise that this book addresses.

One of the most universally recognizable and enduring human institutions is the school. Changes in schools over time have been mainly in the logistics: physical plants, materials, and comforts or conditions of teachers and learners. In many cases, technologies have been brought in to enhance an otherwise static process. The learners gather, the teachers communicate information, the learners reproduce what they have heard and seen, and they are evaluated on their accuracy. The relevance of this process to life has been questioned often but seldom modified substantially and never system-wide.

Over the past 200 years, we have tried to perfect the education services provided by schools. We have managed to evolve the education model from education for the few to education for the many; from education for limited objectives to education for expanded objectives; from the environment as the classroom to the classroom as the learning environment; from elitist endeavors to national education systems. We have succeeded in squeezing a multidimensional, multifaceted world into a flat text (with some audiovisual presentations) in a constrained classroom environment channeled through a teacher. Even technical schools have tried to replicate the workplace in the school.

In this development, we were inspired and helped by the industrial age and its processes. Schools were to a large extent modeled on factories, where cohorts and student flow evoke assembly lines, time-on-task parallels working hours, exams are designed as a form of control of the uniformity of the product, and the production function of a school takes us back to the input/output model of factory production. Despite its shortcomings, the school system has been remarkable in its contribution to the fulfillment of basic learning needs, to skill formation, to scientific progress, to reproduction of the social order and the preservation and evolution of cultures.

As we look back at the achievements of the last century, we marvel at the extraordinary advancements in science and technology—space exploration, unraveling of the atom, genetics, organ transplant, the car, radio, television, the fax machine, the computer chip, the Internet—to name only a few. We also marvel at the progress made in social and economic development, the humanities, and the arts. All of this was possible because of a set of unique human features: the capacity to acquire knowledge generated by others and build on it; the ability to record one's knowledge and disseminate it to others in understandable terms; the desire to search, explore, and make sense of the universe; the urge to apply knowledge to solve day-to-day problems; and the faith that nothing is impossible or beyond the reach of the human mind.

Educational institutions at all levels are the embodiment of these human features and have been at the center of human achievement in science, technology, social studies, and the humanities. They have been the arenas for the generation, advancement, and dissemination of knowledge; the training of human capital; and the engines of social and economic development. They have excited many minds, opened new doors into the mysteries of the universe, and dared many spirits to delve into the unknown. Many have served as strongholds for the pursuit of truth and values against

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prevailing beliefs, prejudices, and intellectual and political tyrannies. This cannot be said of all institutions, however; many have copied the body but failed to capture the spirit.

Despite the relative success of the education enterprise, the new century brings a fresh set of challenges and pressures for which educational institutions, in their present form, are not prepared. Even the best of them have served a different set of demands for a different age. These challenges in the context of the Information Age have put schools and school systems across the world under tremendous pressure to provide every classroom (if not every student) with information and communication technologies (ICTs), including computers and their accessories and connectivity to the Internet. The pressures are coming from vendors, parents, businesses, and technology advocates. Decision makers are faced with two myths: a macro and a micro. The macro myth is that merely providing ICTs to schools transforms the learning process, and merely connecting to the Internet changes the learner's world. The micro myth is that providing technologies means acquiring computers and securing a connection to the Internet. Experience shows that effectively integrating technology into learning systems is much more complicated. It involves a rigorous analysis of educational objectives and changes, a realistic understanding of the potential of technologies, a purposeful consideration of the pre- and co-requisites of effectiveness of ICTs for education, and the prospects of this process within the dynamics of educational change and reform. In fact, experience is proving, to our surprise, that acquiring the technologies themselves, no matter how hard and expensive, may be the easiest and cheapest element in a series of elements that ultimately could make these technologies sustainable or beneficial.

This book (and this chapter) is an attempt to frame the issue of ICTs for education in the context of the educational enterprise's struggle to be relevant, responsive, and effective in meeting the challenges of the 21st century. To this end, the book draws on worldwide knowledge and experience to delineate the *potentials* of ICTs for education, the *parameters* for turning this potential into effectiveness, and the *prospects* of applying these capacities in different environments.

CHALLENGES AND PRESSURES

Countries, institutions, and individuals are faced with significant shifts in the global environment characterized by four challenges:

- exponential growth of knowledge;
- worldwide social concerns for freedom and general quality of life;
- global pressures for more education; and
- changing patterns of trade and competition and technological innovation.

Challenge 1: The Exponential Function

Knowledge, both basic and applied, is being generated very quickly and is growing exponentially. More new information has been produced within the last three decades than in the last five millennia. We should be poised for dramatic technological advances and breakthroughs in the macro frontiers of the universe on the one hand, and microscopic secrets of the human body on the other hand—and everything in between.

Not all generated knowledge is at sophisticated levels, however. Everyday living itself is becoming technologically more and more complex. In fact, all facets of society are becoming knowledge dependent. Moreover, participation in a modern technological world necessitates a significant level of scientific and technological understanding. This applies to all areas of everyday living, from agricultural practice to marketplace processes, banking, business transactions, health services, transportation, entertainment, utilities, and information exchange. Without the ability to find the essential knowledge and acquire the skills for a constantly changing world, people will find themselves—in a very short time—"disadvantaged."

As rapidly as knowledge is being generated, there are growing means by which to disseminate that knowledge through print, audio, video, and electronic media. Unfortunately, though, most developing countries are behind on both counts.

Challenge 2: The Virtuous Domain

There is a growing consciousness all over the world about such issues as democracy, citizen empowerment, freedom of communication, culture, civic participation, gender equity, human rights, civil justice, peace, and general quality of life.

Likewise, development goals are no more restricted to economic growth. The International Development Goals (IDGs)[1] of 2000 target "a world free of poverty and free of the misery that poverty breeds." The goals are set in terms of reducing poverty, improving health and education, and protecting the environment. They have been adopted by the World Bank, the International Monetary Fund, members of the Development Assistance Committee of the Organisation for Economic Co-operation and Development (OECD), and many other agencies. They found a new expression in the Millennium Declaration of the United Nations, adopted by the General Assembly in September 2000.

A major challenge in the face of existing and potential strife, exploitation, and human rights violations is to instill in the minds of citizens at all levels the principles of tolerance, democracy, human rights, responsibility, accountability, and peace—among countries, within countries, and among people. "Since wars begin in the minds of men, it is in the minds of men that the defenses of peace must be constructed" (Preamble to UNESCO's constitution).[2] Meanwhile, and despite advances in health and medicine, massive human suffering continues due to ravaging diseases, bad health conditions, lack of understanding of health issues, and limited use of health services. The General Assembly of the United Nations, in 2001, singled out HIV/AIDS for urgent and concerted action.

The challenges of social development, conflict resolution, peace, and better quality of life are not only formidable, but they belong to a category with which we do not have much experience. Unlike economic development, physical construction, and technological advancement, these challenges are not straightforward. Many of their elements are contextual, fluid, and controversial. It is in the interest of everybody (governments, businesses, communities, etc.) to draw on the best minds, approaches, and technologies, to face this challenge and create stable societies that are essential for political sustainability, social development, and economic prosperity.

Challenge 3: The Moving Target

There is now solid recognition among decision makers and beneficiaries alike that education is crucial for economic development, human welfare, societal advancement, and environmental protection.

We have already entered the 21st century with a basic education deficiency gap of an estimated 100 million children out of school and about 875 million illiterate youths and adults—deprived of the basic skill to communicate and participate in the social and economic life of the community and the nation. The problem of literacy is not limited to poor and marginal groups, however. *Literacy Skills for the Knowledge Society*, the second comparative report from the International Adult Literacy Survey by OECD, presents new findings for 12 OECD countries. Low literacy is a much larger problem than previously assumed in every country surveyed: from one-quarter to more than one-half of the adult population fails to reach the threshold level of performance considered as a suitable minimum skill level for coping with the demands of modern life and work.[3]

Equally pressing will be the demand for higher levels of education, triggered by more completers of first-level education, higher ambitions of parents and students, and more sophisticated requirements of the marketplace. Moreover, the quick changes in knowledge and skills will require further education, upgrading, and reorientation of a significant segment of the population. In two regions of the world, Africa and the Middle East, the demand for education is compounded by demographic trends that further tax the limited resources.

The backlog in meeting the target of basic education for all, coupled with the new demands for education, places a formidable burden on countries. A linear projection of progress thus far indicates that business as usual will not achieve desired targets within reasonable time. This may place some countries at risk of not developing their human capital to a threshold necessary for poverty alleviation and economic and social development.

Challenge 4: The Evasive Future

There was a time when planning for education and training was a straightforward exercise: manpower planners would map out needs of different sectors of the economy with reasonable precision, classify corresponding jobs by level, define skill requirements for each job, and, subsequently, project the manpower needs. Then it was fairly easy for educational planners to take this "dependable" information and build on it when devising education and training programs.

Life is not that easy anymore. Everything is changing faster than the life cycle of an education program: sectoral needs, job definitions, skill requirements, and training standards. The world is undergoing significant shifts in its economy characterized by changing patterns of trade and competition and technological innovations.

First, producers of tradable goods and services now must operate in a global marketplace. Producers will be more interdependent, more susceptible to external economic shocks, and more vulnerable to international changes in demand for types and quality of products and services. Such conditions also make it hard to predict what skills will be needed in the future.

Second, industrialized countries are moving away from mass production toward high-performance systems, and are compensating for high wages with improved productivity. Production of manufacturing and high-valued services no longer filters down "naturally" from high-income to middle- and low-income countries based on labor costs alone. The location of manufacturing and high-value service depends on the producer's ability to *control quality* and manage flexible information-based systems.

Third, as countries become more open to international trade, production will reflect international, not just national, demand. This environment, which will be dominated by private-sector jobs, will place a premium on entrepreneurship, or the ability of individuals to respond to market changes through creating their own businesses.

Fourth, advancements in ICTs have revolutionized the world economy. Information now can be collected, analyzed, and communicated with increasing speed through dramatic innovations in information technology, rapid international communication and transportation capacity, and massive technological connections across national boundaries. Any service that can be digitized and transmitted can be produced and sold anywhere. (See chapter 2.)

These facts change the rules of the game for economic success:

- Countries and firms no longer can rely on a low-wage edge; industry will have to develop and mature technologically and managerially, and it will need to place greater emphasis on productivity, quality, and flexibility in production.
- Workers no longer can be trained just once for life. They need to acquire flexible training to cope with the changing nature of their existing tasks and the requirements of new tasks.
- Learning new skills required by emerging jobs necessitates a solid scientific and technological foundation as well as an array of higher-order cognitive and social skills, such as problem solving, flexibility, agility, resourcefulness, collaboration and teamwork, "how to learn," and entrepreneurship.

IMPLICATIONS FOR EDUCATION

These four dramatic challenges pose serious questions for education and training planning and force rethinking in the way education is perceived and managed and in the priorities, scale, size, and speed of education development. (See chapter 2.) Where does this leave education development? With six far-reaching implications:

Holistic Education Structure

The workforce of the future will need a whole spectrum of knowledge and skills to deal with technology and the globalization of knowledge. It also will need to be agile and flexible, to adjust to continuous changes, both economic and social. This means that countries must embrace a holistic approach to education, investing *concurrently* in the whole pyramid of basic education, secondary education, skill training, and tertiary education. There is an educationally pressing need for:

- a workforce that has the foundation to enhance the quality and efficiency of product development, production, and maintenance, and the flexibility to acquire the new skills required for new jobs; and
- a cadre of highly trained scientific, technological, and processing personnel, including some with sophisticated research skills, who can understand fully material, scientific, technological, managerial, and social developments, and who can take the lead in their assessment, adaptation, and local application.

Since each level in the knowledge structure has its own importance, and one cannot be traded for another, the question is not whether to provide it, but how, how fast, and through what mechanisms.

Focus on Learning Acquisition and Outcomes

The ancient objective of education, teach how to learn, problem solve, and synthesize the old with the new, is now transformed from a desirable to an indispensable one. To achieve these results, education must be engaging and authentic. Engaging in the sense that the student is involved in the learning process, and not viewed simply as a "receptacle" for knowledge; authentic in the sense that what the student is learning has meaning to him or her as an individual, a member of society, and a worker in the marketplace.

Education for Everyone

Modern economic, social, political, and technological requirements demand that all members of society have a minimum level of basic education. No country can afford to leave anyone behind. People without the ability to acquire essential knowledge and skills will live precariously, and society will be deprived of their contributions. Similarly, selective opportunities for higher levels of education must reflect equity concerns so that in times of rapid educational change, historical disparities by gender, region, or social grouping are not propagated.

The biggest challenge is to reach individuals and groups that are historically underserved: girls and women, who face cultural and physical obstacles to educational institutions; rural populations that are too thinly dispersed to populate "regular" schools with reasonable class sizes; adult workers who have no time to attend regular courses; and persons who cannot come to learning centers because of security hazards. Here we need to be innovative and think radically. In some situations, we may need to go "over" the hurdles and provide education where these potential learners are—anywhere and everywhere.

Education Anytime

The need for continuous access to information and knowledge makes learning lifelong and the traditionally neat distinction between learning and work unreal. Education thus becomes a continuum, with no marked beginning and end, which provides opportunities for lifelong learning to help individuals, families, workplaces, and communities to adapt to economic and societal changes, and to keep the door open to those who have dropped out along the way. Learning throughout life is one of the keys to the 21st century, for a number of reasons:

- Rapid technological change and growth in knowledge and information require constant learning.
- As society evolves, we are unlikely to continue the present life-cycle pattern of prolonged education at the beginning of life and an extended retirement period at the end.
- Lifelong learning provides opportunities for those who are unemployed to reenter the workforce.
- Given the importance of learning foundations, and of continued learning in knowledge-intensive societies characterized by rapid change, those who miss out—either initially or later on—are effectively excluded.

Education Anywhere

Lifelong learning and training for the workplace cannot be confined to the traditional classroom. It is unrealistic and unaffordable to continue to ask learners to come to a designated place every time they have to engage in learning. To cope with the diversity, complexity, and changing demands for education services, delivery must extend beyond the face-to-face institutional modality to include distance education, enrichment mass media, and nonformal settings.

Teacher Empowerment[4]

Teaching is one of the most challenging and crucial professions in the world. Teachers are critical in facilitating learning and in making it more efficient and effective, and they will continue to be in the future. They hold children's hands through the hard transition from the warmth of the home to the unfamiliar environment of the school; they help to decipher those funny-looking shapes called letters; they bring life to formulas and equations; they prepare the stage for learners to shout, "eureka"; they bring the world into the classroom and the classroom into the world; they try to make sense of the directives of central education authorities and implement reforms formulated by "experts" and parachuted to them. Teachers are underpaid and ill-prepared, yet accountable for successful teaching of malnutritioned and poorly prepared students, in schools that are unhealthy, unsafe, and inadequately equipped; they are expected to understand and address the needs of students, parents, administrators, society, the economy, the past, the present, and the future.

Modern developments may have eased some teaching burdens, but they certainly have not made life easier for teachers:

- The objectives of education have become more complicated. It is no longer sufficient to teach a certain body of knowledge and skills. Teachers are expected to help students to acquire higher levels of cognitive skills—problem solving, creativity, collaborative learning, synthesis, and, above all, the skill of how to learn new knowledge and apply that knowledge to new situations.
- Our understanding of the nature of learning has evolved. For learning to take place, learners have to be active, learning has to be meaningful and authentic, and the learning environment should be challenging but not stressful—all easier said than done!
- Knowledge is expanding rapidly, and much of it is available to teachers and students at the same time. This puts an unavoidable burden on teachers to continue updating their knowledge and exposing themselves to modern channels of information.
- The social environment in many countries is making it more difficult for teachers to manage classrooms and learning processes. Teachers' authority is challenged and their knowledge questioned continually. Students, in many instances, are becoming less respectful and more belligerent, and in some extreme cases, teachers are functioning in the face of physical threats and psychological duress.
- Information and communication technologies have brought new possibilities into the education sector, but, at the same time, they have placed more demands on teachers. They now have to learn how to cope with computers in their classrooms, how to compete with students in accessing the enormous body of information—particularly via the Internet, and how to use the hardware and software to enhance the teaching/learning process.

Obviously, teachers cannot be prepared for these unfolding challenges once and for all. One-shot training, no matter how effective and successful, will not suffice. A new paradigm must emerge that replaces training with lifelong professional preparedness and development of teachers, along the following continuum:

- *Initial preparation/training* that provides teachers with a solid foundation of knowledge; proficiency in pedagogical, social, and organization skills; deep understanding of the teaching/learning policies and materials they will be dealing with; and broad familiarity with sources of educational materials and support. It is equally crucial that candidates have a sophisticated grasp of the continuous exploration, assessment, and acquisition of new knowledge and competencies, according to future demands.
- *Structured opportunities for retraining, upgrading, and acquisition of new knowledge and skills.* Many professions have such requirements to renew certification for practice. It is only logical for the critical profession of teaching to demand recertification every two or three years based on evidence of professional upgrading, and it is equally imperative for education authorities to ensure that opportunities and facilities for such upgrading are provided systematically.
- *Continuous support* for teachers as they tackle their day-to-day responsibilities.

ICTS FOR EDUCATION: THE POTENTIAL

These six far-reaching implications pose a daunting challenge for the education strategist. On one hand, there is great uncertainty about the labor market, an avalanche of new knowledge, and new demands on education in both traditional and uncharted territories. On the other is the need to provide the whole spectrum of education services to everyone, anywhere, anytime with a focus on learning acquisition and teacher empowerment—all under conditions of an ever-expanding base of education clientele and limited physical and human resources.

Enter information and communication technologies: compact discs and CD-ROMs, videodiscs, microcomputer-based laboratories, the Internet, virtual reality, local and wide area networks, instructional software, Macs, PCs, laptops, notebooks, educational television, voice mail, e-mail, satellite communication, VCRs, cable TV, interactive radio, etc. The list of "hot" technologies available for education goes on and on. Can these technologies help the education strategist face the challenges above? Educators have been told many times before that technologies would remake their world from filmstrips to radio to television. Is it any different this time?

A New Paradigm?

The demands and concerns facing the education enterprise were not created by ICTs and will not be resolved by ICTs either. It is going to be very difficult—if not impossible—for countries to meet the objective of *effective learning, for all, anywhere, anytime*. Our inability to meet this challenge, however, is self-inflicted because we tend to think of linear scaling, that is, using the same model of education (a school constrained by space and time) but more of it and on a larger scale. What we really need is to think differently and radically. The education model developed for the Industrial Age cannot achieve educational empowerment effectively in the Information Age. With ICT tools, we should be able to evolve the components of the conventional model into the corresponding components of the new model (see Table 1.1).

Education will not be a location anymore, but an activity: a teaching/learning activity. This is the ultimate *raison d'être* of ICTs for education. Imagine a highly interactive, synchronous and asynchronous, multimedia learning experience between distant locations over vast national and international networks, allowing learners to obtain simultaneous distance learning services from their geographically dispersed organizations, schools, and other colleagues. In this new paradigm, ICTs are not a substitute for schooling. They constitute one integral element of this education model—supplementing and

TABLE 1.1 • EVOLUTION OF THE NEW PARADIGM

FROM	TO
A school building	A knowledge infrastructure (schools, labs, radio, television, Internet, museums...)
Classrooms	Individual learners
A teacher (as provider of knowledge)	A teacher (as a tutor and facilitator)
A set of textbooks and some audiovisual aids	Multimedia materials (print, audio, video, digital...)

enriching traditional institutions, delivery systems, and instructional materials. In this sense, ICTs contribute to the whole system of knowledge dissemination and learning.

Technology or Technologies?

Policy makers and practitioners tend to refer to ICTs as one monolithic entity, in which case they question the potential of technology—in the singular. Such inquiry is unanswerable because technologies are very different in their potential and use. The potential of different technologies depends on what we use them for. There are at least five hierarchical levels at which technologies may be used: presentation, demonstration, drill and practice, interaction, and collaboration (see Table 1.2). If technology is to be used for representation and demonstration only, investment in computers and connectivity may not be justifiable. On the other hand, the potential for interactive and collaborative learning can best be achieved by networked computers and connectivity to the World Wide Web.

Therefore, technology should not be equated with computers and Internet. There is still an important place for other technologies, such as interactive radio, broadcast TV, and correspondence courses. Moreover, the choice of a technology depends on location, as shown in Table 1.3.

How Can ICTs Help?

Different ICTs have the potential to contribute to different facets of educational development and effective learning: expanding access, promoting efficiency, improving the quality of learning, enhancing the quality of teaching, and improving management systems (see chapters 3 and 5). ICTs also offer possibilities in lifelong learning (chapters 12 and 13), adult training (chapter 17), and e-training for the workplace (chapter 18). Planning for effective use of ICTs in education necessitates an understanding of the potential of technologies to meet different educational objectives and, consequently, to decide which of these objectives will be pursued. This decision affects the choice of technologies and the modalities of use.

TABLE 1.2 • USES OF TECHNOLOGIES

	TECHNOLOGY				
USE	TEXT	AUDIO	VIDEO	COMPUTER	INTERNET
PRESENTATION	x	x	x	x	x
DEMONSTRATION	x	x	x	x	x
DRILL & PRACTICE	x	(e.g., Language lab)		x	x
INTERACTIVE	hyperlink			x	x
COLLABORATIVE				networked	x

TABLE 1.3 • TECHNOLOGIES ON LOCATION AND AT A DISTANCE

TECHNOLOGIES ON LOCATION	TECHNOLOGIES AT A DISTANCE
Printed matter	Correspondence
Slides, transparencies	
Scanners	
Digital notepads and white boards	
Audiotapes	Radio
Films and videos	TV broadcasts
Digital books	Web pages
CDs	Web: Internet, intranet
Computer projection	Webcast

Expanding Educational Opportunities

The potential of ICTs to reach large audiences was tapped initially in the late 1800s, when correspondence courses became an alternative means to provide education for individuals who could not attend regular schools due to geographical, social, or cultural barriers. Experiments with radio broadcast started in the early 1900s, and, in 1924, the British Broadcast Corporation (BBC) began to air educational programs. Since then, radio has been instrumental in reaching scattered and rural populations (see chapter 9).

Although experiments with televised broadcast began in the 1930s, it took another 20 years for television to become popular. Two of the most prominent examples are *Telecurso* in Brazil and *Telesecundaria* in Mexico (see chapters 10 and 11).

Computer-related technologies began to make inroads 30 years ago and are changing the concept of time and space rapidly. There are now virtual high schools,[5] virtual universities, and virtual programs provided by campus-based universities (see chapter 14). About 60% of U.S. universities provide virtual education programs. In addition, open universities expand opportunities to populations that traditionally have been excluded from education due to geographic, cultural, and social barriers: minorities, girls, rural populations, and the elderly (see chapter 13).

Are virtual programs a substitute for educational institutions? Two different questions are at issue here. One is the issue of expanding reach, where distance education programs try to serve a clientele whose needs are difficult or impossible to meet through on-site learning. The other is whether virtual education can be a substitute for on-site, campus-based institutions. This question could be likened to trying to decide whether subways or air travel are preferable: each can admirably serve a specific need that the other could not begin to serve, and neither could substitute for the other. On-site institutions that are vibrant with research, exploration, and intellectual discourse are irreplaceable. The personal contact with peers and with teachers in a good on-site institution is incomparable in its richness. Libraries, possibly obsolete in a not-too distant future, still serve as an unmatched resource for investigation and learning. Distance learning, on the other hand, provides opportunities for those who could not attend courses on campus because of cost and time constraints. Distance learning increasingly provides rapid and personal interaction; it can provide more reliable learning materials than inferior institutions; it is generally far lower in terms of cost to the student; and it often offers more for lower capital and recurrent costs.

Promoting Efficiency

ICTs promote efficiency of delivery of educational services by supplementing conventional delivery mechanisms, for example:

- Technology's capacity to reach learners in any place and at any time has the potential to promote revolutionary changes in the educational paradigm. Such capacity eliminates the premise that learning time equals classroom time. To avoid overcrowded classrooms, a school may adopt a *dual-shift system* without cutting actual study time for its students. The students attend school for half a day and spend the other half involved in independent technology-enhanced education activities at home, in a library, at work, or in another unconventional setting.
- For places with low population density, *multigrade* schools become viable alternatives with the injection of high-quality programs prepared by the best teachers, miles away, and transmitted or transferred electronically to these schools.
- Another illustration of efficiencies is the domain of v*irtual labs.* All school systems want to provide labs because science is empirical. But few schools have them, fewer have furnished them with equipment and supplies, and fewer yet are willing to risk using them. Technology allows for video and digital demonstrations as well as digital simulation of lab activities in a very real manner, but without the risks and costs associated with lab experiments. Simulations will not replace hands-on activities completely; rather, they prepare the learner to conduct real-life experiments—in the same manner flight simulations prepare the student-pilot for test flying.
- Multimedia modules, the product of few instructional designers and master teachers, may be shared with many schools. Since expertise in instructional design and multimedia materials development is scarce, technological networking allows for *economies of expertise.*
- Concerns about costs are always raised in discussions related to technology. Depending on the technology used, start-up costs can be high, but *economies of scale* are significant. That is, the more the technology is used, the lower the unit costs will be. The unit costs of producing a video or writing an educational contentware decrease as more students use the product. In addition, trade-offs must be considered as well when evaluating technology's initial costs. For instance, the costs of simulation software offset the costs of constructing, maintaining, and replenishing school laboratories. Unlike labs, the costs do not increase with the number of schools adopting such software.

Improving Quality

In many schools, *teachers* are not well qualified to translate the curriculum into teaching/learning activities or to be the chief mediators between knowledge and learners. Their initial training, often the only one they have received, generally does not include the preparation of teaching materials or the use of contemporary technologies for teaching. Most teachers are reluctant to invest substantial amounts of their own time and resources in bringing their knowledge and competencies up to date in these areas, and few school systems provide time or incentives for this to take place. But, teachers can be empowered with high-quality educational videos and software. Teachers are no longer the sole providers of information but facilitators of the learning process. Second, most educational software comes with a teacher's guide and tutorials, and support can be found on the Internet. E-mail and Internet-related collaborative environments provide teachers with individualized and immediate help, regardless of their geographical location.

At the same time, ICTs can contribute significantly to the teacher professional development continuum:

- First, ICTs and properly developed multimedia materials can enhance initial preparation by providing good training materials, facilitating simulations, capturing and analyzing practice teaching, bringing world experience into the training institution, familiarizing trainees with sources of materials and support, and training potential teachers in the use of technologies for teaching/learning.
- Second, ICTs open a whole world of lifelong upgrading and professional development by providing courses at a distance, asynchronous learning, and training on demand. ICTs can be revised easily and they can introduce new courses in response to emerging demands.
- Third, ICTs break the professional isolation many teachers suffer from. With ICTs, they become part of a network with colleagues and mentors, with universities and centers of expertise, and with sources of teaching materials.

Equally important, research and experience have shown that ICTs, used well in classrooms, enhance the *learning process*, in many ways. For example, they have the potential to:

- allow materials to be presented in multiple media for multichannel learning;
- motivate and engage students in the learning process;
- bring abstract concepts to life;
- enhance critical thinking and other higher levels of cognitive skills and processes;
- provide opportunities for students to practice basic skills on their own time and at their own pace;
- allow students to use the information acquired to solve problems, formulate new problems, and explain the world around them;
- provide for access to worldwide information resources;
- be the most cost-effective (and in some cases the only) means for bringing the world into the classroom; and
- offer (via the Internet) teachers and students a platform through which they can communicate with colleagues from distant places, exchange work, develop research, and function as if there were no geographical boundaries.

Preparing for Lifelong Learning

How can lifelong learning for all, anywhere and anytime, be achieved? Certainly, formal traditional systems cannot do it, even if they are well financed, run, and maintained. The diversity of needs and settings requires a diversity of means. Here is where learning technologies may provide their most valuable contribution. They are flexible, unconstrained by time and place, can be used on demand, and provide just-in-time education. They have the potential to offer synchronous as well as asynchronous learning opportunities. But, above all, if well prepared, they can pack a wealth of expertise and experience in efficient packages that can be modified and updated all the time in response to feedback, new demands and varied contexts. Possibilities fall in a wide range of technologies, including videos, correspondence, Internet, and e-learning superstructure.

This may be the first time in the history of the human race when lifelong learning is not only desirable and urgent, but feasible as well. However, successful exploitation of technology for lifelong learning for all is dependent on a number of factors:

- Adults need to have a minimum level of basic education, including literacy. Technology should not blind us to the fact that there are still millions of adults who cannot read or write, and, because of that, they cannot use educational programs offered through information technologies, or even through classical correspondence.
- Schools should equip individuals with the necessary cognitive and technical skills to pursue and manage their own continuous learning—how to search, assimilate, define problems, apply knowledge to problem solving, etc.
- Technology literacy—the ability to use technology hardware and software—should be part of basic education and a prerequisite for adults to make good use of ICTs.

Enhancing Training for the Workplace
Traditional training programs cannot address new realities adequately; they are costly in terms of travel and lost time on the job, disruptive, slow to be modified, and incapable of responding to new needs and provisions in a timely fashion. Network technologies have the potential to deliver timely and appropriate knowledge and skills to the right people, at a suitable time, in a convenient place. This is what e-training is about. It allows for personalized, just-in-time, up-to-date, and user-centered educational activities.

E-training has been most popular (and successful) in the corporate world (see chapter 18), probably because of the culture of innovation and light bureaucracies, the feasibility of having limited and clear educational objectives, and quantifiable trade-offs. It also is used by consumers for informal skill formation and for professional training and upgrading in certain specializations. But corporate and consumer e-training modalities have opened new paths, raised new ideas, and generated new paradigms in the academic world, and the sector that responded most to e-training applications is the tertiary-level sector, worldwide (see chapter 14).

Improving Management[6]
Compared with any other national activity, the education enterprise is huge and intricate. It involves educational institutions all over the country, teachers and administrators in large numbers, and students of every age, who can reach a total of up to 30% of the population. For instance, the educational system of a middle-income country of about 10 million people easily can cover more than 11,000 educational institutions, 140,000 teachers, and 3 million students. The budget of this enterprise may reach 20% of the government budget and 3-5% of the gross national product (GNP). By any measure, this is an enormous enterprise to manage and maintain, and for which to ensure quality of input, process, and output.

Recent reforms within the education enterprise have resulted in observable successes in making educational opportunities more accessible and equitable and the teaching/learning process more effective. Yet, these successes are making an already unwieldy system even more complicated:

> Expanding educational opportunities means more schools in isolated rural areas and more diversified modes of delivery.
> Aiming for education for all means including students from underserved populations who require special measures to reach and have special needs to meet.
> The accent on learning requires setting reliable and measurable standards, and attending to individual differences.
> Decentralization and devolution of decisions to district and local levels require better information systems and management procedures.
> Involvement of more stakeholders in the education process (parents, employers, unions, political parties, etc.) is resulting in more transparency and accountability. These developments demand a consistent flow of information and force the education enterprise to be managed better and more efficiently.

Any business that is even a fraction of the size and complexity of a country's educational enterprise and uses the management techniques of most educational systems will go out of business in no time. Big businesses have discovered how important management is to keep their companies well run, efficient, and competitive. In so doing, they have used the potential of technology to restructure their procedures and overhaul their production, distribution, training, feedback, maintenance, and administration processes. However, education systems have been slow in exploiting the power of technology.

Many educational institutions and systems have introduced simple management and statistical information systems; but this should be only the beginning. The same elements of computing and telecommunications equipment and services that made businesses more efficient and cost-effective can be applied to schools and school systems to enable principals and superintendents to streamline operations, monitor performance, and improve use of physical and human resources. At the system-wide level, technologies provide critical support in domains such as school mapping; automated personnel and payroll systems; management information systems; communications; and information gathering, analysis, and use. Technology also can be powerful in driving and managing new approaches to learning that involve more student interaction, more connections among schools, more collaboration among teachers and students, and more involvement of teachers as facilitators. These needs are especially critical in self-study, distance education, and e-learning settings, and many platforms have been developed to meet such needs.

ICTS FOR EDUCATION: THE PARAMETERS

If ICTs possess all the potential, cited above, to improve the teaching/learning process significantly and revolutionize the education enterprise, in the same manner they revolutionized business and entertainment, why have we not experienced such drastic effects? *If technologies are the solution they claim to be, then what or where is the problem?*

In attempting to answer this question, it is essential to make a distinction between potential and effectiveness. No ICT potential is realized automatically—not in education, in business, or in entertainment; many computerized businesses are managed badly and go bankrupt, and many movies are a complete failure. Placing a radio and TV in every school, putting a computer in every classroom, and wiring every building to the Internet will not solve the problem automatically. The problem is not strictly technological; it is educational and contextual; constraints must be alleviated and conditions met (see chapter 4). Experience points to seven parameters necessary for the potential of ICTs to be realized in knowledge dissemination, effective learning and training, and efficient education services.

Parameter 1: Educational Policy

Technology is only a tool: no technology can fix a bad educational philosophy or compensate for bad practice. In fact, if we are going in the wrong direction, technology will get us there faster. Likewise, distance learning is not about distance, it is about learning. Just as we can have bad education face to face, we can have bad education at a distance. Therefore, educational choices have to be made first in terms of objectives, methodologies, and roles of teachers and students before decisions can be made about the appropriate technologies (see chapter 5).

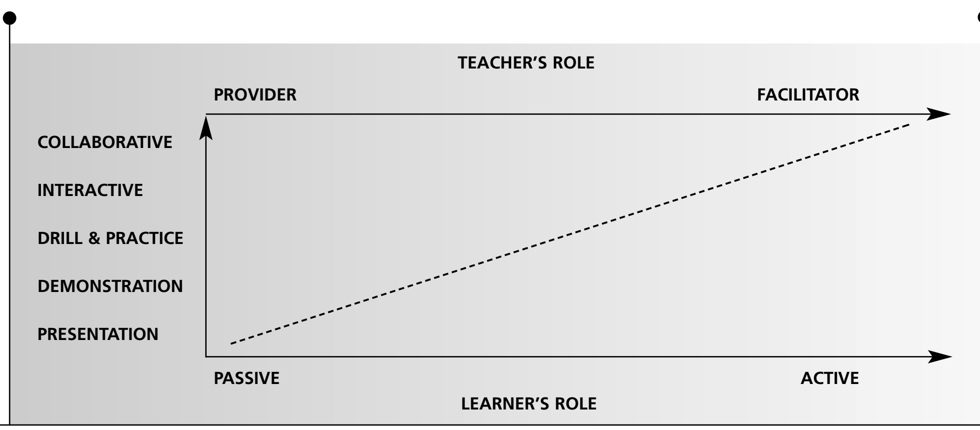
For instance, if teaching is demonstrating and telling, and if learning is memorizing and reciting, using learning technologies and multimedia programs for this purpose will not have the desired impact. Also, if students are not asked to search and work collaboratively, and if teachers function independently, investment in connectivity will not be cost-effective. The effectiveness of different levels of sophistication of use of ICTs depends to a large extent on the role of learners and teachers as practiced in the educational process; see Figure 1.1. Unfortunately, however, much introduction of technology into the educational system comes not from a process of needs identification and analysis but in response to a perceived need to innovate or to pressure from outside groups (parents, manufacturers, employers). This is not necessarily a bad thing for triggering the process, but cannot be the only reason for investing in ICTs.

Parameter 2: Approach

Classrooms are constrained environments, and conventional instructional materials are static. If technology-enhanced education programs are taped classrooms, digital texts, and PowerPoint transparencies, then we are missing out on the tremendous potential of technologies that can animate, simulate, capture reality, add movement to static concepts, and extend our touch to the whole universe. Movies and TV programs are not replicas of theater—packaged theaters; they tell the same story in a more dramatic and multifaceted manner. So should ICT-enhanced education. With imagination and appropriate tools, we can steal the thunder and touch the lightning!

In October 2001, the OECD issued *Learning to Change*,[7] the results of a study of how ICTs are being put to use in the most advanced countries. Essentially, according to the report, they are being used to do traditional things in different ways. Examples include "putting on screen what can be found on the page of a book," using material from the Internet to "support conventional teaching practices," and employing didactic software to rehearse basic skills. This merely replicates existing learning methods in technological form. If ICTs are to fulfill their potential, "innovation and change are called for at all levels of the school environment." And that requires "a far-reaching review of teaching policies and methods."

FIGURE 1.1 • USE OF ICTS FOR DIFFERENT ROLES OF TEACHERS AND LEARNERS



The challenge, therefore, is to rethink learning objectives and teaching methodologies, and to align learning technologies with them. It was never satisfactory merely to be efficient in helping learners to achieve mastery of content and basic skills, but the issue has now become a vital one. As knowledge in itself becomes a perishable item, the ability of learners to think independently, exercise appropriate judgment and skepticism, and collaborate with others to make sense of their changing environment is the only reasonable aim for education. Perhaps the most profound shift is from systems of teaching and supervision of learning to systems of learning and facilitation of learning. These shifts will be difficult in different ways for both rich and poor school systems. In advantaged communities, change is an upheaval for established authorities, systems, and capacities. In disadvantaged communities, the infrastructure must be put into place along with serious attention to pedagogy.

There is also a basic difference between using technology as an add-on to make the current model of education more efficient, more equitable, and cheaper, on the one hand, and integrating technology into the entire education system to realize structural rethinking and reengineering, on the other. It is the difference between a marginal addition and a radical systemic change. It is in the second scenario that technology can provide the greatest impact. This opportunity was articulated by Louis V. Gerstner, Jr., chairman and CEO of IBM, in a 1995 speech to the U.S. National Governors' Association:

> Information technology is the fundamental underpinning of the science of structural re-engineering. It is the force that revolutionizes business, streamlines government and enables instant communications and the exchange of information among people and institutions around the world. But information technology has not made even its barest appearance in most public schools.... Before we can get the education revolution rolling, we need to recognize that our public schools are low-tech institutions in a high-tech society. The same changes that have brought cataclysmic change to every facet of business can improve the way we teach students and teachers. And it can also improve the efficiency and effectiveness of how we run our schools.[8]

Parameter 3: Infrastructure

There is a temptation these days to equate technology with computers and the Internet. As pointed out earlier, there is still an important place for other technologies, depending on how they will be used. The application of each technology falls over a wide spectrum, from the simplest to the most sophisticated. It is important, therefore, to identify the most appropriate, cost-effective, and sustainable technology and level of application for the different educational objectives. Then the whole prerequisite hardware infrastructure needs to be in place with the supporting elements, such as electricity, maintenance, and technical services.

In the case of computer infrastructure, questions about what is appropriate are more complicated (see chapter 6).

- Selecting a computer involves decisions about technical specifications: speed, memory, monitor, etc. Selecting a computer for educational purposes involves decisions about educational goals, classroom methodologies, role of teacher, role of students, modalities of group work, role of textbook and external sources of knowledge, etc.
- Where and how should computers be distributed, connected, and used in schools? Different educational and institutional objectives are served by different configuration options: computers in classrooms, on wheels, in computer rooms or labs, or in libraries and teachers' rooms. Should computers be stand-alone or connected to form a network? If the latter, which network option is the most cost-effective: peer-to-peer, client/server, or thin-client/server? Finally, should computers be connected by wiring the classroom or school, or should they be wireless?
- Turning computers into powerful communication tools requires access to the Internet; however, getting a school online, particularly in a developing country, is not a straightforward task. First, schools need to figure out why they need to connect and to what. The next problem is communication infrastructure. In many areas, it is either nonexistent or expensive to use. Some forms of terrestrial wireless and satellite technologies are being introduced that do not require installation of wireline networks and are ideal for remote and isolated areas. Finally, schools need to find out whether they have the resources, beyond the initial investment, to cover connectivity's operating costs.
- Computers are not dying of old age; however, every so many years they need to be replaced because they cannot handle new operating or application software. This creates a major problem for schools and national governments with limited financial resources. In fact, school systems spacing the introduction of computers over a period of time longer than the life of a computer will never be able to cover all of their schools. Some organizations are trying to address the problem by providing software packages that can be run on any computer, from a 286 to the newest Pentiums.[9]

- ICTs in schools require supporting infrastructure that includes electricity, communication, wiring, and special facilities. Just as countries are experimenting with wireless connections, some in Africa and Latin America are using solar energy to run computers (and radios) in remote and isolated areas (see chapter 16).

Parameter 4: Contentware

Contentware is one of the most forgotten areas, but evidently the most crucial component. Introducing TVs, radios, computers, and connectivity into schools without sufficient curriculum-related contentware is like building roads but without making cars available, or buying a CD player at home when there are no CDs. Development of content software that is integral to the teaching/learning process is a must.

Should countries or institutions acquire or create contentware? This is one of the most difficult questions to answer. Should a country acquire existing educational radio and TV programs and educational software, or should it develop new ones in accordance with its curricular and instructional framework? Acquisition saves time but not necessarily money. In most cases, a country has to buy the material or pay a licensing fee. There are also important suitability issues both from the point of view of learning objectives and acceptability of the means of communication. On the other hand, creating new materials requires sophisticated expertise, substantive time, and significant up-front financing. Depending on the number of schools using the materials, the unit utilization cost may be very high.

This question of whether to acquire or create may be answered in different ways for different available materials and different instructional units. Ideally, the aim should be to

- acquire, as is, when suitable and cost-effective;
- acquire and adapt when not exactly suitable but cost-effective; and
- create when no suitable or cost-effective materials are available.

To follow this decision chain, three interrelated mechanisms are needed:

- Reliable information on available audio, video, and digital materials, as well as relevant educational Websites; many sources exist, such as the Educational Resource Information center (ERIC) and the Latin Network of Information and Documentation in Education (in Spanish, *Red Latinoamericano de Informacion y Documentacion en Educacion*—REDUC).[10]
- An evaluation scheme to ascertain the quality of available materials or Websites; here again, there are groups that provide objective assessment of available materials.[11]
- Identifying specific sections of Websites and relating them to curricular and instructional needs. Selecting relevant Websites is like building a large reference library that is cumbersome and overwhelming to the user. Experience is proving that students and teachers make better use of the Web if their needs are linked to specific sections. One of the most interesting examples is sciLink (*www.scilink.org*), an innovative initiative by the U.S. National Science Teachers Association, which links relevant, age-appropriate, peer-reviewed Web pages to the pages of science textbooks by placing sciLinks icons and codes in textbook margins at key subject areas.[12]

Chapter 7 contains a full discussion of the issues related to the development of multimedia materials.

Parameter 5: Committed and Trained Personnel

People involved in integrating technologies into the teaching/learning process have to be convinced of the value of the technologies, comfortable with them, and skilled in using them. Therefore, orientation and training for *all concerned staff* in the strategic, technical, and pedagogical dimensions of the process is a necessary condition for success.

Cuban examined the history of attempts to use technology to promote reform of schools:

> He concludes that most of these attempts failed to adequately address the real needs of teachers in classrooms. Instead, the efforts too often attempted to impose a technologist's or policymaker's vision of the appropriate use of the technology in schools. Teachers were provided inadequate assistance in using the technology, and the technology itself was often unreliable. As a consequence, the technology was not used by teachers or became very marginal to the schools' instructional activities.[13]

For a full discussion of strategies and options for teacher professional development in the use of technology, see chapter 8; for case studies from the field, see chapter 15.

Parameter 6: Financial Resources

As mentioned earlier, acquiring the technologies themselves, no matter how hard and expensive, may be the easiest and cheapest element in a series of elements that ultimately could make these technologies sustainable or beneficial. Computers, in particular, need highly skilled and costly maintenance to operate most of the time. Yet, in almost all cases, schools invest in buying and networking computers but do not budget sufficiently for their maintenance and technical support. It is important, therefore, to plan and budget for the total cost of ownership (TCO).[14] Elements contributing to TCO include:

- acquisition of hardware and software;
- installation and configuration;
- connectivity;
- maintenance;
- support, including supplies, utilities, and computer training;
- retrofitting of physical facilities; and
- replacement costs (in five to seven years).

It is estimated that the annual costs of maintenance and support for a healthy education computer system can range between 30% and 50% of the initial investment in computer hardware and software. This makes some donated computers quite expensive, especially when they are old, outdated, and require a lot of maintenance.

Parameter 7: Integration

The success of ICTs in education depends on how they are introduced into the system. Here are some strategic options:

- ICTs may be used as an additional layer of educational input, which leaves the current system intact but adds hardware and software for enrichment. The problem here is that both students and teachers may not take the additional materials seriously or know how to relate them to the current program. Also, this may not realize the full potential of, and, consequently, returns from, ICTs.
- ICTs may be treated as an integral part of the existing instructional system. Under this option, the process involves articulating learning objectives, translating objectives/standards into teaching/learning activities, producing multimedia curricular materials, training staff, establishing a distribution communication network, assessing learning achievement, and evaluating the program. Here, ICTs are not a substitute for the classroom setting; rather, they enhance the role of the teacher as a facilitator and the role of the student as a learner.
- ICTs may be introduced through a parallel system such as distance education or e-learning. This option may be used in situations where schools are not available or cannot be provided, or where individuals cannot enroll in regular schools because of lack of availability or for personal reasons, as in the case of working youth and adults.

From an instructional architecture perspective, technology-enhanced materials may be designed in one of three ways:

- They can be enrichment materials that may be used in addition to existing materials at the discretion of the teacher or learner, in the same manner as a library book is used.
- They can be a structured multimedia program that covers a particular course—similar to a textbook-plus that is followed by all students in all schools in the same way. Many publishers have evolved their textbooks into packages of printed (or digital) text plus related slides, videos, audiotapes, and CDs.
- They can be multimedia modules that are constructed in a flexible way so as to serve as building blocks of different curricula and teaching practices. Here, each module is broken down into educational subobjectives to be met by specific technologies, such as video, animation, simulation, real-life exploration, etc. Not only can the modules be put together in different ways, the submodules can be reconfigured to form different versions suitable for different teaching styles and learning needs.

CONCLUSION

To "tech" or not to "tech" education is *not* the question. The real question is how to harvest the power of technology to meet the challenges of the 21st century and make education relevant, responsive, and effective for anyone, anywhere, anytime.

Technologies have great potential for knowledge dissemination, effective learning, and efficient education services. Yet, if the educational policies strategies are not right, and if the prerequisite conditions for using these technologies are not met concurrently, this potential will not be realized.

The strong belief in the potential of technology, market push, and enthusiasm for introducing technology into schools creates the temptation to implement them immediately and full scale. Integrating technologies into education is a very sophisticated, multifaceted process, and, just like any other innovation, it should not be introduced without piloting its different components on a smaller scale. Even the technologies we are sure about need to be piloted in new contexts. No matter how well an ICT project is designed and planned for, many aspects need to be tested on a small scale first. Among these aspects are appropriate technologies, suitability of instructional materials, production process, classroom implementability, learning effectiveness, and cost-benefit ratio. But, very important, appropriate and effective use of technologies involves competent, committed interventions by people. The required competence and commitment cannot be inserted into a project as an afterthought, but must be built into conception and design with participation of those concerned.

The challenge to integrate ICTs into education is enormous, but so are the potential benefits. With technology, the sky is the limit, but with educational technologies, the sky is not the limit. The limit is human imagination and societal creativity.

ENDNOTES

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PART I

RATIONALES AND REALITIES

2

EMERGING TRENDS IN ICT AND CHALLENGES TO EDUCATIONAL PLANNING

Gudmund Hernes

INTRODUCTION

This year I turned 60, yet several years ago, a modern machine I had used was placed in a museum. It is an IBM 1401, which graduate students in the Department of Social Relations learned to use when I came to Johns Hopkins University in 1966. First we loaded a deck of punch cards to make the compiler read our programs. We then mounted magnetic tapes; they moved in a staccato rhythm to read what corresponded to punch cards. Sometimes it was quicker to use the old sorter-counters—they sorted and counted the punch cards mechanically. It was nice to watch as the cards piled up, and you could see your hypothesis confirmed or invalidated by the relative size of the resulting stacks of cards—science, indeed, in the making. It was not so nice, however, when the sorter-counter, like a mechanical dog, ate the cards. Now this IBM 1401—which has been called the Model T of the computer revolution—is stored in the Smithsonian Institution in Washington, DC.

The Hopkins 1401 had 8k of memory. Nowadays, I carry an iPaq personal organizer in my pocket, which has 32 Mb of memory. It keeps a schedule, address book, various calculators, world timer, documents in Word and Excel, and e-books such as Machiavelli's *The Prince*. And I can download music from the Internet as well.

At Hopkins, we were among the first to be exposed to learning by the new information and communications technology. Via teletypes, we could access a remote computer located, I think, somewhere in Pennsylvania. On it was stored a program by which we could learn interactively different statistical techniques, such as ANOVA or regression analysis. We could choose the parameters (such as the grand mean and within-row means) and then add a normally distributed error term to generate data with a chosen standard deviation. We could then order the logical building blocks (such as "total sums or squares") and use them to see what could be retrieved as estimates of the parameters we had put in, and how sensitive the results were to standard deviation of the error term we had chosen—e.g., the "estimated" grand mean compared to the "true" grand mean we had entered. Such programs were designed by the legendary sociologist, James S. Coleman, together with Doris Entwistle. I still rank the course they designed as one of the best statistics courses—indeed, one of the best of all courses—I ever took.

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THE ICT REVOLUTION(S)

I am telling this story to make two points.

> The speed with which the revolution in information and communication technology (ICT) has taken place is phenomenal. My grandfather grew up in a society without the telephone, my father in a society without radio, I in a society without television, and my son in a society without the Internet.

> The changes the ICT revolution has wrought are not limited to one single sector of society, nor do theyjust add another column in the aggregate tables of macroeconomists. ICT transforms all sectors of the economy. The car I now drive has more microprocessors than the university where I started in 1960. Hospitals would have to close and airlines would have to be grounded without them. My uncle's hearing aid is a wonder of transistors and miniaturization. My PC now serves as a post office, word processor, bank window, shopping center, CD player, photo shop, news medium, and, of course, a vast library. The changes have been faster, deeper, and more sweeping than anyone imagined as late as two or three decades ago—even by those who have pushed the new frontier.

It also can be argued that talking about "the ICT" revolution is a misnomer; for there has not been one revolution, but five—so far.

Revolution 1: The Computer

The first revolution started during World War II, with the first large, automatic, general electromechanical calculator, Harvard Mark 1. It was 50 feet long, eight feet tall, and weighed five tons. A couple of years later, ENIAC was presented in Philadelphia, based on radio tubes and practically without any internal memory, yet using 18,000 vacuum tubes and weighing 30 tons. Each time a new task was to be performed, some 6,000 switches covering three walls had to be thrown. In 1947, Walter H. Brattain, John Bardeen, and William Shockley created the first transistor, and, on its basis, faster and more powerful computers were constructed. "Computers" became a new catchword, and input-output technology graduated from punch cards to magnetic tape, faster printers, and more languages for programming. Applications also were expanded, from use in academic research to weather forecasting, from airline ticketing to accounting. This development continues; the first ICT revolution is still under way.

Revolution 2: The PC

The second ICT revolution has its roots in the 1970s, when the first "processors on a chip" and magnetic discs were constructed. But as late as 1977, Ken Olson, the legendary president of the computer company, Digital, stated: "There is no reason anyone would want a computer in their home." He was definitely wrong. In the same year, Steve Jobs and Steve Wosniak started to sell their Apple II, and Bill Gates and Paul Allen had already founded a firm called Microsoft. From being an esoteric toy, the personal computer gradually became a valuable tool for word processing, accounting, and, after a while, pictures. IBM, which at first grossly underestimated the markets for the personal computer (PC), launched its first machine under that name in 1981. Now the PC has become as widespread as the radio when our grandparents were young—indeed, as widespread as bicycles are among today's youth. This second ICT revolution continues like the first: the capacities of the machines increase, their applications expand, and the number of people who use them multiplies.

Revolution 3: The Microprocessor

The third ICT revolution is that microprocessors have become embedded in an ever-widening range of products: the steering systems of airplanes, the control panels of hydroelectric power stations, domestic air conditioning systems, the traffic lights in our streets. Even when we do not recognize it, they have become part of our everyday lives: in video players, credit cards, remote controllers, cameras, hotel room door locks, and smart buildings. There is a microprocessor embedded in our digital scale in the bathroom. If you use an electric toothbrush, its functions are governed by some 3,000 lines of programming. Microprocessors translate bar codes into prices at the cash register, monitor electronic injection of fuel in our cars, and determine where the elevator stops in our building. An ordinary household now contains some 100 microprocessors, in everything from dishwashers to alarm systems. Microprocessors constantly expand their capacity, applications, and users.

Revolution 4: The Internet

The fourth ICT revolution stretches back to the late 1960s, when the U.S. Department of Defense drew up guidelines for a communication network among computers (ARPANET). After a while, universities in and outside the United States were hooked up to it, and some started to use it to send messages. France developed its variant—its Minitel system—at the beginning of the 1980s, at the same time the U.S. National Science Foundation set up its own network among academic institutions that later became part of Internet. A dozen universities on the U.S. East Coast with IBM mainframes contributed with BITNET. In Europe, EARN became a network among academic institutions, while CERN in Geneva was crucial in the development of the World Wide Web, which got its name in 1990. A couple of years later, surfing on the 'net started, and more and more people hooked up. A PC needed a modem to use its potential fully. This fourth ICT revolution continues like the others as more and more computers are interlinked with an ever-growing number of "servers" and an expanding range of applications. Yet, the most important part of the fourth ICT revolution was this: on the computer networks engineers had constructed, users built social networks to make them useful and effective—in this case, the social superstructure built on the material basis became really super.

Revolution 5: Wireless Links

The fifth ICT revolution was linking without lines—the new possibilities opened by mobile phones. At first, they were big and bulky. Reduction in size and weight was accompanied by expansion of reach and functions, and miniaturization was accompanied by multifunctionality. Mobile phones could be used not just for talking, but also to exchange messages, receive news or stock exchange quotes, review restaurants, or order movie tickets. Phones are no longer only for transmitting phonemes; now they can transmit written messages, pictures, and music. Linking without lines now takes place not just intercontinentally via satellites, but also via high-frequency short-range radio transmitters covering a specific area or cell (hence the name, "cellular phones") and inside buildings by "Bluetooth" and infrared light. (For more on this topic, see chapter 6.)

IMPACT OF THE ICT REVOLUTIONS

I am reviewing these emerging trends to make four general points:

- The speed and impact of the ICT revolutions provide modern illustrations of Says's law: Supply creates its own demand. Contrary to Ken Olson's prediction, PCs have become household appliances. When they were linked via telephone lines, they were transformed from isolated stations to nodes in networks, and their usefulness increased exponentially with each additional node. When new functions were added—access to libraries, e-mail, etc.—their value multiplied. PCs, their links, and their multiple functions were innovations that soon became necessities.
- The way the hardware of ICT was produced and operated has itself become *one of the foremost expressions of globalization;* components come from all continents—chips from Asia, software from America, mobile phones from Europe. Brand names have instant recognition around the world: Acer, Sony, Intel, Microsoft, and Nokia. On the other hand, satellites orbiting the globe allow for instant communication on an unprecedented scale.

- The development of new products and services was part of a vast *distributed and yet integrated global division of labor,* whether it was in the development of new for-profit products and services or the more altruistic open-source contributions from a diverse crowd of enthusiasts (such as development of the Linux operating system.)
- The new links—the Internet and the World Wide Web—became the first *truly dynamic and interactive network* that individuals could access from all over the world. Much of what is on the Web is not mass communication in the classical sense: one source, one way, many users. It is by and for interacting people. Indeed, in many respects individuals were ahead of institutions in realizing the Web's potential. For example, music was swapped via the Internet before it became commoditized. Now the passport to world citizenship has become "@."

The ICT revolution has been very much about spotting opportunities and inviting everybody to learn to make good use of them. Indeed, the ICT revolution is perhaps above all else a revolution in learning. Individuals have seen the potential of the new tools and introduced them into their homes on a vast scale. Firms have applied them to an ever-widening range of activities: bookkeeping, production control, management, communication, marketing, and drug development. Public authorities have incorporated them into all of their activities, from vaccination programs to tracking criminals.

REVOLUTION IN LEARNING

Since the ICT revolution is a revolution in learning, it also has transformed available technologies, the means and methods of studying, the modalities of school operations, the manner of investment and expenditure of resources, and the very way we think about what education could be and should do.

Even before the Internet became a new mode of communication, and the World Wide Web made it possible to access learning material anywhere, universities had started to use telecommunications and computers for teaching, as illustrated by my experience at Johns Hopkins University in 1966. But with the advent of the Internet and the Web, these opportunities have expanded vastly, and educational institutions have made more and more varied use of them. Course material is posted on the Web, assignments can be communicated through the 'net, and teachers can be accessed around the clock by the new modes of transmission. The new education programs have *reached out* to off-campus students, often from long distances, but they also have *reached in* to regular students in novel ways by providing learning materials in new forms. They include a wide spectrum, from French grammar to fractal geometry, from guides to trilobites to flash cards for physics.

The Internet also changes the ways schools work by making possible closer cooperation and interaction among them, within the same country and across continents and oceans. One example is joint "virtual projects." Likewise, parents can be kept informed via the Websites of schools—virtual PTAs, so to speak.

Not only has ICT transformed the way learning institutions work, it also has changed the way we think about organized education. ICT has become a medium in the original sense of the word: something in the middle, between the substance to be learned and the student who is to master it. First, it liberates provision of education from the constraints of time and place: many courses can be accessed from more or less anywhere and at any time. Second, training can be customized, by allowing material to be adapted to individual levels and tasks to be paced according to personal progress.

But tailored capacity and development does not mean that students cannot interact—individualized does not mean isolated. To the contrary, the physical network allows students to work together, whether for mutual consultation and advice or support and encouragement. Hence, the new education technologies alter the means and modes of studying. Students can link to other students, across boundaries and across continents. Children can take part in the development of learning materials for each other in other classrooms or countries. Teachers in the remotest places can be encouraged to take part in important professional development projects. Indeed, the whole education system can work like a neural network, where cells with synapses to other cells can fire them up.

The Internet also can become a network for altruism. Institutionally, so much on the Web is there for free and for all. A large part of the available educational resources is created by groups outside of schools and academic institutions, yet is free for all and provides excellent inputs for learning (such as the learning material from the Smithsonian Institution or the World Health Organization [WHO]). Sometimes, such worldwide community service is well organized, such as the scanning, typing, or proofreading of classical texts that are entered on Websites open to all, or when the classification of craters on Mars is set up as voluntary work among informed amateurs linked by the Internet. Individually, some communities have experimented with tutors mentoring students from home. Such acts of generosity allow those participating in them to engage their minds and help others; it sure beats the millions of clicks wasted on solitaire.

CHALLENGES TO EDUCATIONAL PLANNERS

The ICT revolution offers new intrinsic opportunities; it dramatically changes what can be learned and by whom as well as what can be produced and provided by whom. These potential changes, however, pose many new challenges for educational planners. These challenges can be divided into two broad types: those that pertain to equity and those that pertain to quality. But unless educational planners respond to these changes and challenges with commensurate speed, they will become, so to speak, technologically challenged.

Equity

Although in many Western countries, the majority of households have PCs linked to the Internet, considerable differences remain along regional and class lines. Several studies document that boys are more active than girls in using the new technical tools. And though schools also are increasingly well equipped and connected, standards vary within countries with educational level and type. The same applies to teacher training and skills.

This raises the broader question of equity: within countries as well as between countries, particularly between the industrialized and developing world. It is true that millions of PCs are sold every year and millions gain access to the Internet. For example, in Norway, more than half the population is connected to the Web, and some 80% have mobile phones. Yet, half the world's population has yet to make their first phone call. There are as many telephones in Tokyo or Manhattan as in the whole of sub-Saharan Africa. Malaysia is different from Madagascar. Shanghai is very different from its hinterlands. In many countries, practically all the telephones are found in the capital: Bissau has more than 95% of the telephone lines in Guinea-Bissau, and Freetown has more than 85% of the lines in Sierra Leone. A majority of villages in many developing countries lack electric power, let alone Internet connectivity. Elsewhere, there has been a gradual deterioration of public services—access is poor, functioning is irregular, prices are high, and service is scanty.

Hence, the pressing problem for educational planners is how to reach, within a reasonable time, the needs of the majority who are poor, uneducated, and live in rural areas: how to fund, implement, and maintain the educational part of ICT networks. This question is all the more pressing because most major international teleoperators do not include sub-Saharan Africa or the remote areas of Central Asia in their business strategy plans. The bitter fact is this: What happens in a country does not depend on the state of the art, but on the state of its economy as well as the state of its state: its system of law, the functioning of its institutions, and the workings of its civil society.

The question of equitable access is not just a question of who can *use* what is available on the Internet, however, but also of who can *produce* it. There are already great differences across countries in this respect. Similarly, there are great differences between corporate actors, public as well as private, in their capacity to become—to use the current jargon—"net-based education providers." Many countries have adopted ICT policies for their education systems that cover not only hardware and infrastructure, but educational materials available for schools and students as well. Such materials, increasingly available on the Internet, range from mathematics resources in Norway to lists of recommended books for California's schools. They can be accessed freely by both domestic and foreign users. In addition, many teachers and professional associations make their best work available free for anyone to use. For example, a simple search for the "Pythagorean theorem" on the Web yields more than 10,000 sites, many of which make available all kinds of useful material—e.g., animated proofs that are much easier to follow than their textbook equivalents. In this sense, the Internet is the greatest venue for exchange of educational good deeds ever constructed.

And this is not all. Education equals finance—public funds to be spent and private demand to be targeted. Hence ICT, and particularly the Internet, is not only an arena for altruism and experiments, but also for business, entrepreneurship, and, sometimes, exploitation. In other words, education is increasingly becoming a market, and a global one at that. In a market, there are customers and producers. And access to the production side of this market is even less equitable than access to its usage side.

Some nations also actively promote programs for foreigners by distance education via the Internet. Australia is a prominent example, where services from its educational institutions have grown into a whole export industry. This is a very interesting and, in many respects, auspicious development, but it also raises a whole range of questions for educational planners about quality, certification, and accreditation. It is notable that the World Trade Organization is considering proposals to add the import and export of higher education courses to its protocols on services marketed internationally; "education products" can then be traded as a commodity from one country to another. This development provides further opportunities for students. It releases education from national control, and it makes the market a stronger force in the globalization of education. On the other hand, planners and officials in developing or smaller countries may face an expanding international market with powerful actors and many new ventures about which they have imperfect knowledge, exercise scant control, and have few possibilities for participation.

Thus, the issue of equity pertaining to ICT has to be addressed along two dimensions:

> equitable access of students as consumers, where the poorer peoples and nations are put at a disadvantage; and
> equitable provision of content, where the poor are even worse off.

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. (Most of what is provided on the Web comes from the wealthier nations of the Northern Hemisphere.) A formidable challenge, therefore, continues to face planners of international education: how to define the problem and provide assistance for development.

Quality

As ICT is rapidly becoming an integral part of the social environment and as our jobs are being transformed rapidly into tapping on keyboards and looking at screens, traditional literacy is no longer sufficient—what could be called, "Iteracy," becomes imperative. Learning to work a PC and surfing the Internet is becoming crucial for functioning in the workplace, for effective citizenship, for entertainment, and for personal growth. With the rapid change in technology, training cannot be a one-shot affair; we have to be updated continuously to stay abreast of developments. Planning and designing educational systems so that they familiarize students with a technology that is being modified and evolving continuously is not just an intellectual challenge, it is also an economic one.

This problem is exacerbated by the fact that many vendors of new technologies are sometimes more pushers than providers, promoting solutions that have a short useful life or little compatibility with what emerge as industry standards. The history of information technology is not just a history of innovation but also a history of misguided investments.

This situation applies to hardware as well as to "learning packages" and software that promise more than is delivered. What is bought is often expensive and inappropriate, resulting in costly mistakes, not just in economic terms, but in terms of time stolen from students who would have been better off using more proven methods of learning. One could generalize Robert K. Merton's term, "the fallacy of the latest word," to describe this phenomenon. Sometimes new solutions are pushed by politicians and ministers as well: they feel they need to prove they are "modern" by going for gadgets, but they are out of office when the negative results are in. Moreover, it takes time to discover where the potential of ICT in education can best be tapped, and as technology itself is changing, final solutions will continue to evade us.

The learning process also may be skewed in unfortunate directions. Much is made of the fact that ICT has become increasingly "interactive." Learning programs can be tailored to each student, learning at his or her own pace, and being introduced to more challenging tasks as learning proceeds. However, interaction in learning cannot be restricted to person-machine relations; person-person relations will always remain crucial. In industrialized countries, no previous generation of children has had so little contact and communication with the world of adults. Learning has become more age-graded, as has all social interaction. TV, videogames, and Internet-provided pictures and music draw the young into a more virtual world. Hence, rather than formal education also placing students increasingly in front of a screen, planners must be concerned that students are engaged in more real than virtual interaction and connected to actual adults rather than just to their products. Children and youth need positive feedback from applets, but they also need to be seen and respected by peers and grown-ups as real people.

What holds for the educational process also holds for educational content. Demand-driven education means, increasingly, education that is "just in time" and "just enough." Learning what is deemed not immediately relevant may be discarded as definitely wasted. But this concept of knowledge and skills is a perversion, even of a utilitarian justification of it. It is a perversion of the rationale for a broad liberal arts education where the goal is not just to enable one to solve a problem at hand but to develop abilities as a human being to perceive and to participate, to experience, to empathize, and to excel. But then the whole diversity of one's talents must be nurtured and developed. Education, after all, means to "lead out," within and beyond one's present confines, by bringing out latent abilities and talents.

There is another issue with demand-driven education as it is commonly practiced. The growth in knowledge does not just generate a steady stream of new facts, findings, and products—about viruses, proteins, or superconductors. It also means that older knowledge becomes superseded. For instance, it is no longer useful to know which electronic vacuum tubes could be used in a computer. But new facts and data do not only mean that knowledge may become obsolete. They also mean that certain types of established knowledge become more important. The Pythagorean theorem is as valid today as it was in Greece 2,500 years ago. The Linnean system for sorting plants from the mid-1700s is at the heart of classifications still used today. The periodic table of chemistry is as valid at the start of the 21st century as it was at the end of the 19th. French irregular verbs remain as irregular as when I encountered them in high school. In short, there are fundamental frames of reference that are imperative for interpreting new information, for searching for new facts, and for new everyday applications. Knowledge of such valid models, concepts, and theories determines what we grasp of what is unknown. The discovery of DNA does not overthrow molecular chemistry; it extends its uses in biology. Hence, the stream of innovations and findings, more than ever, requires fundamental knowledge—i.e., systems for interpretation and reconstruction. Without familiarity with such systems of reference, the explosion of knowledge leads only to more confusion. Also, from a social point of view, it is the acquaintance with such frameworks that makes it possible to meet new challenges and that prepares us to gain insight, review the situation, and renew strategies; it was general knowledge about retrovirus that made it possible to quickly identify the cause of AIDS.

Even from a purely utilitarian view, "just in time" and "just enough" knowledge is misguided. First, it takes knowledge to know what you need to know. Second, truly new insights are often the result of serendipity—the happy chance combination of seemingly unconnected ideas to a new conception. "Just in time" knowledge is, in practice, often too late, and "just enough" knowledge often makes you miss the critical piece to solve the big puzzle.

The general point is this: Educational planners have to consider what a well-rounded education is. The whole point of education as a common human enterprise is that no student can bring out his or her potential if left to the student's own haphazard personal search. Students have to be led out, "educated" in the original sense of the word.

Finally, one may ask: Is ICT-assisted education better or worse than traditional education? The answer is, probably both. ICT does not suit all students, all subjects, or all phases of learning equally well. There are already considerable differences say, between the offerings in mathematics and history compared to those in music and physical education. Much depends on how ICT-assisted learning is done, and, as in traditional teaching, there are no fast formulas. Discovering and developing the potential of ICT will surely take time, and what we find may not be valid for all time because the context surely will change. Technology in itself is not a panacea; uploading Web content in different subjects does not in itself result in quality teaching or effective use. Teachers have to be trained and need to feel knowledgeable and skilled—not always easy in an environment where young students are often quicker than their teachers to learn new technologies. On the other hand, the lack of willingness to mobilize the young to learn from one another—in the same way as they learn the tricks of new video games—is not only old-fashioned but even counterproductive. Educational planners can focus no longer just on how to secure implementation; they need to arrange for continuous experimentation and innovation to learn by doing in an ever-changing environment where even what is being learned and done is changing.

CONCLUSION

There are optimistic theories about development—about a great technological leap forward or about latecomers' ability to leapfrog generations of already outdated technologies. Yet, the digital divide will be with us for years to come, and the poor will remain in the worst position for a long time, even under the most ambitious programs. Yet, perhaps the greatest divide is between the *gains* we would all reap if all of us could use the potential of the new technologies to develop our talents in ways that could benefit us all, and the *willingness* of those of us who are in the rich parts of the world to enable, empower, and involve all those who are now poor, at the margins, and not connected.

3

ICT FOR EDUCATION: POTENTIAL AND POTENCY

Wadi D. Haddad
Sonia Jurich

INTRODUCTION

Social, economic, and technological changes of the past decades are making education and training for all more crucial than ever. Yet, educational systems, to different degrees worldwide, are struggling to afford educational opportunities for all, to provide their graduates with the necessary knowledge and skills for evolving marketplaces and sophisticated living environments, and to prepare citizens for lifelong learning. To meet these challenges, countries have to focus concurrently on expanding access, improving internal efficiency, promoting the quality of teaching and learning, and improving system management.

A linear expansion of existing processes and methods may not be sufficient to meet these objectives within a reasonable time. Some countries and institutions have turned to information and communication technologies (ICTs) and are exploring ways by which ICTs may help them in pursuing their educational goals. *This chapter reviews research and experience* resulting from these attempts, with a focus on the potential of these technologies to enhance access, efficiency, quality, and management.

Frequently, users and experts tend to concentrate on what a specific technology can and cannot do for education. But, as Table 3.1 illustrates, one technology may have different potentials depending on the purpose for using it. Also, many of the technologies have similar characteristics. Therefore assessments of the potential and appropriateness of particular technologies must be based on educational needs and objectives, rather than on the technologies themselves, as emphasized throughout this chapter.

EXPANDING ACCESS

Education for All: Unattainable Reality?

Expanding access to education is a matter of both economic development and social justice. It is true that worldwide illiteracy rates have declined in the past 30 years,[1] but it is also true that the demands on knowledge are much higher now than 30 years ago. In the past, an agrarian society could thrive economically even when more than half of its population was barely literate, but this is no longer possible in modern societies in the Information Age. To remain economically competitive and prosper in this global, knowledge-driven economy, countries cannot afford to have large sectors of their population excluded from education, or at the lower level of the educational process.

Education is positively related to development—that is, a higher proportion of the population of the most developed countries has attained higher educational levels than the population of developing countries. In regions that have stronger economies, such as North America, Western Europe, and parts of Asia, more than half of the college-age youth population is indeed attending college. Tertiary enrollment in the least developed countries is about 3%.[2] Approximately 90 million secondary-school-aged children in Southern Asia were not in school in 2000, and in sub-Saharan Africa, the number of school-aged children who are not in school continues to grow.[3]

TABLE 3.1 • ICTS AND THEIR POTENTIAL FOR EDUCATION

TECHNOLOGY	OUTREACH	FLEXIBILITY*	SENSORIAL STIMULATION	INTERACTIVITY
Radio	High	Limited	Audio only	Limited
Television	High	Limited	Audiovisual	Limited
Video	Low	High	Audiovisual	Limited
PC	Low	High	Audiovisual	High
Internet	Highest	High	Audiovisual	Highest

* Limited = students and teachers must be present during transmission. High = students can access the material at different times.

In many countries, whose budgets already are stretched thin, expanding access to education under traditional models is not an option. Dramatic conflicts and the burgeoning HIV/AIDS crisis (sometimes occurring simultaneously) in many countries have disrupted social services, including education, and diverted resources that could be used to maintain, let alone, expand educational opportunity. In Togo alone, public expenditure on education already represents 25% of total government expenditures. The country's illiteracy rate for youth aged 15-24 is close to 30% for both genders (45% for girls).[4] A program to eliminate illiteracy that relies on constructing more schools and hiring more teachers will require a level of public investment in Togo that may deplete the country's budget, leaving other essential services unattended.

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Reaching Large Audiences

For more than a century, education has used technology to expand beyond the physical limits of schools and university campuses and reach more and nontraditional groups of students. For instance, in the beginning of the last century, Australia and New Zealand used a system of itinerant teachers to educate children and youth living in sparsely inhabited territories. The teachers maintained contact with their students through postal correspondence.[5] Radio, television, and computer-related technologies have expanded outreach potential further, and higher education institutions have been at the forefront of this expansion. In 1992, 41% of higher education students in Thailand and 38% in Turkey studied at a distance. The China TV University System (Republic of China) and Anadolu University in Turkey each serves more than 500,000 students per year. The United Kingdom Open University has provided education to more than 2 million individuals since it was established about 30 years ago.[6]

Distance learning institutions generally use a mix of technologies that may include printed material, videos, videoconferencing, CD-ROMs, e-mail, and the Internet. Many of them start with less expensive technologies, such as printed materials, and move to faster and more powerful resources as the need for expansion increases. The Open University of Hong Kong (see Box 3.1) is an example of this movement. (For more examples, see chapter 14.)

Including the Excluded

Expanding access also means integrating populations that have been traditionally excluded from education for cultural and social reasons. In cultures with strict rules regarding interaction between genders, girls may be forced to leave school before puberty to avoid contact with male colleagues and teachers. For girls who remain in school, the rules regarding with whom they may or may not talk make it difficult to succeed. If a girl is having academic difficulties, she may rather fail than address the male teacher.[8] Technology can promote alternatives for educating women that are more cost-effective than all-female schools without disrupting cultural traditions. Television and radio broadcasts or Internet-based technologies enable girls to continue their studies from home or small learning centers. Technology functions as a neutral mediator, without gender or cultural allegiances, thereby facilitating communication. An essay exercise in a co-educational class at the African Nazarene University that required the use of computers illustrates the potential of ICTs to overcome barriers in communication. Faced with the challenge of learning a new technology, the students forgot tribal rivalries and gender differences to exchange information and work side by side.[9]

For persons with disabilities—who represent another significant and forgotten sector of the world population—technologies provide essential supports enabling them to participate in the educational system and the job market. VisualTek is a camera and monitor that enlarge print materials for people with visual disabilities. Voice synthesizers enable individuals with muscular dystrophies to communicate. Special computer software can be used to ameliorate learning disabilities or to enhance the memory of individuals with traumatic brain injury. Keyboard adaptations enable individuals with motor disabilities to write, and the Internet can connect homebound individuals to classrooms and workplaces.

Lifelong learning and economic development for populations living outside mainstream cultures are two other venues for using ICTs. The Gobi Women's Project provided nomad women of the Mongolian desert with literacy skills, training on livestock-rearing techniques, and business fundamentals to boost the local economy. The project—a three-way partnership among Danish International Development Assistance (DANIDA), UNESCO, and the Mongolian government—used weekly radio broadcasts complemented with printed material and scheduled teachers' visits. The pilot served 15,000 women in all 62 Gobi districts and initiated spin-off projects for the women's families. The Virtual Souk is a World Bank-supported project that helps craftsmen from the Middle East and North Africa to become economically competitive. The project trains the craftsmen in small-business administration techniques and use of the Internet, and supports their participation in fairs and regional conferences. A multilingual database catalogue offers the artisans' work to a worldwide customer base. The network receives and fills orders and is responsible for quality control. Currently, the Virtual Souk involves more than 700 artisans in Morocco, Tunisia, and Lebanon.[10]

Business organizations are investing heavily in distance learning technologies, particularly Internet-based applications, to train managers and employees while avoiding the costs and disruptions related to travel. The Ford Motor Company spent $100 million on a training network using interactive satellite technology that transmits up to eight live training sessions at a time to any of the 5,000 Ford dealerships across the United States. With the savings in training-related travel costs, the system paid for itself in three years. J.C. Penney, a large U.S. department store chain, uses a similar satellite network for its training program. Savings in travel costs are estimated at $1 million over a two-year period.[11]

BOX 3.1 • THE OPEN UNIVERSITY OF HONG KONG

Hong Kong is a small but thriving economic community with one of the highest gross domestic products (GDPs) in Asia. During the 1980s, the demand for higher education in Hong Kong reached a critical point: the number of students graduating at the secondary level and desiring higher education exceeded, by far, the capacity of the few existing institutions. In addition, the expansion of high-tech industries required retraining for large sectors of the workforce. Limited physical space, funding, and qualified staff were barriers to the addition of new campuses. In 1987, the government provided start-up funds to open an independent institution dedicated solely to distance education at the tertiary level, the Open Learning Institute of Hong Kong (OLI). OLI became economically self-sufficient in 1994 and gained university status in 1997, when it was renamed Open University of Hong Kong (OUHK).

OUHK initially used for its courses prepackaged material, mostly imported from the Open University in the U.K. Printed materials, mailed to the student's home or workplace, are still used, but the courses are now developed by local experts and submitted to a system of internal and external reviewers. With foundation grants, the university developed a television broadcasting system and is implementing a Web-based project with four components: development of multimedia course materials; online drills and tests; monitoring and assessment of students' performance; and communications among academic staff, tutors, and students. In addition, OUHK is involved in research to develop language teaching and speech recognition software for the Chinese language, and in formulating quality standards for distance learning that will be adopted in Mainland China.

OUHK students can work independently or organize self-help groups in their homes, public libraries, the workplace, and the recently built campus. They must attend tutorial sessions in centers spread throughout Hong Kong and surrounding territories. A tutor supports a group of 30 to 35 students and meets with them every two or three weeks. Regular tutorial sessions are scheduled during weekdays and evenings, with optional sessions on Saturdays and Sundays. Beyond these sessions, tutors and individual students maintain phone contact as necessary. The tutors' main role is to support the students through courses and assignments. Some courses require compulsory day school and laboratory sessions. The students are expected to pay for the full cost of their courses, although the university offers public and private scholarships, grants, and loans. Employers pay the costs of employee training.

In 1992, OUHK had 18 degree-granting programs and graduated its first class of 161 students. In 1999, with more than 20,000 students, OUHK offered a doctoral degree program, about 10 master's, 41 bachelor's, and 27 sub-degrees or certificate programs through four schools (Arts and Social Sciences, Business and Administration, Education and Language, Science and Technology) and the Centre for Continuing and Community Education.[7]

PROMOTING EFFICIENCY

The Traditional Paradigm

The internal efficiency of an educational system is measured by its ability to deliver quality education in cost-effective ways. The traditional model for providing primary through tertiary education, adopted across the world, relies on three basic principles.

- Learners must congregate in a building where the teaching/learning process takes place.
- There must be a predetermined path, divided into grades, that leads to a diploma, and students must follow this path, regardless of their interests, needs, or abilities.
- There must be a hierarchic structure where the instructor is the provider of knowledge and the students are the recipients.

The traditional school is, therefore, a physical entity organized into classrooms where learners congregate according to a grade structure and constrained by the limits of space and time. If a school serves students from grades 1 through 12, it must have at least 12 classrooms to accommodate each grade separately. Each classroom must have one teacher. A certain number of teachers require a principal and, often, administrative and teaching support. If the number of students or grades increases, so must the number of needed classrooms, teachers, and support personnel. Generally, beginning in the seventh grade, another dimension is added to the classroom/grade framework: specialization. From then on, the number of teachers is related to both the number of classrooms and the number of specialties offered. Each school must have at least one mathematics teacher, a science teacher, a social studies teacher, and so on. As the educational level advances, classroom organizations will rely more on specialization than grades, but the framework is maintained.

To be cost-effective within this structure, the learning place must have a critical number of students that justifies school construction and maintenance, particularly personnel costs. In areas of low population density, building and maintaining schools to serve the traditional paradigm is economically prohibitive. The requirement of one specialist per specialty makes secondary schools an even more expensive venture. Some countries sidestep the problem by leaving the solution to individual families, with catastrophic results. If the families choose to move to urban areas and ensure their children's education, they jeopardize their country's fragile economic balance and further deplete the economy of their native regions. If they decide to remain, they jeopardize their children's future. Areas of high population density but weak economy are not free of problems. In this case, the traditional model encourages administrators to accommodate as many students as possible in one classroom to control personnel costs, which leads to overcrowded and unsafe environments that are unfit for learning.

Learning Time vs. Classroom Time

The capacity of ICTs to reach students in any place and at any time has the potential to promote revolutionary changes in the traditional educational paradigm. First, it eliminates the premise that learning time equals classroom time. To avoid overcrowded classrooms, a school may adopt a dual-shift system without reducing its students' actual study time. Students may attend school for half a day and spend the other half involved in educational activities at home, in a library, at work, or in another unconventional setting. They may be required to watch an educational radio/television program and complete related activities, or work on a computer-assisted lesson at the school technology lab or in a community learning center. For areas with low population density, multigrade schools become viable alternatives. While more advanced students listen to an educational program on the radio or watch a television broadcast, the teacher can attend to the students who are in less advanced levels or vice versa.[12]

Latin America began experimenting with television to bring education to rural, low-population areas as early as the 1960s.[13] In 1964, the Mexican government tried television as an alternative to provide secondary education (grades 7-9) for children in rural communities. *Telesecundaria* was created to respond to the needs of rural areas where a general secondary school (grades 7-9) was not feasible, because there were not enough students and it was difficult to attract teachers. A quarter-century later, *Telesecundaria* (see chapter 10) has become a success story about the power of television to expand access and improve education in cost-effective ways.

Student-Centered Curricula

Traditional educational systems also tend to rely on curricula that were developed at the beginning of the Industrial Revolution and are now disconnected from the realities of the job market. For bright students, these systems offer little in the way of motivation. Eventually, a few extraordinary students will be able to skip a grade, but rushing through the system is not encouraged, and early graduates may find obstacles when they attempt to gain access to the next level. For low-income students, who have less academic support, the schools offer even less: the wealthier schools lure the best teachers, leaving the least prepared for schools in poor and remote areas. When the need to work conflicts with schools' requirements, the student sees no reason to stay in school. As a result, these systems perpetuate social inequalities, lose many excellent students to boredom, increase the costs of education through high dropout rates and grade retention, and pass on to employers or other systems the costs of retraining their graduates.

ICTs have the potential to bring the products of the best teachers to classrooms anywhere in the world. For self-motivated, disciplined students, ICTs can speed the path toward a degree and expand their learning options through self-study. Students can "shop" courses on the Internet and choose their own program of study and schedules. Students in virtual schools (see Box 3.2) can take extra online courses to graduate earlier or fulfill specific interests and curiosity. For those who need to balance studies with work and family obligations—full- or part-time workers, parents of small children, homebound individuals—this flexibility may be most cost-effective for them.

The management of distance learning projects is not without difficulty, and, in many cases, local regulations function as obstacles to innovations (chapter 4 includes a discussion of this topic). However, the demand for more and specialized education is encouraging new arrangements that rely on ICTs to establish communication networks among partner institutions and facilitate student-centered, rather than program-centered organizations, such as the University of the Highlands and Islands (see Box 3.3).

IMPROVING THE QUALITY OF LEARNING

Learning about Learning

Research on brain physiology and cognitive psychology is challenging the traditional model of learning as mastery of facts and concepts. Descartes's proposal, "I think, therefore I am," is only partially true. Thoughts, feelings, dreams, and imagination are equally involved in the complex phenomenon that is human nature.[16] The acquisition of knowledge encompasses more than cognition. Perception, for instance, includes at least two basic components: (1) an "objective" component mediated through the senses, which provide the brain with information about the objects surrounding us, their descriptions and location, and our position in relation to them; and (2) a "subjective" component that analyzes the perceived objects through the lens of personal experiences and idiosyncrasies, previous knowledge, and cultural biases.[17] A person born and raised in New York City sees only snow, while an Eskimo sees a variety of landscapes and resources for survival.

Images are key components of the process of acquiring and using information because of their ability to condense large amounts of data. Research on working memory proposes that information is stored as images in visuospatial sketchpads to be used later. The process involves both imageries—the mental reconstructions of objects no longer present to our senses, and imagination—the mental construction of unknown objects. In addition to their role in retention and recall, images have the ability to decode unfamiliar symbols into known representations, a helpful function in language acquisition. Textbook images traditionally have been used in foreign language classes with this decoding function. Images are equally important in the acquisition of science and mathematics, which, similar to a foreign language, have their own symbols, terminologies, and grammatical structures.[18]

Although definitions of quality learning may disagree on details, it is generally accepted that, for learning to occur, the learners must be motivated, basic concepts must be understood, and knowledge must be advanced through more complex, higher-order thinking skill tasks. As we move away from linear learning, we get closer to how the brain functions. ICTs diversify the systems of representation through the use of various types of stimuli (images, sound, and movement) and address the needs of diverse types of learning (visual, psychomotor, and affective). In addition, ICTs have

BOX 3.2 • THE VIRTUAL HIGH SCHOOL (VHS)

The Virtual Schools is a research-based project administered by a partnership between the Hudson Public School (Massachusetts, USA) and The Concord Consortium. The project explores the potential of ICT to improve the quality and accessibility of courses offered at high schools without expanding school enrollment. Through the Internet, participating schools can offer new courses and more courses without the need for increasing enrollment to justify the expenses. The project functions as a cooperative. Each participating school contributes at least one teacher and a site coordinator to the project, and, in exchange, the school can enroll a preestablished number of students in any VHS courses. A site coordinator helps to recruit the students and teachers, ensure that the technology is available and functioning, and provide support to the students. The advantage of the cooperative system is that the major cost of a project—personnel—is shared among all participants.

Before developing the online course, the teacher must complete a graduate-level course on design and development of network-based material. Each online course may take a year to develop, and must be approved by the school principal and VHS central staff. More recently, an Evaluation Board has been formed to define standards of quality for the courses. The courses, mostly one semester long, are taken for credits as core subject or elective. The courses are mostly interdisciplinary and use student-centered, hands-on instructional strategies that emphasize collaborative learning and inquiry. Students can take the course at home or during school time. In this case, the VHS coordinator functions as a tutor. The online courses are housed in a LearningSpace educational environment that enables teachers to deliver lectures, moderate student discussions, conduct assessments, and receive students' work. Students can submit work individually or in groups and can participate in discussions with their peers.

The first semester of the project was hampered by a series of technical problems and the lack of participants' experience with the process. For instance, because staff underestimated the server capacity that would be needed to support 350 students online, the courses were offline for a few weeks. As time passed, technical difficulties decreased, the teachers learned how to manage the logistics of online teaching, and students improved their understanding of the responsibility and persistence necessary to participate in distance learning. During the 1997-98 school year, the project had 30 participant schools and offered 30 courses to 700 students. In 1999-2000, the number of schools grew to 87, and the project offered 94 courses to more than 2,500 students. It is estimated that the project will serve more than 6,000 children over the five-year grant period.[14]

BOX 3.3 • THE UNIVERSITY OF THE HIGHLANDS & ISLANDS (UHI)

Scotland's Highlands and Islands region faces many of the problems common to developing countries. The region is geographically dispersed, with a predominantly rural population. The weak economy is heavily dependent on small business and medium-sized enterprises, and the labor force includes unusually large numbers of self-employed, part-time workers and unemployed. Demographic dispersion, multiculturalism, and bilingualism challenge the planning and implementation of local educational systems.

In 1993, UHI was created to promote economic and social development in the region. Its first priority was to provide relevant education and training to the large number of local unemployed and underemployed. To respond to the diverse interest and needs of these nontraditional students, UHI changed its course structure from grades into thematically oriented modules. For each module completed, the students accumulate credits, and, upon completion of 120 credits, a certificate is issued. Paid and unpaid work may count toward credits. The students work at their own pace, and no time limit is imposed. Rather than expecting students to complete degrees, UHI sees them as lifelong learners.

This student-centered structure increases the demand for diversified curricula. In response, UHI has built a network of experts to develop and implement a variety of courses. Through technology, including videoconferencing and the Internet, UHI connects more than a dozen colleges and research institutions with a network of nonformal learning environments (businesses, public agencies, learning centers) where students work under the guidance of tutors. UHI students are never really remote; they maintain regular contact with tutors and professors through e-mail, telephone, and videoconferencing. This networking system ensures a critical mass of students that justifies the costs of producing and implementing a large number of courses. Currently, UHI serves more than 22,500 students, of whom 4,546 are in higher education programs.[15]

the potential to enhance educational quality by increasing motivation, facilitating acquisition of basic skills, promoting inquiry and exploration, and preparing individuals for the technology-driven world.

Motivating to Learn

An effective teaching/learning process must stimulate intellectual curiosity and offer a sense of enjoyment that will move the students from the passive role of recipients of information to the active role of builders of knowledge.[19] Yet, engaging the learner in this process can be the most challenging task for teachers. ICTs are effective instructional aides to engage students in the learning process.

Videos, television, and computer multimedia software provide information that can be authentic and challenging in addition to stimulating students' sensorial apparatus through images, color, sound, and movement. A project in Malawi filmed community members in their traditional jobs to introduce scientific concepts to elementary school children.[20] Brazilian *Telecurso* (see chapter 10) is a televised educational program for young adults in search of a high school equivalency diploma. The program also uses videotapes of activities familiar to the students when introducing abstract concepts.[21] A training program for bank clerks in the United States was unable to offer on-the-job training because banks refused to accept trainees without some experience. The instructors decided to use videos of actual clerks working at a local bank and trainees role-playing clerk-customer situations. Trainees watched the movies and discussed the tasks involved, potential problems, preferred solutions, and their weaknesses/strengths. After the videos were introduced, the program placement rates increased from 70% to 93% over a two-year period.[22]

Although radio programs do not have the visual appeal of television or computer, Interactive Radio Instruction (IRI) uses songs, drama-like plots, and comic situations to attract and maintain the attention of students of all ages in rural and low-income areas of developing countries (see chapter 9).

Facilitating the Acquisition of Basic Skills

Transmission of accumulated knowledge to new generations is an essential component of the educational process. This includes basic skills and information that are at the foundation of more complex knowledge. It would be inefficient to use a time-consuming process, such as inquiry and exploration, to transmit basic information. In addition, nonstructured learning environments based solely on inquiry and exploration may be confusing and overwhelming for some children and youth. These students will do better in well-structured classrooms, where the information is broken into less complex units, thus making it easier to understand. Exposition and practice strategies help to structure the classroom, enhance retention and recall, and cut learning time.

Educational television programs, such as *Sesame Street*, apply repetition and reinforcement to teach children about letters, numbers, or colors. Computers have three attributes that make them powerful aides for drill and practice strategies: large memory, speed, and the capacity to repeat the same task an infinite number of times without reducing performance. In addition, they provide students with the opportunity to learn on their own time and at their own pace. Computer-aided instruction (CAI) has been used successfully in different settings for basic skill instruction. CAI programs are divided into modules that maintain a hierarchy of concepts and skills. The students have to master each module before being allowed to move to the next, more complex level. An evaluation at the end of each module gives the students immediate feedback. If they respond correctly to a determined percentage of questions, they advance. Otherwise, they repeat the module or enter remedial units until the skills or concepts are mastered. The program can keep a history of the students' performance—lessons learned, topics with which the student had more difficulty, strategies that improved learning, and how many times the student had to repeat the module. With this information, the teacher can develop an individualized plan that addresses each student's specific weaknesses and strengths. CAI was introduced as an aid in mathematics classes, but it is now used for different disciplines, grade levels, and objectives. The military has used CAI in training for a long time. Overall, research shows that when CAI is applied well, users learn faster, retain more, and tend to have a more positive attitude toward learning than students receiving traditional instruction.[23]

Computers also can be used as auxiliary tools in mathematics and science classes to free teachers' and students' time. While computers work on repetitive tasks (such as long calculations and statistical computations), teachers and students can concentrate on analytical activities that require higher-order thinking skills.[24] Research indicates that elementary and secondary school students who use calculators have higher test scores and better attitudes toward mathematics than their peers who do not use calculators. Elementary school children who use computers and calculators in the classroom were found to understand mathematical concepts much earlier than expected.[25]

Fostering Inquiry and Exploration

Although basic skills and information are essential components of the teaching/learning process, learning is more than information transfer. Learning requires the ability to analyze and synthesize information, use it in diverse circumstances, and propose new lines of inquiry that foster knowledge. Inquiry and exploration are essential strategies to attain those abilities. Astronomer Carl Sagan used to say that all children start out as scientists, full of curiosity and questions about the world, but schools eventually destroy their curiosity. ICTs have the potential to restore curiosity to education.

ICTs can take students on exciting journeys through time and space. Movies, videos, audio technology, and computer animations bring sound and movement to static textbook lessons and enliven children's reading classes. They also provide social studies and foreign language students with vicarious experiences of distant societies and bygone times. Spreadsheets can store and analyze large amounts of data necessary for complex math and science studies. Computer simulations transform risky and expensive experiments into safe and cost-effective procedures. The Internet offers virtual reality settings where students can manipulate parameters, contexts, and scenarios.

Computer simulations are a good example of the power of technology to improve the learning process. The flight simulator has been used for decades as the initial step in training airplane pilots. A flight simulator offers trainees the opportunity to practice the proper skills to control the plane and deal with emergency situations without risking lives or property loss. Although flight simulators can be complex and expensive machines, no pilot training program would question their utility. Simulators also are becoming essential tools in medical training. Through their use, medical students and residents are introduced to risky and invasive procedures without endangering patients' lives or exposing them to unnecessary pain and discomfort. Simulations are particularly helpful in situations that are too risky, expensive, or time-consuming to allow real-life experiments. For instance, welding simulators have proved to be a cost-effective method to train future welders. Without simulators, this training requires long hours of practice and burning expensive electrodes.[26] Simulations also enable students to test explosive materials virtually without running the risk of real explosions, and to "experiment" on animals without the ethical implications of real-life procedures.

For elementary and secondary school students—and sometimes even for adults—exploring the Internet can be a fun and enriching experience, or a frustrating adventure in trivia. Teachers and instructors play an important role as guides and facilitators by providing background material and guidelines for the search. They also need to monitor the process, particularly for younger students, who tend to browse the Web, rather than follow structured search plans. Teachers and instructors also are instrumental in helping students to separate unreliable sources from reliable ones and make sense of the large amount of information that may overwhelm them.[27]

Preparing for the "Real World"

Globalization, creativity, and collaboration are key words in the modern workplace, where employers and employees are expected to share knowledge and work together toward common goals. In traditional classrooms, students work in isolation, doing tasks that emphasize conformism and boost competition. Trained in such environments, students may leave the school ill prepared to share ideas, divide tasks, or accept different points of view. Since ICTs can overcome physical and geographical barriers and facilitate communication, they have the potential to eliminate the artificial boundaries between schools and the outside world, and promote an environment that emphasizes collaboration rather than competition.

Videos and computer animations enable students to "witness" a volcano eruption to learn about pressure, rock formation, or psychological and sociological responses to crises. A simple radio or tape recorder can allow students in a foreign language class to listen to native speech regardless of their teachers' origin. Better yet, with interactive technologies, such as two-way radios or videoconferencing, students can communicate with native speakers without leaving their classrooms.[28] Videos, DVDs, computer software, and the Internet bring to schools anywhere in the world information that can be obtained only through the use of powerful scientific instruments that no single school can afford.[29]

More than any other technology, the Internet opens new opportunities for collaborative work. From group discussions to full collaborative research projects, the Internet has the potential to connect classrooms to research centers and students to actual scientists, as does the Global Learning and Observations to Benefit the Environment (GLOBE) (see Box 3.4). Research on the Apple Classrooms of Tomorrow (ACOT) indicates that technology-rich classrooms promote teamwork and encourage tolerance for alternative viewpoints, two essential skills for increasingly complex and diverse workplaces.[30]

ENHANCING THE QUALITY OF TEACHING

Teacher Training

Learning is only one component of the educational process, and quality learning cannot be attained without good teaching. Yet, teachers in general, and good teachers in particular, are in short supply even in developed countries. In the United States, for instance, the National Commission on Teaching and America's Future anticipates the need to hire an additional 2 million teachers in all teaching fields over the next decade to replace an increasingly aging workforce. For developing countries, in rural areas and in some specialties such as math and science, the teacher shortage has become critical.

Simply hiring a teacher does not ensure quality education. To be effective, teachers must keep abreast of new perspectives on learning theories and their area of specialization, a task that becomes impossible when teachers work in distant, isolated areas. The mentoring process that has been used traditionally to prepare new cadres is an extra burden on experienced teachers, particularly in places where they are already in short supply. Some schools of education are using videotaped sessions to prepare new teachers to enter the classroom without relying solely on mentors. The process frequently involves videotaping experienced teachers during regular classroom time. Student teachers observe their experienced peers in action, analyzing in detail the strategies used to present the material and interact with the students. The trainees then practice mock lessons with a group of peers or volunteer students while being videotaped. Peers and instructors review the tapes, highlighting weaknesses and strengths and making suggestions for improvement. Only after completing this process is the student teacher sent into actual classrooms.[32]

Videos can also be used to analyze teaching styles and idiosyncrasies and help educational systems to change their approaches. A research project related to the Third International Mathematics and Science Study (TIMSS) videotaped mathematics and science teachers in Japan, Germany, and the United States. The study analyzed variations in teaching style and lesson content among the three countries, looking for correlations between those dimensions and students' performance.[33]

ICTs can be used as tools for training and support of teachers, regardless of their geographical dispersion. Scripted lessons in conjunction with educational programs via radio and television, such as the IRI and *Telesecundaria* projects, ensure that all students receive quality, updated information, while imparting to inexperienced and generalist teachers the appropriate content knowledge and new pedagogical strategies. The use of technology for teacher training has at least three major advantages: it reduces travel costs, avoids disrupting classroom routines, and familiarizes the teachers with the technology. (For a fuller discussion of this theme see chapter 8 on teacher training and

BOX 3.4 • GLOBAL LEARNING AND OBSERVATIONS TO BENEFIT THE ENVIRONMENT (GLOBE)

GLOBE is an Internet-based project that allows students and teachers, in kindergarten through high school, to contribute to scientific research. GLOBE focuses mostly on mapping and understanding patterns and changes in three major areas: atmosphere/climate, hydrology/water chemistry, and land cover/biology. The project, launched on Earth Day 1994, is administered by a partnership that includes some of the most renowned scientific organizations in the United States, including the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF).

The project has three main objectives: to improve mathematics and science education across the globe, to raise environmental awareness, and to contribute to a worldwide scientific database about Earth. To attain these objectives, GLOBE scientists help teachers and students develop projects such as measurements of pH in the water, analyses of temperature readings to observe changing patterns, etc. GLOBE can be implemented in different ways: as part of a science class, a separate class, a club, a lunch group, etc. In kindergarten and grades 1-3, GLOBE teachers work in a project with 10 or fewer students, but as the children advance, the groups can be much larger. The students conduct measurements and analyze data that are then stored in a central database, and scientists use these data for their research. Data and findings are available to all participants in numeric and graphic representation, and ongoing communication between schools and scientists is maintained. To ensure that the data collected are compatible, participant schools must use the same software and measurement tools and obey the project's scientific protocol. Approximately 9,500 schools in more than 90 countries participate in GLOBE, including schools in Benin, Burkina Faso, Cameroon, Chad, Gambia, Ghana, Kenya, Mali, Namibia, Senegal, South Africa, and Uganda.

An evaluation of GLOBE found that participating students perform better than their peers in activities that require an understanding of science, including the ability to interpret data and apply scientific concepts. They also showed a greater appreciation of science. In addition, the project instills in the students pride in their work, which is taken seriously by scientists and community members. For instance, GLOBE students in a North American school were asked by their local fire company to examine the reason for a foul smell in its station. The students' pH measurements of the local water supply helped government scientists to find a gas tank leak in the vicinity. The gas was infiltrating the soil and causing health problems. The students' participation was instrumental in solving the problem and was the best possible lesson in the importance of science for everyday life.[31]

development and chapter 15, which describes experiences in the use of technology for teacher training.)

Teacher Support

The Internet has myriad Websites to help teachers develop or improve lesson plans, exchange ideas, obtain information, and find free animations and simulations to enliven their lessons. Most Internet-based collaborative learning projects include teacher support and training, and conference proceedings are published regularly on the Web. Chat rooms or forums may become a laboratory for new ideas. For instance, teachers in Soweto, South Africa, used their online connection with schools in Birmingham, U.K., to create a support network and promote discussions on curriculum reform and school management practices.[34] Indeed, contrary to the notion that technology is replacing the teacher, ICTs have expanded the quantity and quality of resources available to making teaching a less lonely endeavor.[35]

Teacher Empowerment

More important still, research indicates that the introduction of ICTs for educational purposes has the potential to bring positive changes to teaching practices. In a survey of more than 2,000 teachers and school principals across the United States, the teachers stated that the technology helped them to become more effective (92% of respondents) and creative (88%). Both teachers and administrators agreed that technology had reinforced instruction, and functioned as a motivator for the students, who were more prone to ask questions and participate in the lessons.[36] More dynamic classrooms were also observed in evaluations of ACOT project.[37]

Despite this potential for training and support, ICTs have not been accepted easily among teachers. Some complain that scripted lessons take away their ability to address students' individual differences and improve their own teaching strategies. Others fear that technologies will reduce the role of teachers in defining curriculum and educational strategies, or totally replace them. This theme is discussed further in chapter 4.

IMPROVING MANAGEMENT SYSTEMS

Education policy development is an intricate process that requires reliable, timely, user-friendly data. ICTs can be valuable for storing and analyzing data on education indicators; student assessments; educational, physical, and human infrastructure; and cost and finance. The use of computer-related technology is particularly helpful in this field. For instance, administrators and policy makers can construct virtual scenarios around different policy options to determine needs and analyze potential consequences. Each scenario can be analyzed and evaluated systematically, not only in terms of its educational desirability, but also in terms of financial affordability, feasibility, and sustainability over a sufficient period of time to show results.[38]

The same elements of computing and telecommunications equipment and service that have made businesses more efficient and cost-effective can be applied to schools and educational systems. ICTs can help administrators and school principals to streamline operations, monitor performance, and improve use of physical and human resources. More than other technologies, computer-related technologies have the potential to support the management of complex, standards-related instructional processes in relatively simple ways. They also can promote communication among schools, parents, central decision makers, and businesses, thus fostering accountability, public support, and connectivity with the marketplace. For instance, the Union City School District, located in one of the most impoverished communities in the United States, accepted an offer from the

BOX 3.5 • ICTS FOR EDUCATION MANAGEMENT AND TEACHER TRAINING, A CARIBBEAN EXPERIENCE

The Joint Board of Teacher Education (JBTE) is a partnership among the University of West Indies, Mona Campus, three Ministries of Education, 14 training teacher colleges, and three teacher unions and associations in the Bahamas, Belize, and Jamaica. Its mission is to guarantee the quality of teacher education in the Western Commonwealth Caribbean. During the 1980s, the JBTE introduced significant reforms in the teacher education system, including alignment of teacher preparation programs with the countries' national curriculum; establishment of common admission criteria, curricula, and examinations in all teacher preparation programs; and adoption of a semester structure to deliver the programs with external semester examinations. An immediate consequence of the reform was a significant increase in the number of examinations developed and managed by the JBTE (from about 12 to more than 300 each year). However, as the demand for resources increased, the flow of money to the education sector had been reduced.

Personal computers were used initially at JBTE to produce the examinations. With time, the Secretariat expanded their use to process the exams. PROSOFT, a small Jamaican software firm, was contracted to build a record system that included data on staff and students (demographic information, courses taught/learned, etc.). The teacher preparatory colleges became interested. At their request, JBTE and PROSOFT developed the College Manager, a management system that handles student and staff matters at each college, and allows for online transactions between the colleges and the JBTE/Ministry of Education system. The project faced many difficulties, such as delays in implementation, software bugs, a fire that destroyed part of the database, shortage of competent staff to coordinate and manage the process, and high turnover of clerical and administrative staff.

Despite all of these difficulties, the JBTE partners were able to install a management information system customized to their needs. The losses associated with the delays in the project—which took seven years to complete—were compensated for by the increase in computer power associated with declining prices. The central database has sped up the process of producing the JBTE examination and processing results significantly. JBTE is now planning to expand the use of ICTs for online teaching and support of teachers and student teachers. Some of the technology's potential put in place was not planned originally, such as creation of a common pool of teacher college applicants. Before, the colleges received and processed applications independently. While one college had to refuse good students for lack of accommodations, another college might have to accept students who were less qualified. The common pool ensures that colleges have a more qualified group of students, and good students do not miss the opportunity to enter a teacher preparatory college.[40]

local telephone company to install computers in a pilot middle school and the homes of its teachers and parents. All those involved received training. The project improved communication significantly among parents, teachers, and school administrators and was expanded to include other schools.[39] An example of the use of computer-related technologies to address increasing demands in a time of reduced resources is provided by the Joint Board of Teacher Education (JBTE) in the Western Caribbean (see Box 3.5).

HOW EFFECTIVE?

The preceding sections of this chapter outlined from research and experience the potential of ICTs to enhance educational policies, objectives, and practices. The effectiveness of ICTs—the realization of their potential—depends to a large extent on the context and quality of application. Moreover, since ICTs are only tools for education, it is difficult to isolate the factors that may be contributing to a positive result—such as educational philosophy, quality of teaching, parent support, and students' characteristics.

With these caveats in mind, evidence from large studies and meta-analyses suggests that use of ICTs, particularly computer technologies, is correlated to positive academic outcomes, including higher test scores, better attitudes toward schools, and better understanding of abstract concepts.[41] A longitudinal study of a statewide experiment with computers in the classroom found that those most in need of help—low-income, low-achieving students, and students with disabilities—made the most gains.[42] In addition to better performance in traditional measures of academic achievement, a secondary benefit of ICTs in education is to familiarize new generations with the technologies that have become integral components of the modern world. However, research on the effect of ICTs on academic achievement continues to be open to criticism (as with all other areas of education). Critics deny positive findings as the result of flawed studies, while supporters promote positive results without sufficiently evaluating the quality of the studies.

In the final analysis, ICTs are as good as how they are used. The path from potential to effectiveness is neither easy nor automated. Chapter 4 deals with conditions for and constraints of ICT effectiveness, and Part II elaborates on the options and choices to be made in applying ICTs in education.

ENDNOTES

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[3] UNESCO, op cit., pages 63-64, Figure 3.5.

[4] UNESCO, op cit., p. 164, Table 10, and p. 132, Table 2m.

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4

ICT FOR EDUCATION: PREREQUISITES AND CONSTRAINTS

Wadi D. Haddad
Sonia Jurich

INTRODUCTION

This chapter, like chapter 3, is a *review of literature and experience* pertaining to the use of information and communication technologies (ICTs) for educational purposes. While chapter 3 concentrated on the potential and potency of ICTs for education, this chapter focuses on prerequisites and constraints that influence the use of information and communication technologies as tools to expand and improve education, with an emphasis on current status and existing trends and on possible ways to overcome identified barriers. To facilitate the analysis, the factors identified are organized schematically into three broad areas, as shown in Figure 4.1., access, acceptance, and availability.

Access—includes the basic requisites for the installation and use of technologies:

> Infrastructure—foundations for the technology
> Costs and finance mechanisms—financial sustenance of the projects
> Legal frameworks—laws and regulations that facilitate or constrain the use of technologies for the proposed objectives

Acceptance—cultural and political factors that create or promote barriers to technology projects:

> Cultural perspectives—nationalism, traditions, attitude toward innovations
> Political perspectives—priorities, interests, and negotiation power
> Interest groups—influence of unions, businesses, parents, and other groups
> Educational systems—objective, structure, and organization

Availability—technology-related factors that facilitate or hinder project implementation:

> Contentware—what the technology can offer in terms of content, language, quality, and relevance of material
> Experts—presence or absence of qualified staff (technicians, support personnel, and trained educators) who can implement a quality project
> Capacity building—interest in building or ability to build an expert workforce

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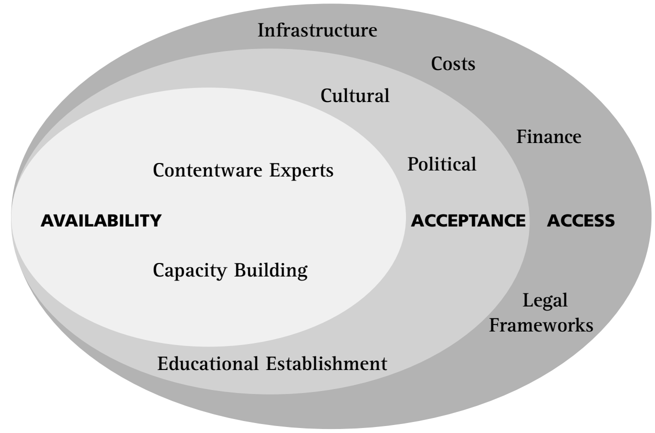
FIGURE 4.1 • PREREQUISITES AND CONSTRAINTS IN THE USE OF TECHNOLOGY FOR EDUCATION

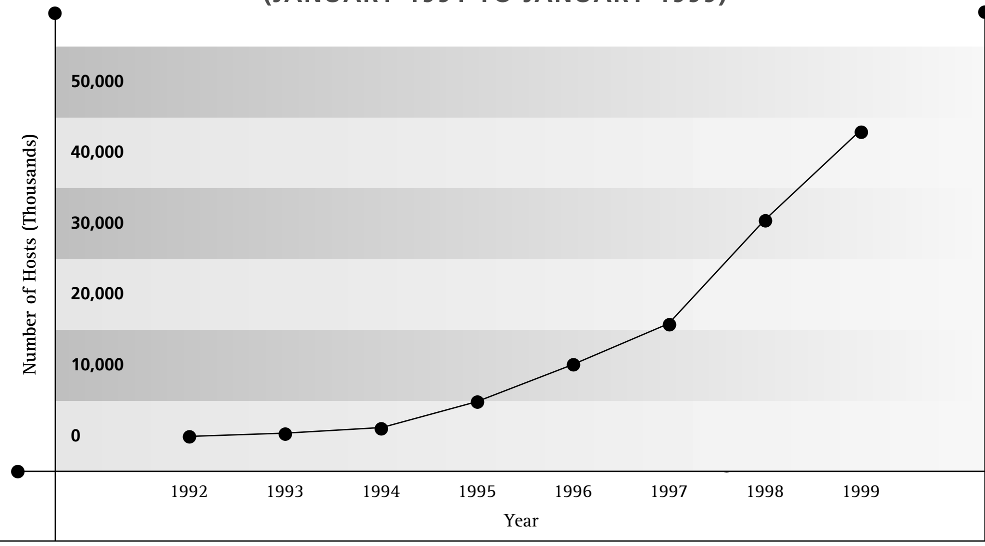


ACCESSING THE TECHNOLOGIES: THE BASIC CHALLENGE

Five major trends have characterized the development of ICTs:

> *Complementarity*—ICTs complement, rather than replace each other. Videoconferencing and digital radio are two examples of how different technologies are associated to improve results.
> *Speed of growth*—ICTs have grown exponentially. In 1950, personal computers were little known or used, but within a generation, they became essential work and communication tools. The number of Internet hosts worldwide grew more than 1,100 times in eight years (Figure 4.2).
> *Reduced costs*—Increased use of ICTs is associated with reduced costs and improved technology. This trend is particularly felt in the computer industry, where hardware prices have fallen, despite significant increases in memory and speed. Internet access is another area where growth has been accompanied by some cost reduction. From 1999 to 2004, the number of U.S. households online is estimated to increase by 66% (from 40.5 million to 67.1 million), but spending on access is estimated to rise only 9.2% CAGR (compound annual growth rate). Similarly, broadband Internet access is expected to increase 800%, from 2.1 million subscribers in 1999 to 18.9 million in 2004, while broadband spending will grow 527%, from US$1.1 billion to US$6.9 billion, respectively.[1]
> *Simplification*—ICTs strive for simplicity of use, even when the technology becomes gradually more complex. The first disk operating system- (DOS-) operated personal computers (PCs) required some training for simple

FIGURE 4.2 • GROWTH OF INTERNET HOSTS WORLDWIDE (JANUARY 1991 TO JANUARY 1999)



SOURCE: RedHUCyT, *www.redhucyt.oas.org/*.

tasks; however, children have no problems dealing with modern PCs. This concern with the user may explain, at least partially, the rapid popularity of the medium.

> *Problem-solving focus*—Perhaps more than any other technology, ICTs strive for efficiency: they are faster, simpler, less costly, and more productive. This search for efficiency propels ICTs to continuous improvements. Auto industries have relied on one source of fuel for the past 100 years, despite warnings ranging from potential extinction of this sole source to environmental disasters. In less than 50 years, telecommunications have experimented with simple telephone lines, fiber optic cables, satellites, and wireless technologies, and research continues.

These characteristics encourage and challenge a planning process that aims at introducing technology in education. The encouragement comes from the fact that educational agencies and countries can leapfrog from pretechnology stages (e.g., the absence of telephone lines) to state-of-the-art strategy (e.g., wireless technologies), thus bypassing less efficient and generally more expensive alternatives. The challenge is that technology planners must be creative and look toward the future to ensure they are not missing a better and less costly option.

Access to ICTs and the Digital Divide—Access to modern information and communication technologies varies greatly around the world. Until now, ICTs have not corrected the divide between technology-rich and technology-poor countries initiated with the Industrial Revolution. As before, ICT access is related positively to economic development—the higher the region's income, the greater the ICT access (Figure 4.3).

But, income is not the only variable that influences access to technology. In the United States, for instance, there is a correlation between race and computer ownership or Internet access. Whites are more likely to own a computer than blacks, even when controlling for differences in education, except for those at the highest income levels.[2] Between December 1998 and August 2000, the gap in Internet access between black households and the national average grew from 15% to 18%; for Latino households, the gap grew from 14% to 18%.[3] In China, significant differences exist in age and gender among Internet users—approximately 50% of Internet users are between 18 and 24 years of age and 75% are male.[4] A similar trend is found in Brazil, where 61% of the Internet users are male, and 56% are aged 14-24.[5]

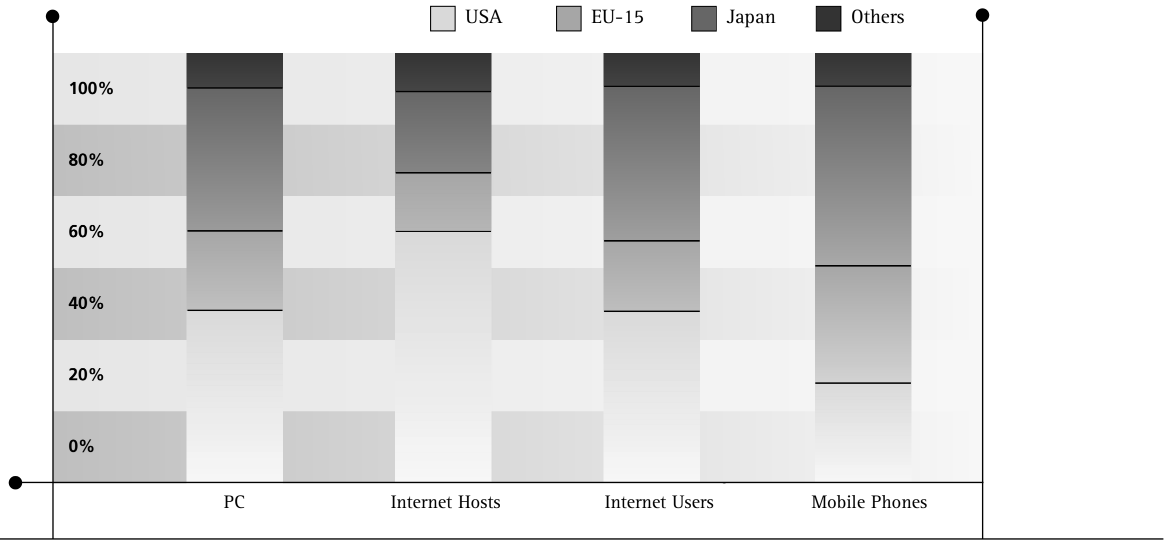
Access to ICTs depends on three basic prerequisites: infrastructure, costs and financing mechanisms, and legal frameworks.

Infrastructure

Current Status

Until recently, most information and communication technologies depended on electric power and telephone lines. The production and consumption of energy varies broadly across countries in direct relationship with their economic

FIGURE 4.3 • THE INFORMATION SOCIETY (PER 100 INHABITANTS)



SOURCE: Deiss, R. (April 2001). *Information Society Statistics*, Statistics in Focus: Industry, Trade and Services, theme 4; Eurostat; Table 1.

development. Developing countries tend to have lower levels of energy production, less efficient systems that produce great loses during transmission and distribution, and lower consumption levels. On average, poor countries consume 5% of the energy consumed by wealthy countries. The consumption range is wide, varying from 21KWh in Ethiopia to approximately 24,000 KWh in Norway.[6]

Availability of telephone mainlines follows similar distribution: wealthier countries—and wealthier regions within a country—have more phone lines per inhabitant than countries and regions with weaker economies. For instance, while Switzerland has 675 mainlines per 1,000 inhabitants, Rwanda has two. Residents in the largest cities in sub-Saharan African countries are twice as likely to have telephone lines as those living elsewhere in the country. In South Asia, urban residents will be five times more likely to have telephone lines, in contrast with the European Union, where the ratio between urban and nonurban areas is approximately 1:1. Within the same world region, differences also can be significant. In Latin America and the Caribbean, for instance, Chile has 203 mainlines per 1,000 (281 in the largest city), while Haiti has eight (17 in the cities). In the Middle East, the United Arab Emirates have 389 mainlines per 1,000 (374 in the largest city), while Iraq has 31 and 75, respectively.[7]

Costs strongly influence access. Despite reduction in costs in the past decades, indicators still show significant cost differences among countries and within countries in a single region.[8] In sub-Saharan Africa, the average cost for a three-minute local call was US$ 0.09 in 1998, but Gambians paid an average US$0.32 per call. International three-minute calls varied from more than US$26 in Syria and Myanmar to less than US$1 in New Zealand and the Netherlands.[9] In 1999, average monthly rates for Internet access in Latin America ranged from US$81.71 in Trinidad & Tobago to US$12.75 in Peru, with a regional average at US$36.23.[10] Business's rates are much higher. In Bermuda, for instance, businesses can pay more than US$850 a month for unlimited Internet access.[11]

A Special Note about Radio

As a means of mass communication, radio has many advantages: it has broad outreach, is relatively inexpensive, is easy to use, and is present in almost all households around the world. In addition, radio programs are less expensive to produce than television, videos, or computer software. Although radio lacks the visual effects of television and computers, educational programs broadcast via radio have popular appeal. Most of all, radio does not require complex infrastructures. Battery, windup, or solar-powered radios ensure transmission even where electricity is not available or dependable. Walker describes a portable FM radio system operated entirely by solar power, part of the Commonwealth of Learning Media Empowerment (COLME) project in Uganda.[12] To overcome the limited and unreliable electricity supply in the region, the project staff built a structure with eight solar panels and seven deep cycle batteries. This structure provides all the lighting and power needed to operate the station during the 18-hour broadcast day. In addition, the solar installations have a life span of more than 10 years and low maintenance costs.

Moving Ahead

If a "catch-up" strategy seems doomed to fail, the technological search for faster, broader, and more efficient means of communication offers new hope to countries or regions with limited infrastructures. Trends in ICTs include:

- *Digital radio*—The association of streaming technology and the conversion from analog to digital radio broadcasting enabled radio stations to reach global audiences. Different from analog radio, where the power of transmitters is essential for broadcasting success, digital radio has low power requirements, which means lower operating costs. This capability enables smaller stations to offer power and quality similar to their wealthier competitors.[13] In addition, digital audio broadcasting allows for transmission of text or graphic information that can be displayed on a small screen on a digital radio. This increases the usefulness of radio as an educational tool, particularly for disciplines where visualization is an essential decoder, such as foreign language, mathematics, or science.
- *Satellites*—Satellites have been used to transmit multimedia information, including television broadcast, for many decades. The large, geostationary satellites orbit Earth at high altitudes (36,000 Km), and data are sent to the satellites and back to large terrestrial transceivers through high-frequency beams. The technology is expensive and limited in quality, with a long propagation delay—about 0.25 sec.—which restricts its use for voice transmission. More recently, low earth-orbiting satellites (LEOs) are being launched. These are small, computerized devices that circle Earth at high speeds and low altitudes (780 Km). Their short propagation delay—about 12 msec.—and virtually error-free connections to ground stations make them popular tools for wireless communication. In addition, LEOs' receivers can be very small, thus increasing their outreach mobility.[14] To compensate for the expensive technology, particularly in the case of geostationary satellites, regional partnerships are multiplying. The Regional African Satellite Communications (RASCOM) is an organization of 44 African nations that aim at connecting all major African cities via satellite network. RedHUCyT is a satellite-based network of higher education and research institutions in the United States and Latin America, with support from the Organization of American States. In addition to connectivity, the project provides equipment and training to participating members.[15]
- *Cables, wireless, and others*—As communication moves from e-mail to complex electronic transactions, capacity or bandwidth requirements increase. Traditional telephone lines are no longer sufficient to carry the amount and type of information that is being exchanged electronically. A simple 2400-baud connection can only transmit about 240 characters per second of an e-mail message. Audio and video applications through the Internet require a minimum of 14.4Kbps, and videoconferencing needs 128Kbps.[16] The expansion of the Internet and, more recently, e-commerce created a new demand (and new solutions) for more bandwidth. The bandwidth demand between Europe and the United States is expected to grow by approximately 80% a year. In response, digital subscriber line (DSL) cable and alternative proposals are multiplying, mostly through private companies' efforts to ensure their share of a promising e-market. Between 1995 and 1997, the private circuit capacity between the United States and other OECD (Organisation for Economic Co-operation and Development) countries had a compound increase of 172% and surpassed the capacity allocated to international message services (mostly public).[17] Education projects may profit from this market-driven growth.

In the past 10 years, wireless technologies have gained increasing acceptance among residential and business users. However, they should not be seen as the solution for all the problems with infrastructure. Start-up costs are high, and the project requires highly trained technicians; some wave-bands are highly sensitive to weather conditions, thus increasing the probability of errors, and they require a high level of coordination to avoid interfering with other radio spectrum users. In places with an already well-developed network, fiber optic cables offer more transmission capacity with smaller margins of errors and at lower cost. Where the infrastructure is missing, wireless technologies may be a solution, even if only a temporary one.

Considering the speed of change in the ICTs industry, discussions on the use of ICTs for educational purposes should focus not only on the technologies available, but also on those that are in the planning stage, and should evaluate how feasible and affordable they are for each specific case.

Costs and Finance Mechanisms

As stated earlier, decisions on the use of technology for education are, first of all, educational decisions. Yet, the immediate costs of a technology project often have greater impact on decision makers than its potential benefits. Discussions on costs of the educational uses of technology tend to compare traditional and technology-mediated approaches as if they had similar purposes. For instance, estimates of higher education costs compare campus universities with distance learning projects as if they served the same group of students. Similarly, research on the use of technology for elementary and secondary students uses traditional measures of outcomes, such as standardized test scores, to compare technology projects and conventional approaches. Results may be disappointing, with many studies concluding that the two approaches have similar results, but the technology-assisted approach is more costly.[18]

Missing in those studies is an approach whereby technology for education is not viewed as a replacement for face-to-face methodologies, but, rather, to attain objectives that have not been attained efficiently otherwise: expanding access, promoting equality, improving the internal efficiency of educational systems, enhancing the quality of education, and preparing new and old generations for a technology-driven marketplace. For each of these objectives, different technologies may prove more or less cost-effective depending on two aspects:

- *The characteristics of the technologies*. Producing a television program, for example, is 10 times more expensive than producing a radio program. While radio may reach a broader audience, television has a visual impact that is missing in radio. Computer-related technologies are costlier than radio or television, but they have greater potential to promote higher-order thinking skills activities while familiarizing students with a technology that is becoming essential in the workplace.[19]
- *Specific conditions where the technologies will be used.* These include local infrastructures, availability of expertise, and appropriate contentware, as well as regulatory and cultural obstacles.

Educational projects frequently suffer from having only short-term objectives. Within this perspective, investing in technology may not seem reasonable. However, research shows that Interactive Radio Instruction (IRI) and television projects (such as *Telesecundaria*) can increase retention rates and improve academic performance. Likewise, appropriate use of computers in schools has been shown to improve academic outcomes.[20] By reducing the number of years a student spends in the system and producing better-prepared workers, technology-mediated projects improve the efficiency and effectiveness of educational systems and promote savings in the long run. Cost comparisons based solely on short-term objectives will not reflect those savings.

Estimating Costs

Curran[21] proposes a simple formula to estimate costs in technology projects: $TC = FC+VC(N)$, where:

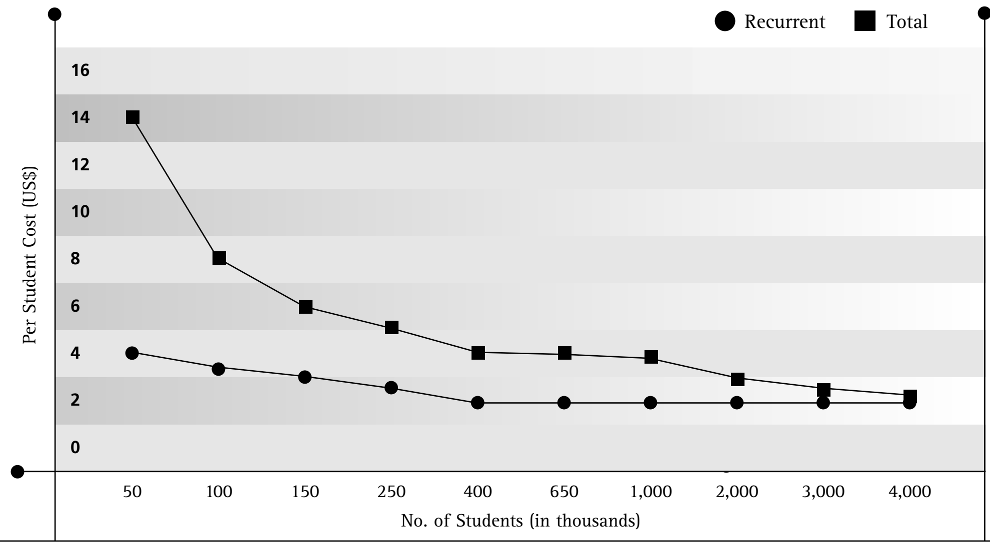
- *TC (Total cost)* is the sum of fixed costs plus the product of variable costs multiplied by the output, N;
- *N* is the project output, generally measured as number of students served, number of graduates, or student contact hours;
- *FC (Fixed costs)* are the costs incurred with the development and initial implementation of the project and may include new buildings, or renovation of old ones, buying and installing hardware, and all expenses related to the development and production of courses, programs, and related material; and
- *VC (variable costs)*, sometimes called recurrent costs, include expenses related to administration of the project, training, distribution of material and supplies, and student support.

The problem is not so simple. Hülsmann observes that administrative cost (a variable cost) does not change linearly with variations in the number of students served (N). These costs will remain constant until N increases, or is reduced by 10%, after which, the administration will have to be adjusted, although by smaller proportions. He calculates that a 20% increase in the numbers of student increases administration costs by 7%.[22] Understanding this balance between fixed and variable costs is key to technology-mediated projects. As a rule of thumb, it can be said that:

- Technology-mediated projects with high fixed costs and low variable costs, such as those involving radio and television, have greater potential for economies of scale.
- Technologies that replace conventional teaching, rather than complement it, also have an immediate cost advantage, since personnel tends to be the largest component of the variable costs in education.
- Technologies with high variable costs and that work in conjunction with conventional teaching are unlikely to bring short-term cost advantages; in the long run, though, they may reduce costs by increasing the quality and efficiency of the system.[23]

Among technology projects, IRI has the lowest cost per student (between US$3 and US$8). As reflected in Figure 4.4, the educational use of radio promotes large economies of scale: as the number of students increases from 100,000 to 1 million, the unit cost of an IRI project may decrease by as much as 40%. For a lower-income country, the scale of the project is a key variable. Adkins estimates that a small-scale project (100,000 students) may represent as much as 84% of the potential discretionary public spending on primary education for the country, while a large-scale project (1 million students) represents only 23%. For upper-middle-income countries, the relationship between

FIGURE 4.4 • THE RELATIONSHIP BETWEEN COSTS AND SIZE IN IRI PROJECTS



SOURCE: Adkins (1999). Figure 5-1, p. 98.

scale of project and potential discretionary spending is less significant: 7% for a small-scale project and 2% for a large-scale one.[24]

For computer projects, infrastructure preparation and hardware are the largest part of the bill, but savings can be obtained if schools act in coordination. A school district has greater purchasing power to negotiate volume discounts than each school has separately. For instance, the U.S. state of North Carolina buys telecommunications equipment and services for all of its schools, saving up to 50% on some items.[25] Partnering also allows schools to share resources, including software, Internet connections, training programs, and full-time support staff, thus reducing significantly the overall cost of the project.

Financing Mechanisms

Many large-scale projects on the use of technology for education are financed through partnerships between governmental agencies and bilateral and international organizations, such as the U.S. Agency for International Development (USAID), the World Bank, and the United Nations Educational, Scientific and Cultural Organization (UNESCO). Within countries, projects may be financed through interdepartmental partnerships. For radio- or television-based projects, private and public broadcast organizations may provide free or reduced-cost airtime. Foundations are key providers of one-time expenses, such as upgrading hardware and software. Public-private partnerships associate the political and financial power of government with the flexibility of private enterprise.[26]

Creative Financing

Educational projects using technologies require start-up investments that may challenge the limited resources of poor countries or locales. However, technologies also offer solutions that help to defray costs without jeopardizing the quality of the projects. Creativity is essential to overcome potential barriers, as shown in the following suggestions:

- *Unbundling*—Educational institutions, particularly universities, can contract out support functions that are complex, expensive, and extraneous to their main purpose. Organizations are already forming to pursue this objective. The only function of the Queensland Open Learning Network in Australia and the European Study Centres is to provide support to learners and educational institutions. The IBM Global Campus and the McGraw-Hill Learning Infrastructure, in the United States, provide consultation, project management, and technical support to educational organizations. The unbundling process enables each agency to focus on what it does best, thus increasing productivity.[27]
- *Focus on efficiency*—If technology projects focus on where the need is greatest, the project can have the most impact. About 50% of the students in community colleges are enrolled in just 25 courses. These are the large introductory classes, generally taught by assistants. Technology projects that prioritize these courses will reach basically all students on the campus. In addition, since those courses feed other disciplines, improving their quality will result in a better foundation for more advanced courses. This strategy

has the potential to reduce repetition and dropout rates, thus increasing the efficiency of the system and offsetting the costs of the project.[28]

- *Recycling*—Computer-based projects require significant investment in hardware. In addition, the expected active life of a computer is about five years, and as the hardware industry develops more sophisticated products, the software adapts to the top-of-the-line products. Between 1998 and 2000, an estimated 70 million computers were discarded in the United States alone.[29] Computer recycling is an ecologically sounded alternative to this problem. A growing number of not-for-profit organizations are dedicated to the tasks of collecting, refurbishing, and finding new homes for old computers.[30] The recycling process has been facilitated by the development of new software. For example, NewDeal provides even old PCs, such as the 386 and 486 series, with the basic features of newer hardware. The software includes a contemporary graphics interface, spreadsheet, database, word processor, e-mail, and a Web browser. It has even a point-and-click interface, like Windows 98, with two major differences: it runs on any PC, from a Pentium III model to a 286, and it costs less than US$50.[31]
- *Collaboration*—Collaboration is key to the feasibility of many projects and can happen in different ways. For instance:

  - *Adapting existing materials*—producing programs is a major part of the fixed costs of a radio- or television-based educational project. Locating and acquiring existing programs may reduce the costs of production while maintaining the quality of the product. The scripts of the English as Second-Language radio program from an IRI project in Kenya were implemented in Lesotho with only minor editing. Similarly, the mathematics lessons developed for the radio program in Nicaragua were used in other Spanish-speaking countries with only minor adaptations.
  - *Dividing the work*—the International Virtual Education Network (IVEN) involves a partnership among a group of Latin American countries to improve mathematics and science teaching in secondary education. The partnership will develop Internet-based modules that cover the range of topics on math and science in the two last years of secondary school. By dividing the work and expenses among all participating countries, the project becomes feasible and affordable for each individual country.[32]
  - *Sharing resources*—Elementary and secondary schools can ensure ongoing and affordable technical assistance for their hardware by offering internships to relevant professional schools and universities. Telecenters (see chapter 12) can provide a diversity of services to accommodate the needs of different uses. The Bindura-World Links for Development Internet Learning Centre, in Zimbabwe, serves teachers and students in the morning, local business and community members in the afternoons and evenings, and students of the Zimbabwe Open University on weekends. Fees from and special arrangements with this diversified clientele ensure both the Centre's sustainability and provision of essential services for all stakeholders.[33]

Legal Frameworks

In planning a technology-mediated project for education, attention must be paid to the laws and regulations that will affect the project, either facilitate it or create barriers to it. ICTs, with their ability to reach beyond political boundaries, defy many of the national and international legal frameworks that were created for a world with frontiers. Solutions, albeit necessary, are difficult to find and slow to implement. Proposals that have been advanced by experts include the following.

Deregulation

Telecommunication monopolies and restrictive regulations have been part of strategic defense programs in many countries; however, calls for deregulation and liberalization of this sector are now heard everywhere. Deregulation is expected to bring competition, thus promoting more supplies and lower prices. While protecting equal access to all must remain a central concern, there is evidence that government-controlled monopolies are not always the best answer in a fast-moving technological environment. In Europe, leased-line capacity expanded significantly in countries that liberalized their telecommunication frameworks. In Denmark, Finland, and Norway, for example, the direct leased-line capacity with the United States in 1995 was seven times that of Sweden. Sweden moved toward deregulation, and, two years later, its leased-line capacity was 11 times greater than the three countries' combined total.[34] In many countries, local education authorities *are* profiting from liberalization of telecommunication services by entering into agreements with private providers, many of which see agreements with community-based projects as a public relations investment that enhances the company's image and increases its local support.

Accreditation and Certification

Accreditation and certification must in the long run maintain confidence in educational offerings by guaranteeing their quality and the acquisition of qualifications both to individuals and to employers. Systems of accreditation developed for concrete institutions may not apply in the virtual environment. Regulations on building safety or student/instructor ratios do not pertain to the virtual world. Credit hour is another concept that does not fit distance learning. Created to protect students in the traditional learning environment, accreditations might become a barrier against a global education market. A student may be discouraged from taking online courses if the institution offering them is not accredited in his or her country, regardless of how prestigious the institution may be. Countries with centralized education may have an advantage in terms of recognizing credentials or facilitating transfer of credits. Decentralization, in this case, may be one more obstacle for students and institutions alike. Country, state, and local regulations can be mutually exclusive, making it cumbersome or potentially impossible to create distance-learning programs that meet the diverse requirements. The members of the European Union began conversations on ways to simplify regulations and recognize qualifications and credentials across country borders, but such discussions are still rare.[35]

Intellectual Property[36]

Since 1886, with the Berne Convention, and later with the Universal Copyright Convention—administered by UNESCO—as revised at Paris on July 1971, countries have recognized the rights of an author over his or her intellectual property. Laws also have been enacted to ensure the financial remuneration of authors and protect the integrity of their work. Each new technology brings challenges to the existing laws, however. While users come to the Internet in search of more and free information, producers look for ways to expand copyright laws and ensure their rights. The Trade-Related Intellectual Property Rights (TRIPS), negotiated under the World Trade Organization (WTO) umbrella, establishes new arrangements for technology-related intellectual property that cover software code. Developing countries see TRIPS as a tool to give developed countries control over the benefits of the new economy. Developed countries, on the other hand, argue that strong intellectual property laws are necessary to promote economic growth and development that eventually will benefit all.[37] For educators, these laws may appear cumbersome. Kerrey and Isakson cite the case of a music instructor who can use songs and pieces of music in her classroom, but has to draft numerous letters seeking permission from copyright holders to incorporate these works into an online version of the same class.[38] Yet, educators and researchers are also rightly interested in preserving their property rights.[39] These global discussions bring to the table problems of jurisdiction and the anachronism of legal systems developed for societies enclosed within political boundaries.

The balance among national and global interests, rights of individuals, and freedom of information is a challenge that must be faced if the potential of ICTs is to be fulfilled. International organizations, such as UNESCO, can have a leadership role in bringing stakeholders together to face this challenge.

ACCEPTING THE TECHNOLOGIES: CULTURAL AND POLITICAL FACTORS

Ensuring access to technologies is just one step in the success of ICT-mediated educational projects. Securing the project's acceptance is equally important. Cultural and political factors may promote or create obstacles to the use of technology or limit its use to certain subgroups of society. Likewise, the structure and organization of local educational systems may favor integration of technology or create a technophobe atmosphere that hinders efforts to change.

Overall, acceptance of technologies has not been a problem. ICTs have been well received worldwide, and it appears that the older technologies opened the door for the more recent ones. As Figure 4.5 shows, it took 74 years for telephones to reach 50 million users, but only four years for the World Wide Web to reach the same number. In India, places that did not have a telephone now have Internet kiosks where families can e-mail their relatives abroad.[40] Likewise, homeless children in Asunción, Paraguay, are learning to read and surf the Web at telecenters where commuters send e-mail messages while waiting for the bus on their way to or from work. [41]

Cultural Barriers and Strategies

Radio and television are now part of the world culture. However, computer and Internet use is still dominated and controlled by a small group of predominantly wealthy, educated, urban males. Regardless of the country, the data are very similar. For instance, males constitute 61% of the Internet users in Europe, 71% in Argentina, and 67% in Korea. Students and professionals make up 70% of Internet users in Russia and in China, 86% of whom have college degrees.[42] Access is a key issue, but access alone does not explain the data. The elderly and women, even in urban areas, trail behind young and men in ICT use. Surveys on acceptance of computer-related technologies among these population subgroups were not found; yet, anecdotal information from the field suggests that males and females of all ages and cultural backgrounds are potentially open to technologies that improve their lives and put them in contact with the world.

Rural Areas

Projects, such as the Telecenters or the Virtual Souks (markets), prove that rural populations are open to technologies that connect them with the world and improve their standard of living. Richardson observes that the challenge to expanding ICTs to rural populations is more political than technological. Government employees and businesses tend to see rural areas as bad investments. Still, experiments with carefully planned rural projects have been successful and even profitable. The Village Phone program of the Grameen Bank in Bangladesh installs rural telephones in strategic points that can be accessed by hundreds of local villagers. Women staff the projects to facilitate access by both men and women. One telecommunication operator reported that 1,500 rural "public calling offices" generate as much revenue as 12,000 urban subscribers to cellular telephones.[43] Likewise, by charging users' fees, telecenters in rural areas of Africa are becoming self-sustaining and are, in fact, expanding.[44] With few exceptions, generally related to religious beliefs (such as the Amish community in the United States), cultural factors seem to have little effect on the acceptance of technology. But, attention to cultural differences when implementing technological innovation is essential to avoid unintended consequences.[45]

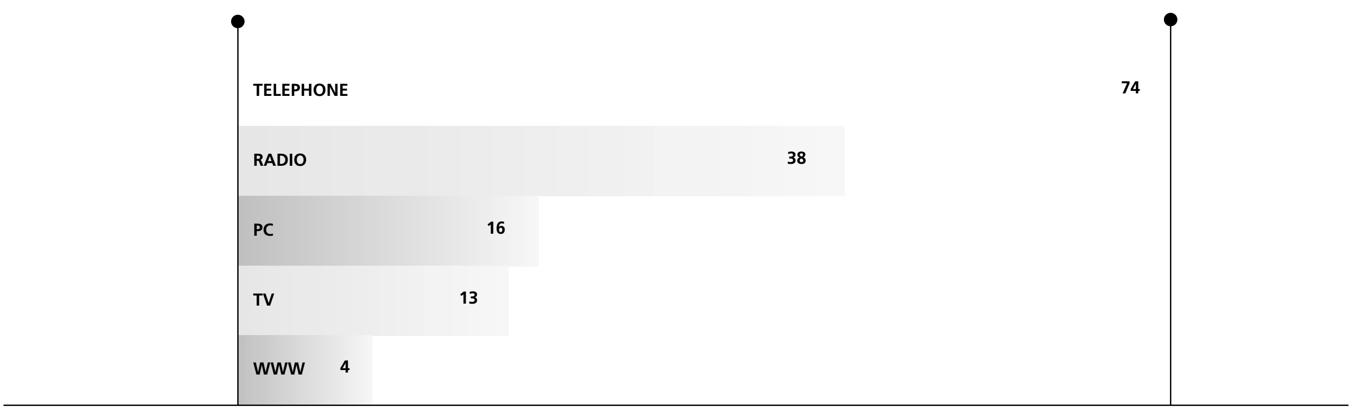
The Elderly

Internet use among the elderly is growing. From 1999 to 2000, Internet use among North American women aged 55 and over grew by 110%, making it the subgroup with the second-largest growth in the country, just behind teenage girls.[46] Educating the elderly is a measure of good economic and social policies. The median age of the world's population is rising, and among the elderly, the older subgroup (80 years and older) is the fastest-growing group. Medical knowledge indicates that an active life is the best protection against emotional and physical illnesses, regardless of age. Moreover, in some countries, such as those devastated by the AIDS epidemic, the elderly already are assuming the unexpected roles of principal breadwinners and caretakers of orphaned children. Preparing them for these responsibilities is essential to reduce the emotional and economic impact of changed roles. Brain research shows that aging does not affect the ability to learn, although it may require different strategies that rely less on memorization and more on problem solving and critical thinking.[47] These are the strategies required to learn new technologies. China is catering to its elderly population through the Universities of the Third Age (UTA). UTAs use distance learning technologies—from postal correspondence to the Internet—to reach urban and rural elderly across the country. The rapid growth of the UTAs reflects not only the large demand, but also the ability of the elderly to adjust to alternative learning environments mediated through technology.[48]

Women[49]

Statistics suggest that, when access and support is provided, women are eager users of technologies. In the United States, women are already the majority, albeit slim, among Internet users, and their numbers are growing.[50] In many developing countries, women are caught in a circle of poverty, illiteracy, and cultural traditions that function as barriers to computer-related technologies, which are expensive, literacy dependent, and defined as a male realm. The stereotypical view of computers as male tools exists even in developed countries. Research in the United States shows that girls are not

FIGURE 4.5 • EXPANSION OF TECHNOLOGY (years it took to reach 50 million users)



SOURCE: International Telecommunication Union (1999). C*hallenges to the Network: Internet for Development. Executive Summary.* Figure 1, page 4. Available at: *http://www.itu.int/ti/publications/INET-99/chal-excsum.pdf.*

expected to excel in technology and are given less encouragement to use computers or pursue a career in the field. Parents buy computer-related gifts for boys more often than for girls, and teachers in technology classes tend to give more time and assistance to boys than girls.[51] The fact that training generally is provided by men adds one more barrier, particularly in countries that impose limits on contact between genders. The scarcity of female role models in technology-related professions is another disincentive on a path already full of obstacles. Yet, research shows that, when girls are given the same opportunities and support provided to boys, they perform as well in technology-related projects.[52] Since the reasons for the problem are varied, the solutions must be multiple. Suggestions include:

> *At the elementary and secondary school level*—train teachers and school administrators to understand their biases in relation to girls and technology and develop strategies to overcome this bias; train female teachers as technology instructors; work with parents to encourage or support their daughters' interest in technology; encourage and support girls to participate in computer clubs and other technology-related activities.
> *At the tertiary level*—implement public and/or private scholarships targeted to women pursuing technology careers, and provide encouragement and support for those who are in predominantly male schools, including offering opportunities for studies abroad.
> *For adult education*—include female instructors in telecenters to ease women's transition into technology; educate the public to understand that technology promotes economic growth for the whole family; promote projects targeting women, since men can profit from them as well, while the reverse may not happen (women are less likely to be involved in a project targeted to men). The Gobi's Women Project is an example of a "women's project" that helped the whole family.[53]

Political Agendas

Acceptance of technology is also related to the level of political support or resistance at local and national levels. National governments have been key players in the expansion of educational projects that depend on technology. Most mega-universities have privileged access to telecommunication systems that is controlled or regulated by the government in their base country. For instance, the Anadolu University in Turkey has access to the national broadcasting network, and the Indonesian post offices act as admission points for the Universitas Terbuka. Countries such as Brazil and China have invested massively in infrastructures and financed educational projects to spread computers into the schools. Mexico's *Telesecundaria* is a federally funded project, and many IRI and telecenter projects include partnerships between governments and international funding agencies. In 1994, Botswana developed a national strategy for the use of computer technology in secondary education and integrated a Computer Awareness Program for the Junior Community Secondary Schools in its Nine-Year Basic Education Program.[54] The South Korean government is promoting a nationwide strategy that uses computer technology to foster an open and lifelong learning society.[55] Measures that government can take to support and expand technology-mediated projects include[56]:

> Invest in infrastructures.
> Review fiscal policy to favor educational and nonprofit use of technologies.
> Deregulate telecommunication monopolies while protecting educational use of telecommunications.
> Reorient funding policies to serve students, rather than institutions.
> Fund technology-mediated projects directly or encourage these projects through tax relief and other benefits.
> Fund projects that ensure access to technology for underrepresented populations.
> Promote teacher training that uses technology to familiarize teachers with these tools.
> Simplify regulations and accreditation requirements to facilitate transfer of credits across states or neighboring countries.
> Implement standards of quality for distance education courses.
> Foster progressive policies on education that encourage activities related to higher-order thinking skills rather than memorization.

Interest groups outside the educational establishment may have powerful influence on promoting or creating obstacles to the use of technology for education. Digital corporations, such as Apple, funded pioneer computer experiments in schools. Many technology giants, such as Lucent Technologies, are directly involved in providing training. Policies to attracting more such groups to educational projects at the elementary and secondary levels is a way to expand the support base for the project, ensure expertise, and improve the project's effectiveness.

Educational Establishments

Within the education establishment, acceptance of technologies is an issue, and the expansion of distance learning institutions has been met with its share of resistance. Teachers, from basic to higher education, are essential to the success or failure of educational projects, but rarely are they involved in the planning stage of these projects. Despite all the rhetoric about modernization, teacher education programs rarely include technology as content or strategy. Graduates of most teacher training institutions have little experience in using technology and no information about how to integrate ICTs into curricula and practice. The technology is mostly seen as an add-on to traditional classroom teaching, and many times as an unfamiliar, and therefore, threatening imposition. An add-on approach inhibits the potential of the technology to improve the quality and effectiveness of education and decreases support from parents, students, and the public in general, who see technology as an expensive investment with no visible trade-off.

Totally integrating use of technology into the teaching/learning process presents another challenge. Teachers may feel they are losing control over the content of the course and the students. The path from center of instruction to facilitator requires a new paradigm, and many teachers are not prepared to make the change. Distance learning stretches the paradigm even further. The personal interaction that had been the basis of the teacher-learner society is no longer there. For students, the distance learning approach may be seen as depriving them from contact with the teacher—although many times, this contact in a campus university is a myth as a weekly class for 300 or more students jams into an auditorium. For instructors, distance education requires greater preparation for planning and production, extra training in technology, and less control over students' reactions to the material. It also brings concerns over job security. For schools and universities, distance education requires greater investment, including preparation and delivery of materials ahead of class time, ensuring office hours for student queries related to academic content and to technology issues, access to library and other resources, and an efficient system of tutoring and support. Yet, changes in the student population and their interests, employee demand for training and retraining of the workforce, and market pressures will be the determining forces in the expansion of technology-mediated learning.

The movement toward distance education has the potential to bring cultural changes that have yet to be understood fully. Blight, Davis, and Olson express concerns that use of imported standardized packages will impose extraneous cultural values on developing nations. Daniel remarks that the result of a movement toward a learner-centered, more specialized education may be a fragmented education that will preclude the "civilizing function" that has historically been associated with universities.[57] In other words, the boundary-less characteristic of distance education seems to equally threaten the existence of national cultures and of a universal culture shared by all educated human beings. These are epistemological concerns that raise a new perspective on the social role of education in the years to come.

Few studies on cultural and political influences over the acceptance or rejection of technology-mediated educational projects are available. More is known about teachers' reaction toward technology. In general, this reaction moves from resistance to acceptance as soon as the value of technology is understood. Research in these areas will bring valuable contribution to the success of educational projects.

AVAILABILITY: CONTENTWARE, EXPERTISE, AND CAPACITY BUILDING

The model proposed early in this chapter (Figure 1.1) functions like a tripod, where the three legs (access, acceptance, and availability) may have different widths, but are of equal importance. Ensuring access to the technology without promoting its acceptance may lead to an underused project. Likewise, securing access and acceptance without availability of content, experts, and a potential for capacity building may result in a well-received but short-lived project plagued by technological glitches.

Contentware

Educational materials for ICTs are easy to find; the challenge is to find good materials that incorporate sound pedagogical strategies and use the potential of the adopted technology fully. Two basic criteria that must be taken into account when evaluating an education material are quality and viability.[58] The quality of a product can be judged through direct examination, references, reviews, testimonials from users, or awards. Viability is related to the useful life of the product. A good product that maintains its usefulness for a long period will produce reasonable returns on the investment. This is easier when the potential number of users is large, posing particular challenges for groups limited in size by language, culture, or educational needs. Many organizations have developed criteria to evaluate contentware, particularly software,[59] but each educational system should define its own standards to reflect the project's objectives and curricular requirements and the specific needs of students and teachers.

The use of commercially developed material saves time and avoids production costs, but also has disadvantages, such as: (1) the material may not meet local curriculum standards or educational objectives; (2) the content will reflect the ideologies and lifestyles of the producing country, generally the United States; (3) for non-English-speaking countries, language is a barrier; and (4) most of all, product licensing and royalties can erase the savings realized at the production stage.

Sharing materials among countries is a better option when agreements on royalties can be reached. Sharing is easier for countries with the same language and similar customs, and for topics that have a more universal nature, such as mathematics and science. Translations, albeit expensive, may prove cost-effective, and software translators are becoming common, although the quality of their work is still questionable. Partnerships with universities, broadcasting, or software companies offer another prospect for obtaining educational materials that are customized to a country's reality and needs.

Open-source software is a response from the digital community to the increased control of technology-related property by large corporations. Not all open-source programs are free, although most require only nominal fees or voluntary contributions. The movement regulates itself through ethical norms that ensure recognition to the author and protect the integrity of the product, while encouraging new product development. Since the program codes are open to reviews and improvements from a number of experts, the quality of open-source software tends to be superior to that of commercial products. In addition, the programs can be customized to the user's specific needs. One disadvantage is that most programs are written for UNIX or Linux, two platforms that require technical expertise to use. For developing countries, the open-source movement makes it easier to obtain high-quality products, avoid the costs of commercial software, and develop an expert workforce. Rather than buying a package of commercial software for each of its computers, a school district in a developed country can hire a skilled programmer to configure an open-source material to the district's specific needs and duplicate it for as many computers as necessary. The district will have a quality product for less cost, without infringing on national or international laws. In addition, the process stimulates growth of local programmers, supported by an international network of experts.[60]

Training and Capacity Building

In technology-mediated projects, two different types of expertise are required: the technical expertise related to the hardware employed, and the content expertise in using the technology for educational purposes. Projects fail when planners invest heavily in hardware and software, but minimally in hiring and training competent people, thus leaving the project without expert support and guidance.

Equipment failures are common, particularly in the initial stages of projects, when the lack of familiarity with the technology increases the numbers of errors. The more complex the equipment is, the greater the probability that technical problems will occur. Continuous glitches will hamper the flow of information, reduce students' enthusiasm and motivation, and threaten the success of the project. A teacher with a good working knowledge of the technology may be able to solve the most common problems. However, not all teachers are technology-savvy, nor are all technology problems easily solved. Rarely does an educational system have the luxury to pay for a technician to support the instructors and ensure that the hardware is functioning appropriately.[61] Technicians are difficult to find, and with the expansion of the digital industry, they are in great demand. Individuals with expertise in technology are finding jobs before graduation and offered salaries that educational systems can hardly afford.[62] Training for educators generally is limited to use of specific programs or software packages; beyond that, educators are on their own. No institution will train educators to be technology experts, and few will provide them with a broad understanding of the requirements and potential of the technologies they will be using. Improvisation is currently the norm in this field.[63]

However, countries should look more carefully at technology for education. The development of specialists in educational material reduces dependency on imported products, while increasing the probability that the language and content of the products are appropriate for the users. It also creates a workforce that brings a fresh perspective to a field controlled by a small group of producers—a competitive advantage in the global market of educational services. Over time, investments in this workforce will bring large returns. Education services constitute the fifth largest service export in the United States. In 1997 alone, the United States spent US$26 billion on education-related goods and services, including textbooks and supplementary materials (US$11.6 billion), technology (US$4.8 billion), and testing/test preparation (US$3 billion). The growth of educational expenditures is not limited to the United States. Worldwide sales of educational software to schools in 2000 were estimated to be US$4.1 billion, with another US$2.1 billion sold to consumer markets outside schools. By 2009, the education market is projected to grow to US$200 million in India, US$580 million in South Africa, and US$1.7 billion in China.[64] Capturing this market is a tempting possibility for many commercial enterprises, particularly if developing countries choose to remain buyers rather than producers.

Currently, few tertiary institutions and projects seek to create this cadre of specialists. The Universidade de los Andes, in Colombia, has a project focusing on the development of interactive games for education. The International Virtual Education Network (IVEN) for the Enhancement of Science and Mathematics Education in Latin America[65] is forming teams of content experts, graphic designers, instructional designers, and programmers to develop educational material focused on mathematics and science for secondary education. A few universities in Latin America offer courses to train distance learning educators, such as the Universidade de Brasilia or the Universidad Abierta de Venezuela. This is a new frontier that merits careful attention and support from educators and decision makers.

CONCLUSION

In estimating an educational project's potential for success, decision makers should take into account four characteristics: desirability, feasibility, affordability, and sustainability.[66]

> A *desirable* project responds to identifiable needs and is more likely to garner support and funding.

> A *feasible* project is one that may be accomplished within an established time frame, available personnel, and budget. Projects that are badly planned and underfunded are less likely to fulfill their obligations within the proposed time. They also risk being discarded as failures, when, in truth, they were not given an opportunity to succeed.

> *Affordable* is not synonymous with inexpensive. The concept of affordability is relative to the benefits expected from the project in relation to its costs. Even if a large-scale IRI project represents a high proportion of the potential discretionary public spending for primary education in lower-income countries, if it also reaches a substantial proportion of the country's young people who otherwise would be without schooling, it will surely be affordable over time. A project's affordability must be estimated in comparison with the costs of building and maintaining traditional schools for all those children or maintaining the status quo.

> *Sustainability* is an often-forgotten aspect of any project. Projects that rely on different funding mechanisms are more likely to avoid closure when one funding source is lost. Negotiating long-term contracts for airtime, technical support, upgrade of computers, etc., is another strategy to ensure continuity of the project. For elementary school projects, parents can be a major source of financial and in-kind support. In the IRI project in Lesotho, parents and teachers supplied batteries for the radios to compensate for a lack of power supply.[67] Many parents and community members are willing to help a project they consider helpful and one that gives them a feeling of ownership. Private enterprises may look at such projects as a way to gain the support of potential clients. Successful projects are careful to involve community members from the beginning. Parents and community representatives are powerful advocates when political support dwindles.

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5

OBJECTIVES AND STRATEGIES FOR EFFECTIVE USE OF ICTS

Gajaraj Dhanarajan

INTRODUCTION

In a report to the Canadian Council of Ministers of Education on *e-learning*, authors reflected:

> In the fifth century B.C., Plato predicted that the invention of writing would weaken the oral tradition that sustained poets such as Homer. Yet poetry is still alive and well 2500 years later. Similarly, 500 years ago many believed that the invention of printing, by making intellectual creations easily available, would dry up the springs of intellectual creation by ending a long-standing tradition of oral debate and expression. As we look back over the last five centuries from the vantage point of our knowledge-based society, a decline in intellectual vitality is more than a little difficult to discern, though certainly there may have been changes in some aspects of intellectual life. In fact, the existence of today's knowledge-based society is in part a testimony to the enormous intellectual energy of the last 500 years. No one would seriously argue today that the intellectual enterprise or teaching have suffered because of the invention of writing or printing.
>
> The new knowledge tools represent similarly revolutionary technologies, and we ignore them at our peril. Their potential is also clear. Online learning will be central to fostering the lifelong learning culture that will be essential to sustaining a civil and prosperous society in 21st-century Canada.[1]

The last 20 years have seen some remarkable innovations in the delivery of education. Nevertheless, many would argue that, as remarkable as these innovations are, they are no more than a beginning. Developments over the next 20 years will make, as one former U.S. secretary of education, John W. Gardner, remarked, "education as it is practiced in most schools today [look] so primitive." While this may be overstated optimism, Prof. Gardner's views are not totally unrealizable.[2] The technologies available today, and those about to emerge, have the potential to transform the business of education. However, what may be impeding that potential is our academic culture and traditions. Nine centuries of organized education have generated strong views and deep-seated beliefs about what is best and what is not.

This chapter examines the role of ICTs in the context of the global opportunities and challenges confronting the design, delivery, and administration of education to meet the diverse needs, clients, demands, goals, and objectives of nations and communities—particularly during a period of transition of societies and economies from an industrial base to one that is knowledge- and information-centered. To this end, the chapter raises a number of policy considerations and outlines a series of strategic options that could facilitate an effective role for ICT.

POLICY CONSIDERATIONS

Cynics would claim:

> Some nations may decide to invest in technology for education for the "glitz factor": the technology is there; it is fashionable to have the latest and the best, and it gives a sense of progress to use state-of-art-technology. This can be described as the technology for its own sake rationale. Other nations may base their investment decisions on the genuine case for improving the efficiency of their education systems or for some other benefits intrinsic to education. For instance, databases and computerized records in education systems have clear advantages and benefits. This is the "technology for educational benefits" rationale. A third rationale may be external to education and concerned with developing skills for the labor market.[3]

A different view of the use of ICTs is Bill Gates's, who says: "Students can look at their grades and even turn in their homework over the Web. Teachers hold online discussion groups. Students e-mail friends and family as naturally as they call them. Students are the ultimate knowledge workers. Their 'job' is to learn and explore and find unexpected relationships between things."[4]

In between cynicism and optimism, one government took the view that it is "fully committed to ensuring that all schools and teachers are in a position to deploy new information and communication technologies [ICTs] to raise educational standards to enhance learning and to prepare young people with the ICT skills they will need in society and at work in the twenty-first century."[5]

This section considers the policy questions that drive decisions such as the one that was made by the UK government to promote the use of ICTs in its educational sector.

How Essential Are ICTs to National Goals?

This is the first question national and educational authorities have to answer. Is the introduction of ICTs into education driven by vendors, by the need to conform to world trends, is it derived from national educational objectives? Are ICTs considered a luxury or a necessity? To help answer

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this question let us look at the challenges confronting countries worldwide.

Demand for More Education

The demand for more open and accessible learning has continued to increase since the early 1950s, but even more so following the World Conference on Education for All in Jomtien, Thailand, in 1989. Many factors are contributing to this changing educational culture, the most important of which are economic, social, and technological forces. These forces are worldwide in scope and power, and have had a profound impact on business practices, manufacturing processes, financial services, government policies, and, more recently, teaching practices and learning behaviors. It would not be an exaggeration to say that as we embark on a new century, we are also moving irrevocably in the direction of changing the way we think about information, knowledge, and learning.

Individuals and governments are beginning to recognize that planning for "competitive advantage" will require a labor force that has literacy and numeracy skills beyond three to six years of primary schooling (the current situation in most industrialized and newly industrializing countries, and even grimmer in developing nations). Globally, some 2 billion people who are in today's workforce will continue to be there well into the first quarter of this century. Their knowledge and skills will need continuous renewal. Added to this, we need 1 billion more young children and adults who will require initial education and training. The level of supply (or lack) of education and training for this huge demand for initial, continuous, and lifelong education using current patterns of delivery are, in the words of Sir John Daniel, "at a crisis point."[6] The challenge of providing education and training to a huge and diverse population with a variety of learning goals and styles, at an acceptable cost, will require new forms of global educational delivery. Notwithstanding the skepticism of many in the academic community, recent reports from agencies such as UNESCO, the Organisation for Economic Cooperation and Development, and the World Bank seem to say as much. In some ways, the emergence of new technologies may have something to do with the push to make drastic changes in the nature of the learning environment.

There is also a change in the nature of those requiring education and training. Communities no longer are content (nor should they be) to limit access to education and training to the fortunate few who are able; literate; live in urban communities; have access to communications, infrastructure, and classrooms; are knowledgeable about learning opportunities and options; and have the resources to pay for them. A fairer, kinder, and more concerned humanity requires that the education we provide must be made available to a broader range of historically underserved groups, including:

- Functional illiterates: Apart from about 900 million illiterates globally, there are almost half as many adults who cannot cope with the demands of daily life because they lack literacy.
- Physically disabled: Annually, in Asia alone, about 15 million people become disabled as a result of war, diseases, accidents, and malnutrition. Their major hope for self-improvement lies in obtaining needed skills.
- Long-term unemployed: Long-term unemployment is a debilitating pathology; training people in such situations poses special challenges to delivery and pedagogy.
- Out-of-work youth, especially boys: This group is highly vulnerable to socially disruptive behaviors. Youth need vocational training, including apprenticeship and self-education, to be part of a productive economy.
- Women and girls: In many parts of the world, women and girls still find themselves marginalized in education and training; ways may have to be found to circumvent the social, cultural, and economic impediments they face.
- Refugees, recent immigrants: Today, roughly 125 million people live outside their countries of origin, and this number is ever increasing. This flow of people for political, social, or economic purposes is not expected to slow down. To help these people resettle, educational programs, language teaching, and training for social and job skills must be designed and delivered.

In contrast with this escalating demand is the lack of preparedness of a vast majority of our education systems to deal even with existing demand, under circumstances that, in the words of one activist group, "violate the rights of children" through "dilapidated schools, inadequate facilities, poorly trained and under trained teachers, inadequate supplies of learning materials, irrelevant curricula, disregard for minority cultures and languages, gender bias and instructional methods which undermine, rather than nourish the potential of children."[7]

World over, the arrival of newer technologies certainly seems to have stimulated a resurgence of interest in diversifying methods of knowledge delivery. Almost daily, yet another Web-based course becomes available from one university or another. *Smart schools* are springing all over the richer world, and *virtual learning, online learning,* and other, newer forms of educational delivery are becoming part of the educational jargon of the new century. Even before the arrival of the newer technologies, institutions such as the

Correspondence School of New Zealand; the National Open School of India; the Open Universities of Sri Lanka, Hong Kong, and the UKOU; and the Indira Gandhi National Open University of India were providing good-quality, mass, flexible, and lower-cost education for remote learners from basic to university-level education using the older analog technologies of print, audio, video, and radio and television. The experience and successes of these institutions around the world are testimony to the effectiveness of technologies to reach individuals and large communities simultaneously. They have transformed the delivery of education and, in the process, also transformed the business of education.

In addition, full-time study within the timetabled constraints of the classrooms is only accessible to a few; for many who wish to study, learning has to occur at a time and place of their choice. The growth of open schools, polytechnics, and universities, as well as the numerous suppliers of correspondence and online education, are all manifestations of peoples' desire to learn at their own convenience rather than at an institution's call.

Information Explosion

It is estimated that the total amount of information doubles every four to five years. Stated in another way, the total of information available to an undergraduate in 1997 was less than 1% of what will be available to a student in 2050. Teachers have to become expert in helping learners to navigate through this sea of information rather than attempt to be effective transformers of that information into knowledge for the learners. Students must be trained to bring about this transformation, during and beyond the school years. ICTs are crucial in coping with the explosion of knowledge over the lifetime of the learner; otherwise, people's knowledge becomes obsolete, and countries become marginalized.

Citizenry in Modern Society

To function effectively in the modern world, citizens need more than a basic education. The structure and content of learning activities should equip all children, youth, and adults with the knowledge, skills, values, and attitudes they need to survive, to improve their quality of life, to empower them to participate fully and responsibly in the life of their communities and nations. This education also should help them to initiate and adapt to the changing circumstances of their environment, and to continue learning according to their individual needs and interests. Clearly, any strategy to engage all citizens in lifelong learning will require application of technologies, especially mass media. For the first time in the history of humankind, communication technologies enable us to reach millions of people across continents simultaneously. At the same time, variations of these modern technologies allow educators to tailor content to suit a narrow local audience to respond to individual learning needs. Satellite, community, and Internet-based (through telecenters) delivery of content all enrich the environment for learning. Agriculture, farming, health, market conditions, maternal care, and reproductive sciences all being delivered today through ICTs. Local community radio and telecenter facilities are extremely versatile tools and are used effectively and imaginatively around the world today (see chapter 12). The Commonwealth of Learning's (http://www.col.org) pilot projects using small, portable community radio transmitting stations illustrate how older analog technology has evolved into a newer digital tool incorporating FM broadcast capabilities and functioning as a hub for communication for rural communities (see Box 5.1).

A key feature of the modern global society is the "primacy associated with the exchange over computer-communication networks of intangibles such as knowledge, ideas and intelligence, rather than tangible goods that have long been the basis of human interaction"[8] It is also becoming fairly clear that the power of the computer chip will continue to increase while the cost of building it decreases; bandwidths will broaden and convergence heighten; and the penetration of the Internet will continue to rise while the lack of connectivity drops. Acquisition of up-to-date knowledge, skills, and education will determine the success of individuals and democratic societies both economically and socially. It is not surprising, therefore, that an ever-increasing number of countries wish to see their citizens technologically literate. From "telecenters" to "smart schools" the push to make every child computer-, Internet-, and Web-savvy has fast become an overriding concern for education ministers of developed and developing countries.

Illiteracy

Despite the knowledge explosion and advances in information and technologies, in many countries, there are significant numbers of people who cannot read, let alone enjoy the benefits of a technological society. Every country in the world has committed to decreasing drastically the number of illiterate citizens. Mass media, especially print, radio, and, to a certain extent, television, has played a significant role in adult literacy programs. In some parts of the world, newer technologies have been applied, albeit in a modest way. An increase in the use of ICTs seems to be constrained by financial resources, shortage of literacy workers skilled in using technologies, and lack of technical support for a well-functioning technology environment. However, ongoing developments using online resources to train literacy workers and

BOX 5.1 • COMMUNITY RADIOS PROVIDE NONFORMAL EDUCATION AT LOW COST

Radio systems, such as the portable solution the Commonwealth of Learning (COL) and others have used in community FM radio initiatives, also can be effective in delivering education to the masses without the high infrastructure costs associated with radio broadcasting. Community broadcasting can address local needs through locally produced programming, but it can also provide a tremendous variety of quality educational content freely available for rebroadcast, from national and international sources, through satellite or the Internet. Care should be taken, however, to ensure that rebroadcasting is balanced with the needs of the local community and the provision of appropriate and relevant programming content. Low-cost, portable, suitcase-size community broadcasting stations have been set up by COL in Belize, Guyana, Namibia, and South Africa, as has a solar-powered version in Uganda. The stations broadcast a wide range of educational and informational services tailored to meet local needs. Associated training on program production and broadcast technology has been provided to local operators. Also, in cooperation with the Sri Lanka Broadcasting Authority, COL supplied and provided training for a portable FM radio station as a broadcasting and journalism training aid and, in collaboration with the Commonwealth Educational Media Centre for Asia, the Sri Lanka Open University, and the Ministry of Agriculture, a Rural Communication Research Project has been initiated to integrate traditional and experiential knowledge with modern scientific advances. The project's findings will be shared through audio broadcasts to educate rural communities on environmental conservation and sustainable development. Given its availability, accessibility, cost-effectiveness, and power, radio represents a practical and creative medium for facilitating mass education in rural settings.

create literacy products seem to demonstrate significant results. ICTs have the potential to:

- reduce the isolation many adult literacy providers and students experience;
- facilitate communication among staff and students within and between programs;
- increase access to high-quality materials and emerging research;
- streamline administrative and reporting processes; and
- help to provide the delivery vehicle for innovative instructional and staff development approaches.[9]

Short Supply of Talent

On one hand, the planet is filled with highly skilled and talented people in all fields of human endeavor. On the other, critics of global educational systems constantly bemoan the fact that, by and large, the academic talent needed in our schools, colleges, and universities to enhance the quality of the learning environment beyond perceived levels of mediocrity is in short supply. We need excellence in our teaching, and we need to obtain our teachers from the best in the local community and distribute them to the whole learning community. The Western Governors Virtual University[10] initiative among the northwestern states in the United States is in fact an attempt to do this. This attempt envisages going beyond campus walls to obtain academic "teaching" talent. Contributors to courses will come from business, commerce, industry, and government, and those who take the courses will include ordinary people, along with thousands of college and university students.

ICTs for What Educational Objectives?

Planning for effective use of ICTs in education necessitates understanding the potential of technology to meet different educational objectives and, consequently, deciding which of these objectives to pursue. This decision affects the choice of technologies and the modalities of use. This section structures the discussion around four objectives that may be enhanced by ICTs:

- expanding access to all levels of education;
- improving the quality of education;
- enhancing lifelong learning; and
- facilitating nonformal education.

Expanding Access for All to All Levels of Education

In most developing countries, full-time study within the time constraints of classrooms is only accessible to a few; for many who wish to study, learning will have to take place at a time and location of their choice. In addition, access to learning for those living in remote areas and those who are marginalized, isolated, or disadvantaged has to be sought vigorously as nations respond to the declaration made at Dakar in 2000.[11] Either synchronously or asynchronously, barriers such as time, distance, and social and cultural constraints must be overcome. At the same time, rapid changes taking place in the workplace will require training to be delivered quickly. Such training must be high-speed, low-cost and capable of reaching small and large groups. As a policy consideration, the application of ICTs to enhance access to learning must receive the highest priority. ICTs in their many forms have been applied in a variety of contexts, including:

Reaching Learners in Remote Communities

Provisions have to be made to reach, in particular, children in many parts of the developing world where formal schooling is likely to account for less than 1,000 days in their entire lifetime. Fewer than half of primary-school-age children actually are enrolled in school, and more than two-thirds of those who do manage to enter school fail to complete three years of schooling. While it will take a massive effort to change this situation, as an interim measure, ICTs can be employed in formal and informal settings to deliver essential knowledge and information. The National Open School in India, using print, audio, local tutors, and ICT-based assessment and testing system on-call, provides postprimary education to remote villages throughout India. About 400,000 children have access to education up to grade-12 equivalence, and lessons prepared by teams of highly qualified teachers are made available to students free or at very low cost[12] (see Box 5.2).

Taking Education to Girls

Gender disparity in educational access is a major challenge in many communities because of family and social circumstances. Inequalities between women and men extend from literacy classes to access to formal schooling and prospects for completing school. Social, cultural, religious, and economic factors all combine to create barriers and place girls and women at a serious disadvantage. While such barriers will take time to remove, ICTs provide one way to circumvent them. Learning and training will have to find their way to girls and women where they are located, rather than expecting them to come to places where teaching is conducted. The Allama Iqubal Open University of Pakistan approached the challenge of illiteracy among women in Pakistan through a unique combination of print, audio, radio, and mentors.[13] Though all the technologies used were analog, the opportunity to digitize this effort and deliver it through local telelearning centers offers immense opportunities, in both qualitative and quantitative terms, to scale-up the effort.

Providing Learning Opportunities for Individuals in Challenged Circumstances

Increasingly, ICTs are being recognized and used to bring education and training to those individuals who are challenged in one way or another. These tools include digital voice control software, audio to visual conversions for the hearing impaired, electronic text, and digital audio. The technologies, either stand-alone or as part of integrated systems, help to overcome barriers such as instruction based only on print and dependent on sight, audio dependent on hearing, and video requiring vision. The systems themselves have to be developed for individual use, so they require careful study of individual students' needs. Vincent[14] describes a few such approaches taken by the UK Open University where print-based courses are adapted using ICT to enable challenged individuals to benefit from them.

Providing Education for Out-of-School Youth

Education of out-of-school youth, especially beyond the basic level, can benefit from the application of ICTs. Vocational and trade skills, competency-based training, and alternate entry paths to higher education can be achieved through creation of knowledge products for a variety of situations, from self-learning to flexible learning environments. Multimedia commercial training products are becoming increasingly available for training in vocational skills. Governments can play an important role in enabling vocational training institutes, encouraging nongovernmental organizations (NGOs) engaged in supporting youth development, and prodding media outlets to use ICTs for youth training and personal development.

BOX 5.2 • NATIONAL OPEN SCHOOL, INDIA

The National Open School (NOS) India was established in 1989 to support India's National Policy on Education. The school caters to the needs of school children as well as children from socially marginalized communities in both urban and rural locations. While the school's early focus was on academic programs at the secondary school level, it currently offers courses in vocational and other life-skills areas. It also has extended its range from elementary to preuniversity programs. Some 400,000 children are enrolled, and they come from challenged communities, socially disadvantaged groups, and isolated populations. The school uses ICTs for course development, administration, testing, and to deliver some content by audio and local radio. Its plans for the future include even more extensive use of the newer technologies through tele- and community-learning centers.

Creating Open and Virtual Learning Environments

Smart schools, online education, and *virtual universities* are labels that have been attached to institutes applying a new set of strategies to deliver education using digital networks either synchronously or asynchronously. The technologies are used to deliver instruction, to manage the system's administrative services, and to provide support for learners. The last four decades have seen the emergence of colleges and universities dedicated to delivering tertiary-level education off-campus to learners, especially in those countries where the gap between the supply of and demand for tertiary-level education is huge and largely unmet. These universities apply open learning principles and distance education practices to deliver learning. They are generally universities with big student populations comprising mature and mostly part-time learners. Ten of the largest universities in the world are open universities, and all but one of them is located in developing countries. In total, they may have as many as 2 million students enrolled in their programs.[15] ICTs have always played an important role in managing and administering these universities, and older analog technologies such as radio and video also have been used to enrich the learning environment of the open universities. With the arrival of the newer digital technologies, ICTs also have begun to figure much more intensely in this role.

Improving the Quality of Learning

One of the most powerful reasons for considering using ICTs in an educational system is that they put learning in the hands of the user. They facilitate individualizing curriculum, permit learners to dictate the pace of learning, and widen sources of information. ICTs also promote active learning and allow for interaction between and among peers and mentors. Many would say as well that the quality and effectiveness of learning is enhanced many times through the use of ICTs. The technologies allow faculty to incorporate new information and update learning materials, and they enable immediate and rapid transfer of information pertaining to the administration of a course or program of study (see chapter 3). Of these many educational objectives, the five below stand out as extremely important.

Curriculum Enrichment

The Delors Commission report[16] to UNESCO clearly and eloquently described the need to reform curriculum at all levels of education to prepare citizens for the new millennium. Learning to know, learning to do, learning to be, and learning to live together are all ideals that are achievable within the framework of basic and postbasic education. These recommendations recognize that today's learners, young and old, will spend their lives in a century that is information-rich, knowledge–dependent, and global. They need the skills to cope with this dynamic period. The growth of online library systems, easy access to expert knowledge through the Web, the variety of sources of learning, and frequent change of careers and location of residence during a person's productive lifetime will necessitate learning new skills and refreshing old skills. The curriculum should reflect these concerns and will include:

> The ability to frame problems when facing unfamiliar situations. Tomorrow's problems may be similar to yesterday's once they are well understood. But these present themselves in new forms. Once a problem has been framed, it must be solved and, often, both framing and solving problems will require powerful information technologies. Framing and solving problems sometimes will be simpler, but they often are likely to be more difficult than before.

> The ability to communicate, including with people from other groups. Nations' ethnic composition is becoming more diverse, and increasing globalization has meant having frequent contact with people of other nations and cultures. All of this requires sensitivity to numerous cultures, and some common and shared values and insights, if political and social tensions are to be avoided and conflicts minimized.

> The ability to work in, form, and lead teams and coalitions, including involving people of other cultures. This vital skill is seldom taught comprehensively in schools, and, as global interdependence increases in importance, so, too, does collaboration.

> The ability to identify what needs to be learned, and then learn it efficiently. ICTs often will furnish the means for learning. Every educated person will need to spend a certain fraction of his or her life keeping up with changes in that technology.

In all these areas, ICTs are an extremely invaluable asset. The Web, more than any other tool we know of, has the power to make enormous amounts of information from their original source available at the click of a button. This information, in its multimedia form, provides teachers and learners with information to support and enrich curriculum in the modern classroom. Subscriptions to digital libraries, collaborative projects with peers outside of one's own classroom, and access to remote knowledge and expertise make lessons richer in content and, in the process, learning more exciting.

Flexibility

The time-driven, rigid organizational structures of our institutions of learning, our assumptions of learning, and our traditions of teaching, as well as the urban location of teaching institutions, have combined to present barriers of one kind or another to learning for all but a small proportion of citizens. The new ICTs provide enormous flexibility of use unlike older technologies, which required learners to be assembled in a controlled environment at a specific time and location. Radio and television had to be tied rigidly to schedules developed centrally. On the other hand, the new technologies are available for use "anytime, anywhere." The emergence of virtual education is very much a reflection of this versatility: Learners can access their education or training at the workplace, home, library, or anywhere connection to a telephone and power supply is available.

Transformation in the Teaching/Learning Process

Learning technologies can affect education in systemic and structural ways. The challenge for educators is to bring about a balance among content learning, technology learning, and social experience. This balance depends on instructional strategies that accommodate individual learning styles and, at the same time, provide for effective assessment. Successful introduction of ICTs into the learning environment also includes support for interdisciplinary interaction with peers and instructors and among groups. This arrangement allows learners to interact with their institutions and their communities.

The newer technologies can change the relationship between teachers and learners to improve the learning process and learning experience. Traditional teaching and learning habits always have favored a certain passivity. Professors lectured and students listened and took notes; sometimes they asked questions, but they seldom contributed to knowledge. That was also true for the older technologies of print, radio, and television, despite the hype given them. Though active and independent learning were aspired to, they were hard to achieve, given the limitation of the technology. New ICTs make it possible for students to be active learners. Both teachers and students can control, manipulate, and contribute to information and knowledge generation. Using ICTs, students not only make choices about the pace and order of a presentation, but also may choose topics for explorations; take notes; answer questions; explore virtual landscapes; simulate experiments; enter, draw, or chart data; create and manipulate images; make their own PowerPoint presentations; and communicate with others.

ICTs have great capacity to facilitate the educational transaction between providers and users. For instance, ICTs can be used to:

- *Keep students well informed* about the courses that are available to them.
- Enhance *teacher-learner contact,* an essential part of a good educational environment, through e-mail, chat sessions, etc.
- Encourage *active learning.* Students do not learn much from memorizing facts and reproducing set answers; they derive greater benefits by being active in their learning.
- Facilitate *peer support in learning.* Sharing one's ideas and responding to the ideas of others improves thinking and increases understanding. Learning can improve if it is a team effort rather than a collection of solo performances.
- Provide immediate *feedback and encouragement.*
- Encourage *paced learning* through tools such as assignments, tutorials, broadcast programs, computers, conferencing, etc.
- Allow for effective mapping of *learning pathways,* which facilitate different styles of learning.

Professional Development of Teachers

Like all other professions, teachers need constant and continuous renewal to be effective, motivated, and up to date in their knowledge and skills. While this is not a mandatory requirement in many national jurisdictions, those that do have such requirements use and see ICTs as important vehicles to provide continuing professional development to teachers. The use of ICTs, especially in support of distance education activities, adds enormous value to the training. Where the infrastructure exists, and connectivity costs are subsidized, the opportunity to create virtual online learning communities of teachers within nations and across regions exists. Such learning communities enable and empower trainee and practicing teachers to share experience, curriculum, learning materials, lesson notes, and collaborative projects. ICTs can be applied in at least three training contexts: basic training, upgrading and advancing pedagogical skills and content knowledge, and continuous professional development. (For a full treatment of this topic, see chapter 8.)

Resource Sharing

Though we have shared knowledge through the wonderful medium of books, only a fraction of human knowledge actually is published. Until the arrival of the computer, sharing knowledge, an important basis of education, was more wishful than real. With ICTs, sharing knowledge resources is enhanced many times over. Putting information on the Web makes it available immediately to anyone in the world with a suitable connection. Teachers can share lesson plans with their colleagues in their own jurisdictions and with those far removed from their jurisdictions. Students from all over the world can undertake joint projects, exchange findings, analyze data collectively, and draw reasoned conclusions. Knowledge about and of interest to minority groups, languages, and interests can enjoy the same opportunity to publish and share.

Enhancing Lifelong Learning

Lifelong learning is a necessity in a world that changes and renews itself so rapidly. Such dynamism makes demands on individuals to update themselves constantly in the context of their workplace, social life, and participation in healthy and vibrant democracies. Two broad categories of individuals use lifelong learning opportunities.

- The first group refers to those who are underrepresented across a whole range of postbasic education and includes, among others, illiterate and neoliterate populations engaged in unskilled work; ethnic, marginalized, and minority groups; people with learning difficulties; and the physically challenged. These learners face such obstacles as lack of learning skills, confidence, money, counseling and advice, and personal support, and they require active intervention by the state, the business sector, and voluntary organizations.
- The second group refers to those who have had the benefit of some form of postbasic education but are not equipped to deal effectively with the technology-driven environment in which they find themselves. This group includes out-of-school youth, employees in workplaces, individuals with basic training, professionals needing continuing education, and older adults seeking personal enrichment. These people are expected to know their needs, but they face challenges such as inadequate supply of learning opportunities, inflexibility of learning systems, lack of money, and inadequate supply of information.

There is increasing evidence that ICTs are beginning to play an effective role in promoting lifelong learning. Supported by a greater bandwidth capacity, digital and interactive radio and television, and multimedia, pathways are extending the speed with which learning products can be delivered to learners over large catchment areas. However, to make this happen, some basic conditions need to be met, including regulatory frameworks, infrastructure, affordable cost structures, public access to multimedia facilities, skills training in ICT use and employer support, and institutional commitment of learning providers.

Continuous Education of the Workforce

As shifts occur in economic activity, so does the need to "retool" the workforce in response. This applies as much to a rice farmer as it does to an ICT worker. To maintain and enhance the competitive advantage of their workforces, nations are beginning to give more attention to training or retraining people. In a world made up of some two billion workers who will require regular access to training where they are working, the role of ICTs becomes critical. In British Columbia (BC), Canada, for example, a program called SkillPlan[17] does exactly that. The training facility was developed as a result of a partnership between the Open Learning Agency (OLA) of BC and the province's Construction Industries Unions. The OLA identified a computer-managed learning system that provided adult basic education courses aimed at those who had completed high school certification. Workers who need to improve their reading and writing skills can "drop in" at the Agency's local centers and use the system when it suits them. The system keeps track of each individual's progress and enables learners to carry on where they left off the last time they were able to drop in. The training center is equipped with ICT appliances and connections such as telephones, fax, and online. Another example of a dynamic arrangement is the Queensland Open Learning Network[18] (see Box 5.3).

Just-in-Time Training

The rapid changes taking place in the workplace will require training to be delivered quickly. Such training needs to be high-speed, low-cost, and accessible to small and large groups. Traditional ways of delivering training are time-consuming, labor-intensive, socially disruptive, and expensive. Workers have to acquire new skills quickly and affordably. It becomes even more attractive if such training can be delivered at the trainees' workplace. Also, adult learners require flexibility, and they have families, work commitments, and social obligations around which they have to fit their training. This simply means that, ideally, training has to be accessible anywhere, anytime. Just-in-time-training is especially relevant in the context of business and industrial training where there is a continuous need to respond quickly to demands from the work environment.

Facilitating Nonformal Education

ICTs are being used to make information and knowledge available in nonformal contexts. The demand for enrichment learning is on the rise, particularly in countries experiencing an increase in aging populations and in populations with more leisure time who want to use it in intellectual pursuits. These are learners for pleasure, and, for them, activities in a classroom are not the ideal solutions. ICTs offer a convenient solution, but only if the individual has the skills needed to use the appliances and navigate through the millions of Web pages and is able to pay for the cost of the digital connection.

Besides structured learning for enrichment purposes, unstructured learning opportunities are increasingly available

BOX 5.3 • THE QUEENSLAND OPEN LEARNING NETWORK

The Open Learning Centres of Queensland, Australia, are fully wired telelearning centers, managed by local communities under the oversight of the Queensland Open Learning Network [QOLN]. Its main function is to provide locations where citizens can access formal accredited programs of study from colleges, universities, and other providers. The Centre also receives specially tailored programs from the QOLN. The Centre's aim is to foster lifelong learning and motivate and empower people to acquire new knowledge, skills, and understanding so they can lead fuller and more productive lives capable of adapting and responding collectively to new circumstances and environments.

The Centres are equipped with a network of computers with shared peripherals, software applications, software and hardware facilities for multimedia learning, printing and photocopying facilities, Internet access, phone, fax, and audio, video, and audio graphic conferencing facilities. Each telelearning center is managed by a local coordinator who also acts as "community learning leader."
The Centres' four main functions are:

> program design, from needs assessment to developing program specifications;
> program development, including sourcing and evaluating existing course materials, access to online technologies, and matching training aims with open learning strategies;
> program delivery and support—training trainers, tutors, and local content experts and providing learning materials; and
> program management and administration—developing appropriate systems, processes, and strategies and identifying fiscal and human resources.

through zoos, museums, planetariums, research institutions, professional societies, interest groups, commercial companies, and national agencies, among others. The knowledge to be gained can range from virtual tours of, for example, archeological sites to the epidemiology of HIV/AIDS. It is as possible to learn to cook exotic food as it is to design and make quilts. One can participate in a debate on the World Trade Organization organized by supporters or detractors or engage in a discussion with a Nobel laureate on rain forest exploitation. All of these learning opportunities inform citizens, enrich their lives, enable them to share indigenous knowledge, and empower them to participate in functioning democracies. The British government, for example, plans to connect all of the country's libraries to the Internet through a National Grid for Learning.[19] In theory, this will allow citizens to browse through holdings throughout the country, a service that is especially valuable to those who are homebound.

STRATEGY QUESTIONS

Strategic planning for inclusion of ICTs in a nation's or institution's educational system is likely to be based on a number of perceptions, such as:

> acceptance of a learner-centered educational approach that involves the use of multimedia resources for self-paced, self–directed, flexible learning;
> acceptance that the role of teachers is changing from transmitters of knowledge to mediators in learning from a variety of information sources;
> the belief that systems that include technology can improve efficiency and/or effectiveness of student learning; and
> a perception of accelerated growth in demand among stakeholders for access to technology coupled with a rise in availability and use of ICTs elsewhere in society.

Strategic planning questions about the use of ICTs in education invariably will include a need to recognize the competing interests of stakeholders. It will be particularly important to align the learning technology strategy with strategy planned for related areas such as libraries and information systems, academic management (student records, accreditation's, credit banks, etc.), student support systems, student administration, and electronic media. In relation to ICTs for education, there are three basic questions:

> Which technologies?
> How will they be used?
> Will contentware by created or acquired?

Which Technologies?

Even as recently as 10 years ago, the choice of technologies for delivering education was somewhat limited, partly because they were expensive, analog stand-alones with limited versatility, and they required skilled technicians to create and deliver the product. Radio and television are prime examples of the demand these technologies made on educational systems. Those that did not fall into this category, such as overhead projectors, slide projectors, etc., had limited reach. Today the picture has changed almost completely. Technology application in education no longer is limited by the versatility, convenience, cost, and potential of the technology but, rather, only by our imagination in the way technology can be applied. Through integration, convergence, miniaturization, and intelligence, technologies have become friendly. The question is no longer whether technologies are useful in the teaching and learning environment but which technologies are best suited for a particular purpose. Digitization of many information and communication technologies has made it possible to design, develop, deliver, manage, and assess the learning and training process.

The new digital technologies are not single technologies; they are combinations of hardware and software, media, and delivery systems. They are evolving and converging rapidly, as seen in PCs, laptops, notebooks, and digital cameras that are both video and single-image; local area networking; the World Wide Web; CD-ROMs and DVDs; application software, such as word processing, spreadsheets, and simulations; e-mail; digital libraries; and computer-mediated conferencing, videoconferencing, and virtual reality. They also have a capacity to integrate with older analog technologies from print, and through audio and video, make it possible to retrieve information stored in older technologies and to develop synergies between the old and the new. There are excellent reviews of the older analog technologies, which still have tremendous value, especially in many developing countries and their educational systems.[20, 21, 22, 23]

This section of the chapter focuses on newer technologies, which are mostly available to and used in developed countries for education, but hold tremendous promise globally in both rich and poor communities. They also differ in several important aspects from older technologies in their integration of multimedia, convergence of communication and information technologies, interactivity, flexibility of use, and connectivity. Understanding these differences will help us to appreciate why the use of ICT in education is expected to grow.

ICTs for teaching and learning range from those that rely on ubiquitous low-cost technology, such as the stand-alone PC, to those deployed for specific purposes at higher cost, such as the electronic classroom. Decisions on the choice of technologies are subject to many considerations and constraints, ranging from constancy of power supply to availability of skilled technical and managerial support to maintaining the technological infrastructure. Assuming these are available, then questions of pedagogical strategies of the system, accessibility, scale, and cost will play a role in the choice. Some of the newer IC technologies available and used today are discussed below.

E-mail

Increasingly, e-mail is becoming the most widely used medium, ranging in function from exchange of gossip, to serious dialogue and collaborative research. It also has become an important supplement to classroom teaching. Bulletin board services extend the classroom beyond fixed timetables; listservs bring communities of learners together; and assignments and term papers are beginning to be channeled routinely through e-mail. On-campus education is being enriched by e-mail facilities, and off-campus education is made more personal and interactive. In economically developed countries, e-mail is almost as common as the telephone. In many cases, connections are free of charge, appliances are provided at low or no cost, and training is available for neophyte users. In poor economies, e-mail has yet to make its presence felt throughout society, but is increasingly available at community service centers such as libraries, telelearning centers, and "cyber cafes."

Presentational Software

PowerPoint and similar programs are already commonplace among academics and other professionals. While a simple slide presentation requires little skill to develop, the increasing sophistication level of such a presentation requires higher-level training.

World Wide Web

Many on-campus instructors are beginning to use the Web to make their lecture notes available to students at any time. The Web also has the advantage of providing access to primary sources of information in most media (print, graphics, photographs, audio, and video) through streaming. This technology requires good organizational and pedagogical skills to profit from its enormous potential, and faculty training in its use will be essential. Bates[24] considers the Web to be a low-cost technology for several reasons: the existence of simple computer languages such as HTML and intermediary course authoring systems such as the WebCT and Blackboard; it uses the Internet as a transport vehicle that involves no direct charge for independent packets of information, and pricing is by volume and not by time or distance; the Web's ability to combine media, thereby increasing its range of applications; access to high-quality learning resources inexpensively; it allows asynchronous interpersonal communication through e-mail, bulletin boards, and discussion forums; and it enables cross-cultural, international, collaborative learning.

Multimedia, CD-ROM, DVD

Multimedia, CD-ROMs, and DVDs are very exciting learning tools. Their development costs can be very high, especially those at the very high end that can carry large quantities of data in a variety of formats, such as audio and video clips, Internet connections to other databases, large amounts of information, and built-in simulation and other enrichments. Putting all these together in user-friendly packages will require teams of experts, from media producers to content experts. The reproduction cost of CD-ROMs can be reduced considerably if large numbers are "burned." Consequently, this medium is a consideration only when enrollments are large enough to justify the development expense. However, there is a strong case for developing the medium when the course can be used by a consortium of institutions working together.

Satellite Broadcasting

Satellite broadcasting for educational purposes has a long history. Countries such as India[25] and China,[26] and such regional universities as the University of the West Indies[27] and University of the South Pacific[28] have long used satellites to deliver audio- and video-based lectures to all corners of their region. Satellites serve as good vehicles to carry lessons, and, by marrying satellites to ground facilities, it is possible to build a two-way learning environment. In addition, their digital technologies allow for further sophistication to be built into the learning systems. However, because of their high start-up cost, satellites' value for educators is limited. Recent developments sponsored by private enterprises such as World Space have combined satellite technologies with digital ones to broadcast voice and data directly to specially designed digital receivers over very large geographic areas. While this venture is driven by and for commercial interests, special provision for educational purposes allows educational providers to reach very remote and isolated parts of the world. World Space eventually expects to reach an audience of some 3 billion people. While satellite technology has some significant advantages in terms of reach and low unit cost, for it to be truly effective as a learning technology requires extensive local support on the ground, either on an interpersonal basis or through telephony, the Internet, etc. Ground support will cause costs to increase considerably, thereby reducing the economic benefits. As Bates[29] concludes, "well designed printed texts can be more educationally cost-effective than real time or even recorded satellite lectures."

Videoconferencing

In the late 1970s, multicampus postsecondary institutions began experimenting with videoconferencing to distribute their education and training services and lectures in real time. With the decreasing costs of telephony, videoconferencing has become relatively popular, especially in Australia and the United States. This technology, an amalgam of telephony and computer-compressed technologies, reduces the amount of time instructors and students spend traveling from campus to campus to deliver and receive lessons. It also saves instructors from having to repeat lectures. The traditional culture of classroom teaching is preserved, and no new skills have to be learned by students or teachers. It is not a flexible system of learning, however. New innovations incorporating videoconferencing technologies with the Internet and Web technologies offer new opportunities, notwithstanding some concerns about the visual and voice quality of such arrangements.

How Will They Be Used?

Broadly speaking, ICTs can be used for either one of two purposes, or, in some cases, for both purposes simultaneously. The first purpose is to enhance the richness and quality of education on-campus and in the classroom; the second is to distribute campus-developed knowledge products off-campus through distributed learning, distance education, and open flexible learning. In either case, the selection of technological tools will depend on costs, the technology infrastructure of the learning system, learner access to the technology, the support personnel and facilities available to create digitized knowledge products, and the institutional commitment to sustaining the venture. Based on an extensive survey of European universities, and embedded in a few assumptions relating to the use of technologies, the Association of European Universities—under the sponsorship of the European Union's Socrates program—developed a set of guidelines for using ICTs[30] (see Table 5.1). Under the right conditions and used properly, the technologies can be highly effective as both teaching and learning tools. The challenge for institutions is to develop the knowledge and skills to exploit the technologies' full potential.

Create or Acquire Contentware?

At the heart of all learning that uses ICTs are materials specially designed to exploit the full potential of the available technologies. These materials normally include content in the form of texts, special "books of readings," specially developed study or learner's guides, assignments and assessments pads, and instructor's or tutor's guides. These resources, along with appropriate learner support systems, complete the educational or training environment. There are two ways by which institutions acquire these learning and teaching

TABLE 5.1 • ICT APPLICATION TO SUPPORT EDUCATION

TECHNOLOGY STRATEGY TO SUPPORT PEDAGOGICAL APPROACHES	PEDAGOGICAL TACTICS AND EXAMPLES	TECHNOLOGY INFRASTRUCTURE REQUIREMENTS
Using tools and templates	*Individual or group projects by students* > Course work preparation, building models, simulations, programming > Web page construction	> PC486 (nonmultimedia) > Pentium multimedia > Stand-alone or networked > Individual ownership or provided on campus
Using models/simulations	*Individual self-paced learning* > Enhancing textbook and other resources; > "Virtual" laboratories/workbenches > Typically developed by publishers or consortia of university	> PC486 (nonmultimedia) > Pentium multimedia > Stand-alone or networked; possibly accessed via Web (e.g., Java applets) > Individually owned PC, subject to ability to license individual copies; otherwise confined to campus-based PC workstations
CSCW environments (computer-supported collaborative work)	*Collaborative learning* > Support for group work > Mediated class discussion > Group & individual projects	> PC486 (nonmultimedia) > Pentium multimedia > Connected to a network, accessible on-campus only or accessible from off-campus > University must maintain host server; CMC (computer-mediated communications) software (groupware) required > Can be Web-based (e.g., TopClass) or proprietary
Electronic mail	*Student-teacher and student-student communication* > Improved access to academic staff, submission of course work, feedback, advice, and discussion > Allows asynchronous dialogue	> PC486 (nonmultimedia) > Connected to a network, accessible on-campus only or accessible from off-campus > University must maintain host mail server
Video- and/or audioconferencing and audio graphics	*Outreach to remote tutorial groups; institutional collaboration* > Use generally confined to small groups at senior, undergraduate, or graduate level	> High-quality videoconferencing systems require dedicated rooms, typically 2 or 3 cameras, microphones, and some form of electronic "whiteboard" or method displaying computer-projected images at both ends; high-grade telecommunications links are typically required—e.g., ISDN. > Small-scale videoconferencing can be achieved using PC with video card and top-mounted camera. Systems often use proprietary software, and networking between systems is not always adequate. Subject to networking, control software can be used to allow shared working on files in standard formats—e.g., word processing, spreadsheet, CAD. The tutor may transfer active control to/from remote locations, and all participants view the active image on their local screen. > High-grade telecommunications lines are normally required. > Limited workability is possible over the Internet.

TABLE 5.1 • ICT APPLICATION TO SUPPORT EDUCATION (CONTINUED)

TECHNOLOGY STRATEGY TO SUPPORT PEDAGOGICAL APPROACHES	PEDAGOGICAL TACTICS AND EXAMPLES	TECHNOLOGY INFRASTRUCTURE REQUIREMENTS
Lecturing/demonstrating	*Audiovisual presentation* > Support for lecture-style presentations incorporating audiovisual/multimedia elements	> Fixed projection installations in large or medium-size auditoria. > Fixed video and/or PC consoles or facility for presenter to connect laptop computer; portable projection devices for smaller rooms: LCD projection panels, connected to PC for use with overhead projectors. > Data projectors: self-contained units with built-in light source.
Broadcasting	*Extension of conventional lecturing* > Elements of distance education programs, providing off-campus access to traditional stes of teaching. Sometimes used in combination with audio-conferencing or simple telephone to provide feedback/questions from remote sites. Lecturer frequently delivers lecture simultaneously to live audience on campus. Broadcast can be terrestrial or by satellite.	> TV technology > Normally uses dedicated classroom, with 2 or more cameras, controlled by lecturer
Hypermedia resources	*Course resources for self-paced, self-directed learning or for private study directed by teacher* > Corpus of loosely structured documentation, including multimedia (sound, graphics, animation, and video) with embedded hypertext links > Can be made available on CD-ROM or via the Web	> Pentium multimedia PC > Stand-alone (CD-ROM) or networked (WWW)
Didactic courseware	*Self-paced learning* > Computer-based training (CBT) or computer-assisted learning (CAL) resources, typically used in highly structured didactic format, with sequential lessons, examples, and tests; may replace or supplement aspects of conventional teaching	> PC486 (nonmultimedia) > Many CBT applications do not require multimedia facilities and may be loaded directly from floppy disk > Pentium multimedia > Stand-alone or networked, for CBT/CAL courseware that makes use of multimedia—typically distributed on CD-ROM > Use off-campus may be limited, depending on terms of copyright or site licensing
Automated testing/feedback	*Assessment* > Can be used for systematic objective testing > Useful where large class groups are to be tested and where subject matter lends itself to this type of test > Includes banks of test questions, automatic marking and generation of feedback to students, summary information on student performance for teachers	> PC486 (nonmultimedia) > Connected to a network, accessible on campus only or accessible from off-campus (depending on provision of site license for relevant test management software)

TABLE 5.1 • ICT APPLICATION TO SUPPORT EDUCATION (CONTINUED)

TECHNOLOGY STRATEGY TO SUPPORT PEDAGOGICAL APPROACHES	PEDAGOGICAL TACTICS AND EXAMPLES	TECHNOLOGY INFRASTRUCTURE REQUIREMENTS
Intelligent tutoring systems (ITSs) (adaptive courseware)	*Self-paced learning* > Adaptive courseware extends the CBT/CAL approach by seeking to customize "lessons," based on dynamically modeling individual student performance	> PC486 (nonmultimedia); ITS applications do not always require multimedia facilities > Pentium multimedia—stand-alone or networked, for courseware that makes use of multimedia—typically distributed on CD-ROM > Use off-campus may be limited, depending on terms of copyright or site licensing

resources: they design and develop them either by themselves or in partnership with like-minded collaborators, or they purchase, lease, or acquire—through other arrangements—materials already developed and adapt them for their unique needs.

Materials Creation

Developing interactive multimedia learning materials is an exceedingly interesting challenge. They can be constructed from a combination of media, sometimes quite modest in cost and sophistication, such as a combination of computer-aided instruction (CAI) and print, and at other times very expensive and elaborate, using a combination of DVD, CD-ROM, hypermedia, and virtual reality. Discussing this issue, Miller[31] compared the process of production to

> an orchestra in which each musician not only plays a different instrument, but also speaks a different language. Such is the case with interactive video, where the assembled team includes instructional designers who speak of authoring, pedagogics and remediation; graphic artists who talk of drop shadows, GUI's and animated sprites; video producers who think in terms of wipes, fades, pictures, plots, scenes and storylines; and computer specialists who deal in bits and bytes, images and data, icons, picons, microns and programming language all their own. Add to this a systems person who wants to integrate DVD's and CD-ROMS and Windows via SCSI or R232 ports, and then telecommunicate the whole mess to a host...

Despite the complexities involved in the design and creation of multimedia materials, it is important to plan before developing and producing learning materials that integrate print, audio, and video into a seamless and fluid learning experience. (For a full treatment of multimedia materials development, see chapter 7.)

For well over three decades now, and long before the arrival of the newer technologies, dedicated distance teaching institutions such as the open universities of the UK, Canada, India, Thailand, Turkey, Israel, South Africa, and other countries have been developing courses using a variety of media. The experience gained through these institutions is just as relevant in today's technology-rich environment, where digitization allows for totally seamless integration, as it was then in an analog world. Unlike face-to-face teaching, the design and development of interactive multimedia materials involves the knowledge, skills, and expertise of a number of individuals. Therefore, assembling a team to undertake the task is almost a prerequisite if a high-quality product is the ultimate objective.

The size of the team, and the skills of the individuals who make up the team, will depend on the sophistication of the product to be developed. It is possible, though not advisable—as is often the case in many small operations—for one person (normally the content expert) to create the learning materials. At a minimum, the course team should have a content expert and an instructional designer. In addition to content experts and instructional designers, complex course team composition may involve audio and video producers, editors, ICT specialists, publishers, and project managers. The team approach will require a totally different work culture from what is normally associated with academe.

Materials Acquisition

Digitization of knowledge products opens up unprecedented opportunities for their portability. CD-ROMS, DVDs, and other multimedia have the capacity to carry entire courses on a single disc. Furthermore, granulation of knowledge allows for greater manipulation of the content to suit particular needs and clients. There are also economies to be gained. However, acquiring knowledge products from other sources for local use requires careful consideration of many issues and factors, besides intellectual property rights and economic concerns; sometimes it is cheaper to produce courses in house than to purchase and adapt them. Questions to be asked before acquisitions include:

- Does the product meet national and/or institutional objectives?
- Does the product contribute to the aims and objectives of the course?
- Is the content current, unbiased, and politically and socially sensitive?
- Is the use of text and media appropriate for the needs and objectives of the course?
- Can the product be used with locally available resources?
- Is it cost-effective to purchase the product?
- How well does the product fit the local learning environment?
- Does the product create barriers to learners (language, cost, technology)?

Each question requires a carefully considered response to make the right decision about acquisition. Broadly speaking, three types of factors influence that decision:

General Factors
These factors apply to all materials that are moved from the originating location to a new location for possible use. They include such items as:

- Contextual—the cultural, learning, and teaching traditions and the location of learners require consideration. In cultures where traditions of learning and teaching are more didactic, enquiry-based approaches to learning may not be a suitable fit. This is especially so at lower levels of study. Also important is the tone and simplicity of the language used.
- Disadvantaged learners—individuals from minority groups, as well as physically, aurally, and visually challenged individuals, may require special attention when materials are adapted for their purpose.
- Instructor skills—using the imported multimedia material skill of instructors has to be taken into account; provisions need to be made to train such teachers in new skills.
- Professional human assets—to enable local professionals to adapt the imported materials for local needs, all of the professional skills needed to create the original material need to be assembled and trained for purposes of adaptation.

Specific Factors
Certain factors specific to a lesson or a course have implications for repackaging imported multimedia materials for local use. These include:

- Suitability of purpose—materials produced for a particular group of learners in a specific learning location may not be a total fit in a different location for another group of learners; extensive adaptation may be necessary.
- Suitability of aims—aims of a learning experience vary from context to context. Context-sensitive materials may require major adaptation if the context of the new user is different.
- Relevance of learning objectives—objectives often are defined generally or specifically, and they focus on precise learning outcomes. If the objectives of an imported knowledge product are not sufficiently specific or relevant for the needs of a local course, revisions become mandatory.
- Match between syllabus and content—seldom does an imported multimedia package meet all of the needs of a local syllabus; amendments and supplementary materials may be necessary.
- Potential for adaptation—digitized materials do allow for manipulation of text, graphics, visuals, and audio; however, such adaptation requires skilled technicians, content experts, and resources.
- Promotion of active learning—the new technologies allow for extensive active learning opportunities; in selecting multimedia material from external sources, attention to this requirement is useful. As an alternative, such interactive learning can be incorporated during the process of adaptation.

Media Factors
Serious thought has to be given to the range of media technologies used in a course. Despite consortia such as the IMS Global Learning Consortium standards, there are still considerable differences in the range of technologies used to produce, distribute, and use multimedia materials. Some of the items requiring attention include:

- Range of media used—multimedia courseware clearly provides an interesting learning experience; therefore, when acquiring off-the-shelf materials, it is better to acquire material with a rich media mix than one without. However, overuse of media mix can be distracting. There is fine balance that needs to be achieved.
- Suitability of media used—it is also necessary to ensure a match between the hardware and the courseware. The rate of change taking place in both hardware systems and software programs can result in a mismatch that will be expensive to put right.
- Flexibility in the use of media components—imported multimedia may have media items that are not suitable or appropriate, or they may even be offensive to local

cultures. In such cases, it is helpful to local users to use some of the items and not others, if such use does not damage the integrity of the product. Such built-in flexibility will require clever instructional design.

> Options for media substitution—multimedia packages that allow for substitution of one component for another without losing the educational significance of the course is a lot more useful than one that does not have this facility.

CONCLUSION

This chapter began by examining the context within which policies and strategies for applying digital technologies to education and training must be considered. While there are enormous benefits to be gained in terms of quality, enrichment, and flexibility in using ICTs throughout formal educational systems, there is even greater value to be gained in using the technologies to increase access to millions of individuals who are currently outside the educational footprints of nations. A combination of the newer and older technologies has the potential to overcome the barriers of time, distance, and inadequate prior learning facing all those who wish to be informed, educated, and trained.

It is clear that ICTs offer opportunities not available previously to educators. Using tools such as e-mail; the Web; audio-, video-, computer–conferencing, both synchronously and asynchronously, a very rich interactive and individualized learning environment can be created that allows learners to dictate their pace of learning, place of learning, and the company they wish to keep (or not keep) while learning. While the ICT tools empower the learner, they need not take away from the role of the instructor. Instead, communities of learners and instructors come together for a common purpose and on a shared platform. These communities can encompass all levels and sectors of learning, from basic education to postgraduate studies, from teacher training to business studies, and from nonformal studies to language instruction. Only skills, knowledge, telecommunication infrastructure, fiscal resources, and policy support inhibit exploitation of this potential. Global experience already is beginning to demonstrate what is possible, how it is done, and what tools can be applied to the task. It is an exciting new world of learning and training.

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PART II

ICT APPLICATIONS: OPTIONS AND CHOICES

6

INFRASTRUCTURE: HARDWARE, NETWORKING, SOFTWARE, AND CONNECTIVITY

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INTRODUCTION

Education systems must help to build higher-order cognitive abilities, strengthen processes of inquiry, enable collaborative problem solving, and prepare people to compete in local and global markets and become productive members of society. Providing citizens with quality education is becoming ever more important with globalization and the increasingly dominant role information, knowledge, and digital technologies play in all economies. A new gap is arising between those who have access to and can use modern information and communication technology (ICT) systems and those who lack the access and ability to participate actively in the Information Age.

No single solution exists to address the immense challenges of providing quality education and bridging the ICT gap. One possibility is to develop and apply new approaches and strategies for teaching and learning that integrate computers, Internet-enabled collaborative learning, and related educational technologies with routine teaching and learning. When used effectively and integrated into education, computers and Internet technologies can improve teaching and learning, strengthen teacher professional development, support broad educational reform, enhance school-community partnerships, and improve school management (see chapter 3).[1]

The demand to realize these educational objectives by integrating computer and Internet technologies into education forces education planners, principals, teachers, and technology specialists to make many decisions about the technical, training, financial, pedagogical, and infrastructure requirements of school computerization programs. Some of the more challenging questions planners and educators must answer have to do with infrastructure issues. In this chapter, infrastructure includes what types of computer hardware to use, where and how computers should be distributed and networked in schools, if and how school computers can and should be connected to the Internet, and the software choices schools need to make. This chapter also touches on policies that can help to develop enabling environments to support school computerization and connectivity programs. There is no single *best* computer configuration[2] or single infrastructure solution to suit all situations. Rather, there are only optimum solutions for each school. Arriving at these optimum solutions is not simply a technical process but requires a careful consideration of educational goals and an understanding of the different costs and benefits, both economic and educational, of different technology options.

SCHOOL CONTEXT: ASSESSING OBJECTIVES, CONDITIONS, AND OPTIONS

Since infrastructural questions are dominated by a complex mix of technical factors, requirements, and options, decisions about infrastructure often are divorced from educational concerns and driven by technical matters and technology experts. In reality, infrastructure questions and decisions are coupled with educational needs, opportunities, and outcomes. Therefore, to achieve optimum educational results, each school or school system should base infrastructure decisions on an assessment of a mix of technical factors and educational needs and objectives. The results of such an assessment then must be compared to the costs and benefits of a variety of computer system configurations and infrastructure options. When carrying out an educational/infrastructure assessment, the following questions may need to be considered:

- *Educational goals:* What educational goals and learning objectives will be accomplished by using computers in schools? Different computer configurations have direct relationships to how computers and the Internet can and will be used by teachers and students to enhance education.
- *Professional development:* Will the computer system be used for teacher professional development and to supplement classroom teaching? Enhancing teacher professional development by training teachers both to use computer and Internet technologies and to integrate these technologies into education, along with improving subject matter competence and strengthening pedagogical skills, are often important objectives of school computer programs. Ensuring that such objectives are achieved often requires that teachers be provided with special access to computer and Internet technologies and a complex mix of initial and ongoing training and support. If online professional development is planned, suitable Internet connectivity and time to engage in online learning will be required.
- S*tudent-to-computer ratio:* What target ratio of students per computer is the school or school system aiming for? Most schools calculate this ratio by simply dividing the number of students in the school by the number of computers available to students. This simple calculation may not present an accurate picture of students' productive access to computers, however. In secondary schools, the issue is viewed more appropriately in terms of how much computer and Internet access, frequency, and duration students in different disciplines have.

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- *Community use:* Will a school's computer system be used by members of the community during nonschool hours? The high cost of investing in technology in public schools often can be justified partly by allowing the new computer facilities to be used by members of the school community. If this is a priority, then a lab or computers-on-wheels configuration (see below) may be needed, necessitating additional investments in staff and security.
- S*chool's electrical system:* What is the state of the school's electrical system? What is the availability and quality of electrical power and the type and distribution of electrical wiring in the school? Computers operate better and last longer when the electricity that powers them is continuous and of consistent voltage. Many schools, especially older ones, have an insufficient supply of electricity to withstand the additional demand made by the computers. Further, electrical cables may not be the correct gauge to withstand the additional load caused by computers being connected to the school's electrical system. Or the electrical cables may be composed of aluminum, which oxidizes over time and can become a fire hazard. Lack of electricity or poor wiring may require the school to refurbish the existing electrical system or add a whole new electrical supply system. This is one reason why many schools decide to install computers in labs, which reduces the amount of electrical wiring needed. Also, computers, especially those connected to a local area network (LAN), require a grounded electrical system to operate smoothly and trouble-free. Again, this is less costly if done to one or two computer labs or rooms, rather than to the entire school. The quality of electricity coming to a school also may be inconsistent and fluctuate between low and high voltages. These conditions can disrupt students' use of computers and result in premature and sudden failure of expensive computer equipment. These problems are often dealt with by installing line stabilizers to make the voltage constant and uninterruptible power supplies to provide a short-term (10 to 20 minutes) supply of electricity to the computer to allow work to be saved and equipment to be turned off safely when the electrical supply fails. Adding this equipment to a school computerization plan can increase costs significantly. When electricity is not available, it may be possible to install solar-powered systems for the computer equipment (see chapter 16). Solar equipment can be very expensive and is often best used with laptop computers, since they use less power and can use direct current (DC) electricity directly. Also, since laptops come with their own batteries, less money may need to be spent on a battery back-up system for the solar panels.
- *Other physical conditions:* What are the sizes and shapes of classrooms? What is the quality of natural or electrical lighting? Are telephone lines distributed throughout the schools? What types of desks, chairs, benches, and tables are available? As described below, one of the major questions about school computer systems focuses on whether to install computers in classrooms or computer labs. If classrooms are small and crowded and without lockable doors, it may be more appropriate to use labs. Creating optimum lighting conditions, especially where electrical light may be difficult to manage, often can be achieved most easily by modifying computer labs for skylights rather than trying to adjust the lighting in every room in a school. Often, as described below, the simplest way to connect computers to the Internet is through telephone lines and a dial-up connection to an Internet service provider (ISP). However without existing phone lines, it can prove difficult and expensive to provide wiring for telephone connections in more than just one or two computer labs.
- *Physical security:* How secure are the schools and the classrooms in which computers may be installed? Is the school located where the risk of theft is high? Providing sufficient security in the classroom and at the school to prevent theft of equipment, software, and supplies can be expensive and it is often only possible for one or two rooms in a school. When security plans are made, it is important to achieve a balance between protecting equipment from theft and allowing easy access to computers as often as possible. Fears of being blamed for damage to or loss of equipment can cause principals and teachers to make it very difficult for students to use computers, or for community members to benefit from investments in technology through after-school use.
- *Students per classroom:* What is the average number of students per classroom, and how large is the student population expected to grow over time? Schools with large numbers of students per classroom are likely to have limited space for permanently installed computers. Under such conditions, it may be best to install computers in one or more lab facilities where students can use the equipment. For smaller children, it is possible to have two to four students per computer. However, it is difficult and restrictive to have more than two older students per computer. To allow multiple students per computer requires sufficient space between computers with enough room left over to allow teachers to move among students to review work and offer support and feedback.
- *Technical support and management:* What strategies will be used to provide support, management, and maintenance of computer facilities? This concern, which has significant financial implications, is beyond the scope of

this chapter. But it cannot be stressed enough that the sustainability of any scheme to introduce computers into the educational process depends on careful attention to technical support and to equipment maintenance and renewal.

- *Financial resources:* How much money is available to purchase and install the equipment, buy software, train teachers, and support, maintain, and use the equipment? Is there a budget for ongoing maintenance, supplies, and technical support, and for replacing aging equipment and obtaining more computers? Technology budgets for initial installation of systems and ongoing support likely will be a decisive factor when deciding which configuration is best for a school or school system. As a result, budgets for ongoing equipment support, supply, repair, and replacement often are neglected or insufficient. Also, funds to purchase and install equipment and provide initial teacher training may come from national or state budgets. In contrast, local government and school budgets often will have to cover the purchase of consumables, pay for connectivity, and fund technical support and maintenance to keep the systems running. Without additional funds, these ongoing responsibilities and recurrent expenses often are not met. It may be necessary, therefore, for schools to devise special fund-raising schemes such as opening up the computer system to fee-based use during nonschool hours, reaching out to parent-teacher associations (PTAs), and soliciting the local business community for funding. In addition, where families have sufficient disposable income, some schools have charged an annual computer use fee to cover the cost of consumables and equipment maintenance. No matter what the solution, schools should develop and implement strategies immediately to guarantee sustainability of their computer systems.
- *Educator technology skills:* Do the teachers know how to use computers and, more important, do they have the skills to integrate computer and Internet use into routine teaching and learning? Only knowing how to use the technology will not enable teachers to use computer and Internet technologies to enhance learning significantly. Initial and ongoing teacher professional development focusing on using computers and effective pedagogy usually is required to enable schools to gain the greatest educational benefit from their investments in computers (see chapter 8). The configuration of computer facilities plays a major role in providing effective learning opportunities and professional development for teachers.
- *School routine:* Do students move from class to class throughout the day, or spend most of their time in one room? The answer affects decisions about using computer labs and/or placing computers in classrooms.
- S*pecial-needs or disabled students:* Will special-needs students use the computer system? Is physical access to computers by students in wheel chairs an important issue? If so, ramps, extra space between computers, and a few special desks will be needed. At another level, will there be need to install special software to make it easier for a visually impaired student to read the screen, or screen readers and headsets to allow blind students to listen to the screens being read? Learning-disabled students may need special keyboards with large keys and audio and tactile feedback to engage the technology effectively. Computer technologies have had some of their greatest impact in educating special-needs students. However, ignoring their special mobility and technological needs at the start of the planning and design process will guarantee that these benefits will be unrealized.
- *Temperature and air quality:* Will rooms with computers need to be air conditioned or protected from excessive dust? Modern computers and cathode ray tube monitors generate a great deal of heat. The lack of sufficient ventilation, especially in humid climates, can result in a very uncomfortable working environment for students and, occasionally, can even cause computers to overheat and malfunction. However, opening windows to improve air circulation can result in a damaging level of dust entering the computer room and increased risk of equipment theft. The combination of heat and dust often forces school computer programs to install expensive air conditioning units. Before committing to the purchase of air conditioning systems, programs should consult with architects, often as volunteers, about alternative strategies suitable for local environments to keep computer labs comfortable and free of excessive dust.
- *Connecting computers together:* Will the computers be installed as stand-alone systems or connected together to form a local area network (LAN)? Connecting computers together in a LAN, as described in greater detail below, can have significant educational benefits. At the same time, creating a LAN has financial and infrastructure effects that need to be weighed carefully against possible educational gains. LANs, if carefully planned, can be installed after the initial computer system is put in place if funding prohibits installation at the start. However, careful planning will be needed to avoid any duplication of effort and wasted investment.
- *Internet connectivity:* Will the computers be connected to the Internet? If so, what type of connection (intermittent use of normal phone lines, dedicated phone or cable connections, wireless links or satellite) is possible and affordable? Internet connectivity should be

dealt with at the very start of devising a school computer plan. Alternative approaches to connectivity are discussed below.

These questions are not equally important in all situations, so answers should be weighted according to the specific school's situation and requirements. One of the most difficult challenges, however, is balancing educational objectives with technical limitations and hard financial realities. Ultimately, the goal of assessing objectives, needs, conditions, and options is to determine the optimum configuration for integrating computers into education at a specific school.

There are many ways to describe different infrastructure needs and computer system configuration options and strategies. In this chapter, we use four organizing themes:

> physical configuration options,
> networking technology options,
> Internet access options, and
> software and operating system considerations.

PHYSICAL CONFIGURATION OPTIONS

Computers can be distributed in schools in three basic ways to meet educational goals. They can be provided to individual classrooms; installed in central computer labs, libraries, and teachers' planning rooms; or moved from room to room on mobile carts. Each of these options, and combinations of them, has associated benefits and costs that need to be considered carefully to select the options that best meet a school's needs. Some educational technology specialists argue that proximity and easy access to computers achieved by placing them in classrooms are crucial in achieving high rates of student and teacher use and, thus, educational benefits. Similarly, some people think installing computers in central computer rooms or labs is "old fashioned" and inhibits effective educational use. These are overly simplistic perspectives because the distribution of computers is only one factor in determining how teachers and students use them, and the Internet, to enhance teaching and learning.

Computers in Classrooms

One of the greatest potential benefits of distributing computers to individual classrooms is to provide teachers and students with easier access to these educational tools. More specifically, having computers in classrooms can:

> make it easier for teachers to integrate computer and Internet use into routine educational programs—but this cannot be guaranteed;
> allow for spontaneous use of these tools during instructional activities;
> permit teachers to organize students into a variety of learning activities, some using computers and others not; and
> make it easier to individualize instruction and strategically integrate computer and Internet technologies into project-based learning.

Achieving the multiple benefits of classroom-based computers demands significant financial investments to:

> purchase sufficient hardware and software so that all classes have equal access to computers;
> refurbish all classrooms so that there is sufficient room for the computers and a suitable electrical supply, security, networkability, and connectivity;
> provide each teacher with a high degree of computer technical and pedagogical skills since education technology specialists will not be available to help as they would in a computer lab; and
> supply ongoing technical and educational support.

Unfortunately, not all schools can afford enough computers to enable effective student access and use. As a result, some schools may decide to install only one or two computers per classroom, which likely will have little or no impact on learning. Experience also shows that when there is only a single computer in a classroom, it often becomes the "teacher's" computer and is rarely used by students.

Considerations for installing computers in classrooms include:

> *Teachers' skills:* Computers in classrooms usually require teachers to have a high degree of technical skill and the capacity to integrate computer use into their teaching.
> *Space and student numbers:* Placing clusters of computers in a classroom to enable effective student use requires enough space for both the computer systems and groups of two to three students to sit comfortably in front of the computers, circulation area for teachers and nontraditional student seating arrangements.
> *Quality and availability of electricity:* As mentioned above, computers demand a quality electrical supply. Remodeling classrooms to meet the electrical needs of computers is usually very expensive, especially if it needs to be done in many classrooms.
> *Security:* Maintaining sufficient security to prevent theft of equipment, software, and supplies, while also enabling open access to the classrooms to a variety of users, is usually impossible.
> *Availability of maintenance and support services:* Distributing computers throughout the classrooms in a school makes it more difficult, and more expensive, to provide effective maintenance and support services.

- *Internet access:* Providing even limited Internet access in each classroom via intermittent use of a single dial-up phone connection can be expensive, and high-speed access can become prohibitive.
- *Connecting computers within the classroom and the school:* Most schools require extensive remodeling to enable computers in classrooms and schools to be connected to form cabled networks. Also, creating classroom networks can require significant investments in additional hardware (servers, hubs, routers, etc.).
- *Community access to school-based computer systems:* Installing computers in classrooms can make it more difficult to provide community access to these costly resources. This difficulty is exacerbated if the number of computers per classroom is relatively low, since no single room may have a sufficient number of computers to meet community use and training needs. As a result, schools with classroom-based computers may not be able to generate enough revenue to cover the costs of consumables, maintenance, and replacement of systems through community access to their computers.

With sufficient funding, and under the right conditions, with highly skilled teachers, classroom-based computers can have a significant impact on the quality of teaching and learning (see Box 6.1). Classroom-based computer installations with low student-to-computer ratios also can provide unparalleled student access to computer use and enable teachers to integrate the use of computers and the Internet in ways that cannot be achieved by any other configuration. However, for most schools, especially those in developing countries and poor communities, it isn't possible to install computers routinely in classrooms. Under these more common conditions, alternative strategies must be considered.

BOX 6.1 • COMPUTERS IN THE CLASSROOM—A SUCCESS STORY!

Mrs. Barbara Bell teaches fifth grade in Montgomery County, Maryland. Over the last 15 years, she has accumulated a menagerie of 18 Apple computers, ranging from an "ancient" Apple II to a recent G3 powerhouse. Each of these machines is arranged in her classroom, filling each corner and empty space to afford optimum use and enable individualized and small-group learning. Many of these computers were scavenged from garbage piles behind schools at the end of the year and repaired and upgraded by her son and husband. An old large-screen TV is connected to several computers so she can switch the display to the TV for all students to see clearly. One system is connected to the Internet via a modem to enable e-mail communication and student research, often spontaneous and arising from class discussions. A special large-character keyboard and headset enable a student with Down's syndrome to be part of a "normal" classroom and participate in some class activities.

Along with her assortment of computers, Mrs. Bell has acquired a library of software, much of it purchased with her own money over the years. Some software titles are no longer published and are primitive by today's standards, with black and white graphics, no sound other than beeps and chirps, and no wildly interactive screens. Even without any essential multimedia elements, Mrs. Bell's students eagerly use these ancient software programs—often when a more modern version is available.

Maintaining her classic mix of computers, protecting and cataloging her rich collection of software, setting up the computers in a relatively small classroom with 32 students, and orchestrating the organized use of her computers in routine teaching and learning is not easy. So, why does Mrs. Bell continue to do this, year after year, without technical support from the school and when she is the only teacher with such an odd classroom?

The answer is easy: "It makes teaching and learning more effective, rewarding and fun!" According to Mrs. Bell, the routine and integrated use of computers in her classroom makes learning more effective and fun for her and for the students. It also makes it possible to individualize instruction at a level not possible without computers and allows Mrs. Bell to meet the learning needs of each student. It also enables planned and spontaneous peer-to-peer instruction among students. Mixing computer use with routine classroom activities allows for complex student-organized and -managed, project-based, and collaborative learning activities that often extend beyond curriculum themes.

When observing Mrs. Bell's class, one is struck by an apparent contradiction. The room is full of active, learning children, students working alone and in small teams, teaching each other, receiving focused instruction and tutoring from Mrs. Bell, researching answers to questions, struggling with problems, completing assignments, sharpening skills, and making seamless use of computers, blackboard, paper, books, and other learning tools. Yet, even with all this energy and activity, the room is surprisingly quiet; there are no arguments or disruptions, even from students diagnosed with attention deficient disorder; no one is goofing off, dozing, or eyeing the clock, eagerly awaiting the end of the day.

Computer Rooms or Labs

Establishing one or more computer rooms or labs is a popular way to provide equitable access to computers for the greatest number of users at the lowest possible cost. Computer labs enable schools to concentrate expensive resources in a common space that can be used for student educational activities, teacher professional development events, and community groups. When using computer labs, it is important to arrange computers along the walls of the room rather than in rows facing the front of the room, so teachers can view all the students' work from a common point and move quickly and easily from student to student, providing feedback, support, and guidance. This arrangement also can make it easier and less costly to provide electricity and network access for the computers. Some of the benefits and challenges of using computer labs are discussed below (see Box 6.2).

Benefits

- Establishing computers in a lab or dedicated room only requires schools to install quality electricity, network cabling and servers, Internet access, effective security, climate control systems, good lighting, and specialized furniture in one or two rooms in a school rather than in many different rooms.
- If designed effectively, a dedicated room ensures sufficient space to allow students to work in groups and move about to see each other's work, while also allowing teachers to move from group to group to provide input and guidance.
- Computer labs can be maintained by one or two staff members who also can provide technical and pedagogical support to teachers.
- Equipment and software can cost less for computer labs used by all classes than for classroom-based systems.
- Computer labs can optimize return on technology investments if their use is scheduled effectively.
- It can be easier and less costly to provide access to the Internet via computer labs than with classroom systems since many computers can use a common connection to the Internet.
- Computer labs can make it easier to encourage collaborative interdisciplinary projects among groups of teachers and students.
- Computer labs make it easier to provide community access to computer systems for public relations, and to generate revenue to cover the costs of consumables, Internet connectivity, and replacement of old equipment.

Challenges

- Computer labs can become oversubscribed quickly, and competition for use may make it difficult for teachers to engage their students in longer-term projects and activities.
- Scheduling conflicts can frustrate teachers and inhibit their use of computer labs.
- Once the novelty of using computers wears off, encouraging teachers to move their students to the lab may become more difficult.
- Spontaneous need to use computers for research, reference, word processing, etc., can be difficult or impossible to accommodate.
- In some schools, principals or lab coordinators may implement policies designed to keep the computers safe at the expense of using them.

Schools can overcome many of the challenges of using school computer labs by devising and implementing effective policies governing the use of the labs. A computer lab coordinator is a critical asset and can continue to promote use of the lab and help teachers deal with scheduling conflicts. Labs also can include one or two open- or free-access computers that can be used by students and teachers without scheduling.

Computers-on-Wheels (COWs)

Computers-on-Wheels (or COWs) systems are essentially rolling carts that hold one or more computers (often 10 to 20), usually laptops, often with a printer, and with the possibility to connect the cart to the school LAN via a single classroom network connection. COWs can be brought into a classroom, often by an educational technology specialist, when the teacher wants to use computers for a specific activity. Some of the benefits and challenges of using COWs are discussed below.

Benefits

- COWs make it possible to provide teachers access to computers in their classroom without having to remodel the room significantly, provide special furniture, or reserve space for dedicated computers.
- Working in small groups at their desks enables all students to have access to computers even in crowded classrooms.
- Using battery-powered laptops makes it possible to avoid providing special electrical power or installing additional power outlets.
- Using infrared printing and wireless networking cards enables the students to print their work and connect to each other and the school network for e-mail, electronic communication, and, possibly, Internet access without cables.
- COWs allow schools to optimize the use of expensive equipment by enabling teachers to request a cart of computers.

BOX 6.2 • COMPUTER LABS IN BRAZIL

Brazil's Ministry of Education officials were faced with a set of needs and constraints common to many education departments and ministries around the world. They wanted to provide as many public school students as possible with access to computer and Internet technologies, but they had limited financial resources. Also, few, if any, of Brazil's public state and municipal schools have the infrastructure to support computer installations without significant modifications and additions. Furthermore, most schools are used for two or three different school sessions during the day, thus making it impossible to install computers in individual classrooms. In addition, few public school teachers had the technical or pedagogical skills needed to integrate computer and Internet technologies into routine teaching and learning effectively, and there was no local, state, or national capacity to provide ongoing technical and pedagogical support to teachers who might use computers.

Faced with these and other constraints, Brazil's Ministry of Education, through the ProInfo program, decided to establish computer labs in refurbished existing rooms or in new rooms when existing space was either unsuitable or unavailable. Each lab holds 15 to 25 computers, often arranged along the walls of the room and connected together by a hub and server to form a LAN. Internet connectivity, where installed, consists of a single shared computer with a dial-up link to a local ISP or a dedicated 64Kbps line connected to the server so that all computers in the lab have shared access. Where needed, the labs, are powered by new or refurbished electrical systems and a combination of stabilizers and Uninterruptible Power Supplies (UPS) systems to protect the computers from potentially damaging electricity fluctuations. Special care was taken to provide a combination of quality natural and electric lighting while preventing excess glare and heat caused by strong tropical sunlight. Where needed, labs are air conditioned to provide comfort and limit dust. The labs are managed by teacher/lab coordinators who have had special technical and pedagogical training and who receive ongoing support to enable them to work with their fellow teachers to use the computer facilities and participate in interdisciplinary, project-based learning activities. Scheduling ensures equitable access to the computer labs throughout the day. Unfortunately, successful integration of computer use into regular teaching has resulted in teacher and student demands for access to labs that exceed available time.

A network of 229 computer resource and training centers across the country trains teachers from schools with labs to enable them to make effective use of computers, and provides them with ongoing professional development, pedagogical, and technical support.

- COWs may be more affordable than remodeling classrooms, building special computer labs, providing special electrical supplies, installing cabling to network all the computers, and buying special furniture.
- Since software only needs to be purchased for the computers on the carts, and not for dozens of computers in each classroom, the cost of software can be much less with COWs than with classroom-based installations.
- COWs can be stored in secure rooms when not in use.
- COWs can provide access to computers in situations where students have classes in different rooms.
- COWs can be customized to include expensive specialized equipment that normally would not be part of a classroom system.
- COWs often are brought to classrooms by an educational technology specialist who can help teachers to make effective use of the computers in teaching and provide immediate technical support.
- COWs can be used in teacher professional development programs.
- COWs can be used to support school-community computer programs because they can be brought to the room in the school used by community members.

Challenges

- The cost per computer to create a COW system with laptops and wireless networking capabilities is higher than for conventional desktop computer systems.
- There is a greater risk of equipment damage from accidents, hard use, or dropping.
- Dedicated staff is often needed to maintain COW systems, deliver them to teachers, and help teachers set up and use the equipment.
- Schools with multiple floors and no elevators have to have COWs for every floor or restrict their use to specific floors. The same is true for schools made up of different buildings.
- The difficulty of scheduling the use of a limited number of COWs may frustrate teachers and deter them from using these systems.
- COWs can perpetuate the belief that computers in education should be limited to "special" computer-aided activities.
- COWs, especially when used in secondary schools, can limit opportunities for interdisciplinary teaching and learning, since it can be more difficult to bring a mix of teachers and students together in a one-teacher classroom than in a common space.

For schools with few extra rooms for labs and no space or funds to build them, COWs offer a cost-effective way to provide teachers and students with access to computers and Internet connectivity. If COWs are used, effort should be made to promote the use of the COWs and to help teachers move beyond simple uses of computers in education. Without added educational inputs, COW systems can fall into disuse and rarely find their way into the classroom.

Computers in Libraries and Teachers' Rooms

When funding and staff resources are scarce, schools can optimize investments in computers and Internet access by installing a few computers in public spaces, such as the library or teachers' room. Giving teachers private access to computers and the Internet can encourage them to learn to use these technologies and integrate them into their daily routines.

Hybrid Options

Wherever possible, the greatest educational returns on technology investments can result by using combinations of the above configuration options. For schools with sufficient room, suitable infrastructure, and adequate funds and technical resources, distributing some computers to classrooms either as stationary systems or via COWs can be an effective means of easy and spontaneous access. Computer labs then can be used for whole class access and interdisciplinary use. Library computers can be used to focus on research activities, while special classrooms can be outfitted with computers, especially for special-needs students, creating benefits that are difficult to achieve from computer labs. The combination of these different options with one or more computer labs can create an ideal solution to providing students and teachers with access to these rich and powerful educational tools.

NETWORKING TECHNOLOGY OPTIONS

Connecting computers together to form a network, and connecting school, lab, and classroom networks to the Internet can multiply the educational value and impact of computers in schools. There are a variety of options for creating classroom, lab, and school computer LANs.

Peer-to-Peer Networking

As with all networked computers, users can share files and resources located on computers in the network. With peer-to-peer (see Figure 6.1) networking, however, there is no file server or central computer to manage network activity. One or more of the computers in a peer-to-peer network can provide centralized services such as printing and access to the Internet. Most desktop operating systems come with software to enable peer-to-peer networking once the computers are connected by some cable or wireless networking infrastructure.

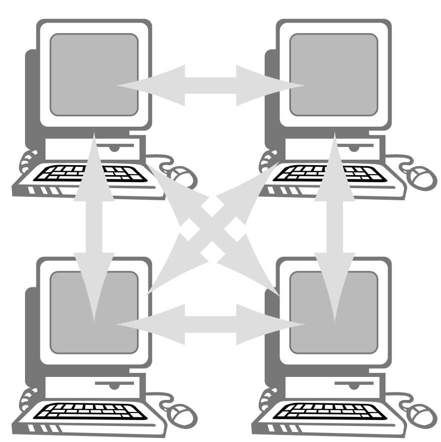
Peer-to-peer networking is good for small networks where a centralized file server is not needed and network security is not a major issue. This type of networking is less expensive to set up since the only additional expense is in the cables and networking hardware (one or two hubs). Most common computer operating systems (Mac OS and Windows 95/92/Me/2000/XP) come with software to establish a peer-to-peer network, so it may not be necessary to purchase, install, and configure special network operating system software such as Windows NT, Novell Netware, or Linux.

Client/Server Networking

As a computer network grows in size and complexity, it may be necessary to shift to a client/server style of network using more advanced network operating software. In these networks, as seen in Figure 6.2, one computer centralizes such functions as storing common files, operating network e-mail delivery, and providing access to applications and peripherals such as printers.

One of the advantages of client/server networks is that they are scalable: more clients and servers can be added to the system without changing the network significantly. These centralized networks are easier to manage, administer, and secure than peer-to-peer networks. These benefits come with some disadvantages, however. Because of the need to have a central "dedicated" server, initial costs are higher. Also, they are more complex to set up and maintain than stand-alone computers and peer-to-peer networks, often requiring schools to hire a technician to oversee the network. Also, if the server fails, all network functions fail.

FIGURE 6.1 • PEER-TO-PEER NETWORK[3]



Resources are shared among equals in a peer-to-peer nework.

Thin-Client/Server Networking

A thin-client/server network is similar to a traditional client/server network except that the client is not a free-standing computer capable of operating on its own. In contrast, thin clients are desktop appliances or network devices that link the keyboard, monitor, and mouse to a server where all applications and data are stored, maintained, and processed. The server, often called an application server, is built to provide all networking services and computer calculations. Since all network and computer services are centralized, all maintenance and upgrading is done at the server; there is no need to service the clients.

Proponents of thin-client/server networks emphasize that even though initial purchase costs are usually higher than with traditional PC/server networks, lifetime costs or total cost of ownership can be significantly less. For example, a recent "survey of 25 [business] sites using thin-client technologies conducted earlier this year by Datapro concluded that on average, deploying thin-client devices cut support [lifetime] costs by more than 80 percent."[4] A low cost of ownership in this case is achieved primarily through a reduced cost of centralized management, which can be from centralized remote sites, and from less costly software and applications upgrades. Thin-client/server networks are also easier to install than traditional client/server networks. In addition, since the client appliances cannot function without the server, there is little risk of theft. Thin-client systems are very efficient at providing access to the Internet, and, because the client appliances have few moving parts and limited functions, thin-client/server networks are more reliable and stable than traditional network systems.

A major disadvantage of some thin-client/server networks is that little educational software is written to run on thin-client servers running a version of UNIX. Most of these servers come with special emulation software, but this is usually an incomplete solution: software often runs slower and some applications fail to function. Since many thin-client/server networks are based on a type of UNIX operating system, skills with UNIX are needed to set up and administer. However, if schools have no staff with these skills, but do have access to the Internet, it is possible to have a technician at some remote site administer and maintain the network. This enables a school district to have one highly skilled technician manage thin-client/server networks in several schools, thus reducing management costs further.

Even though thin-client/server network systems are relatively uncommon in K-12 educational environments, they are a viable alternative to traditional client/server network systems. A careful assessment of total cost of ownership and the availability of technical skills at a school or school system can help planners decide if the thin-client/server network is best for their needs.

Connecting Computers

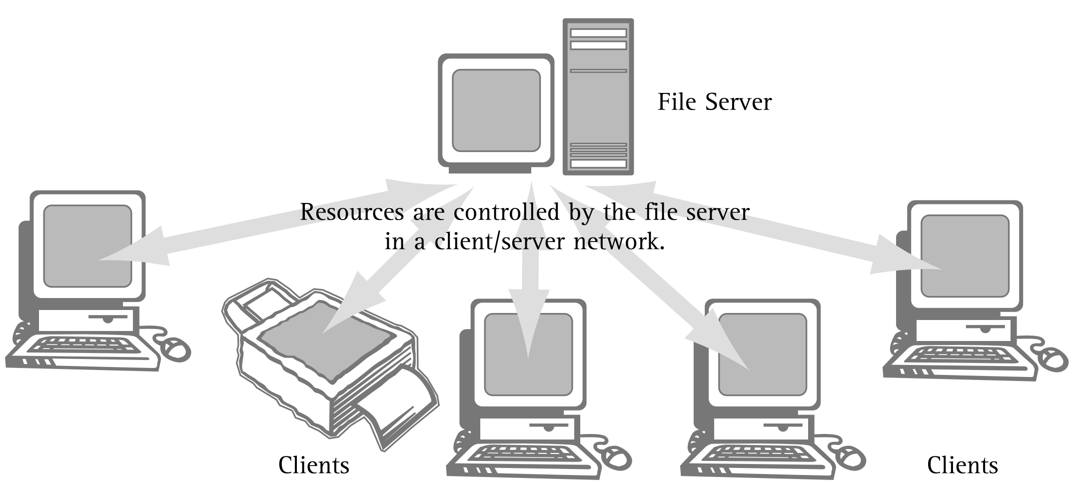
There are essentially three ways to connect computers to form LANs: cables, wireless, and power line systems.

Cabled LANs

Installing cabling in older buildings or in schools with thick walls built of brick and cement can be expensive, difficult, and time-consuming. To provide a sufficient number of individual connections for each computer, and to allow for flexible arrangement of computers in a room, many ports and cables must be installed.

Each cable connected to a computer must be connected as well to a network hub, an electronic device that controls

FIGURE 6.2 • CLIENT/SERVER NETWORK



the flow of network traffic between individual computers and the system's server, usually in clusters of 20 to 30 cables. Several hubs can be connected together to allow larger numbers of computers to be networked together. Hubs usually are housed in shielded and locked network closets to protect the hubs and prevent people from accidentally rearranging the network cables. Cabled networks provide reliable, high-speed—up to 100 Mb per second—transmission of network traffic. Because cable systems are more common than the other two options, it is usually possible to find firms and technicians with the skills needed to install quality cable LAN systems.

Wireless LANs

An increasingly popular alternative to cabled LANs is wireless networks. This type of system does not require cables to connect computers to each other and to the server and shared peripherals. Instead, wireless network adapters (receivers) are installed in all computers that will be part of the network (either as an internal network card or as a device that plugs into the computer's universal serial bus [USB] port). One or more wireless network hubs/transmitters are connected to the server, usually by a cable (several wireless network hubs can be connected to each other in a daisy chain). Network traffic is then transmitted by the hub to each computer and to and from the server. Wireless LANs have many advantages:

- They can be installed and configured in a very short time, since limited or no construction is needed.
- They allow for a high degree of flexibility. Computers, especially laptops, can be moved around a room or building, within the range of the network signal, without losing their connection to the LAN.
- They can be less costly to install and use than conventional cabled systems.
- They allow schools to create customized LAN systems covering single rooms or whole sections of the school. They also can be mixed with cabled systems to create greater flexibility.

Wireless LANs are not a perfect solution for all environments. The speed of network traffic depends on how many computers are using the hub's bandwidth simultaneously. Distance from the hub and thickness and character of walls between the transmitter and receiver can affect the speed and quality of the network signal significantly.

Because of the benefits of wireless LANs and their growing popularity, the technology is improving rapidly, and new standards with higher transmission rates are emerging.[5] Over the next few years, the speed and range of transmission will increase, and reliability and security will improve. Wireless LANs will become an increasingly desirable LAN solution for school computer systems.

Power Line LANs

Another alternative to installing special network cables that recently has become a reliable technology for some situations is to use the existing power lines in the school to carry the network traffic. Power line networking (PLN) currently is capable of providing reliable network communication speeds between 250Kbps and 500Kbps for six to 20 network access points. Higher-speed systems, ranging from two to 12 Mbps, are also available. Equipment costs are higher than conventional and wireless networking technologies, but these are expected to fall as technical improvements are made and larger-scale systems become available. In some situations, the costs of using PLN can be less than installing cable or wireless systems.

INTERNET ACCESS OPTIONS

By accessing the Internet, computers can become powerful communication devices with many educational applications. A variety of options and technologies should be considered when deciding whether and how to access the Internet.

Simulated Internet. If direct connection to the Internet is not possible, for economic or technical reasons, students and teachers can still gain simulated access to a selection of Internet resources by copying valuable Websites to CD-ROMs. Then they can use the CDs to access these sites, thus simulating the Internet. For example, the Rio de Janeiro municipal school system provides schools that cannot access the Internet directly with a CD containing a selection of more than 100 Portuguese-language educational Websites. The CDs, which are updated periodically, use the same browsers that are used with the Internet, so that when Internet access becomes available, teachers and students will have no difficulty using this technology. The "Internet" CDs also can make it easier for teachers to prepare structured educational activities using Websites since they can preview the resources quickly before the class session. In addition, this approach can focus student inquiry because students can explore the CD's resources but cannot surf freely beyond the scope of the activity or become distracted by noneducational Websites. Also, since these Internet resources are stored locally, no time is spent waiting for Websites to load. Even if Internet access is available, a CD with copied Websites can make it easier for students to access Internet resources rather than relying on a slow, congested connection.

Dial-up Connection. The simplest and lowest-cost connection to the Internet is through dial-up access using a single standard phone line. A dial-up connection can provide Internet access to a single computer (for example, in a lab, classroom, teachers' room, or library) or, by using software on a server, networked computers can share this single connection. However, with a shared connection, access can become very slow, since the total available bandwidth (the total amount of data that can be moved through the network per unit of time) is divided among all the computers sharing the same Internet connection.

If two or three phone lines are available, these lines can be combined using an analog router to enable multiple phone line access to an ISP, thus increasing available bandwidth.

Dedicated Connection and Other Connectivity Options. Schools can get faster and more reliable Internet access by using permanent "dedicated" high-speed connections where they are available and affordable. A variety of dedicated high-bandwidth options may be available to schools, including integrated services digital network (ISDN), digital subscriber line (DSL), terrestrial wireless, digital cable, radio modem, and satellite access, as described below.

Several new technologies offer the potential for developing countries to leapfrog earlier generations of equipment to provide connectivity. Terrestrial wireless and satellite technologies offer many advantages because they do not require installation of wireline networks. Satellite facilities also can be installed where communication is needed, even in remote and isolated areas, rather than waiting for terrestrial networks to be extended from the cities.

Terrestrial Wireless

Cellular: Cellular telephony has become the first and only telephone service for many people in developing countries, where it may be available much sooner than fixed-line service. In countries such as Côte d'Ivoire, Gabon, Rwanda, Tanzania, Uganda, Cambodia, and the Philippines, there are now more cellular telephones than fixed lines.

If no fixed lines are available, but there is cellular service, a cell phone with a cellular modem can be used to allow access to the Internet. For example, the community telecenter in Buwama, Uganda, about 60 km from Kampala, connects to the Internet via cellular modem. However, cellular access is often quite costly, and bandwidth is limited. It is likely to be more practical for short bursts of use for e-mail communication than for surfing the Web.

Wireless local loop: Wireless local loop systems can be used to extend local telephone services to rural schools without laying cable or stringing copper wire. Thus, instead of a fixed-line connection, schools would have a wireless link to the telecommunications network. Wireless local loop costs have decreased, making it competitive with copper. Wireless systems enable faster extension to new users than extending wire or cable; they also have a lower ratio of fixed to incremental costs than copper, making it easy to add more customers and serve transient populations. Wireless is also less vulnerable than copper wire or cable to accidental damage or vandalism. Countries with wireless local loop projects include Bolivia, Czech Republic, Hungary, Indonesia, South Africa, and Sri Lanka.[6]

Point-to-point wireless systems: If the telephone company does not provide wireless local loop, schools may be able to install or lease their own wireless links to the Internet. Point-to-point fixed wireless, such as microwave systems, can provide high-speed Internet access by connecting to an ISP's point of presence (POP). These fixed wireless links may be the least expensive means of getting high-speed Internet access if wireline services are not available.

Cordless: Short-range cordless extensions can provide the link from wireless outstations to subscriber premises; the DECT (digital European cordless telephone) technology standard also can allow the base station to act as a wireless private branch exchange (PBX) and reduce costs further.[7] For example, DECT has been used in South Africa to provide links to rural pay telephones and telecenters. However, DECT has very limited bandwidth, making it unsuitable for accessing the World Wide Web.

Wireless access protocol: This wireless protocol has been developed to make it possible to transmit Web pages and other data to cellular phones. It can be adapted for wireless services in developing countries so that Internet information can be transmitted to low-bandwidth wireless systems. However, the variety of Web content accessible through devices enabled by this protocol is still very limited.

Third-generation mobile services: Third-generation mobile networks are beginning to be introduced in some industrialized countries, and eventually may be made widely available in developing regions. They offer greatly increased bandwidth over existing mobile networks, with the possibility of Internet access to handheld devices such as portable phones, personal digital assistants, and small personal computers. However, the capital cost of upgrading existing networks is very high, and the price of access for Internet applications may be greater than for other options.

Satellite Technologies

Very small aperture terminals (VSATS): Small satellite earth stations operating with geosynchronous satellites can be used for interactive voice and data as well as for broadcast reception. For example, banks in remote areas of Brazil are linked via VSATs, and the National Stock Exchange in India links brokers with rooftop VSATs. VSATs for television reception (known as TVRO—television receive only) deliver broadcasting signals to viewers in many developing regions, particularly in Asia and Latin America.

Internet via satellite: Internet gateways can be accessed via geostationary satellites. For example, MagicNet, an ISP in Mongolia, and some African ISPs access the Internet in the United States via the PanAmSat global satellite system, and residents of the Canadian Arctic use Canada's Anik satellite system, while Alaskan villagers use U.S. domestic satellites. However, these systems are not optimized for Internet use, so they may be quite expensive. Also, there is a half-second delay in transmission via geosynchronous satellites, although it is a more obvious hindrance for voice than data.

> *High-speed downlink:* A system designed by Hughes, known as DirecPC, uses a satellite to deliver high-bandwidth Internet content downstream to a VSAT from an ISP. Upstream connectivity is provided over existing phone lines. This approach is designed for rural areas with telephone service, but where bandwidth is very limited. Some rural schools in the United States are using DirecPC for Internet access.

> *Interactive access via VSAT:* Several companies offer fully interactive Internet access via satellite; examples include Gilat, Hughes Gateway, and Tachyon. Systems typically are designed for small-business or home office use, but could be a solution for schools with no other communication options. For example, schools in Alaska and the Canadian Arctic access the Internet via satellite.[8] The price of Internet access is likely to decline as new protocols are developed to make more efficient use of bandwidth and, thus, lower transmission costs for users.

Data broadcasting by satellite: Geosynchronous satellites designed for interactive voice and data can be used for data broadcasting as well. For example, the WorldSpace satellite system delivers digital audio directly to small radios. While one market for these products is people who can afford to subscribe to digital music channels, the systems also can be used to transmit educational programs in a variety of languages for individual reception or community redistribution. It can also be used to deliver Internet content; schools or telecenters can identify which Websites they want to view regularly, and WorldSpace broadcasts the data for reception via an addressable modem attached to the radio. WorldSpace has donated equipment and satellite time for pilot projects at schools and telecenters in Africa.[9]

Global mobile personal communications systems: Using low earth-orbiting satellites, these systems provide voice and low-speed (typically 2400 to 9600 bps) data virtually anywhere, using handheld transceivers. However, the price per minute for these services is typically much higher than national terrestrial services, and the first generation of low earth-orbiting satellites (from Iridium and Globalstar) has very limited bandwidth.

Store-and-forward messaging: Volunteers in Technical Assistance (VITA) has developed a satellite-based system, called VITAsat, capable of delivering sustainable, low-cost communications and information services to remote communities. The system uses simple, reliable, store-and-forward e-mail messages relayed to the Internet via low earth-orbiting satellites. Using compression technology and software that allows access to Web pages using e-mail, VITAsat can make the Internet accessible virtually anywhere. VITA's two current satellite systems have the capacity to serve about 2,500 remote rural terminals that could be installed in schools, clinics, community centers, and NGOs. VITA plans to include local skill and organizational capacity building and development of targeted information content and services designed specifically to meet the needs of small businesses, local NGOs, educators, health workers, and other relief and development workers.[10]

Bandwidth on demand: Future satellite systems are being planned to provide bandwidth on demand. Constellations of low earth-orbiting satellites such as Teledesic and new generations of geosynchronous satellites such as Loral's Cyberstar and Hughes's Spaceway will be designed to offer bandwidth on demand for Internet access, videoconferencing, and distance education.

Wireline Technologies

Innovations in wireline technology make it possible to provide high-speed Internet access over telephone lines, rather than having to upgrade existing copper networks.[11] These technologies may be used in urban areas where basic telephone service is available.

Integrated services digital network (ISDN): Regular twisted-pair copper telephone lines can carry two 64 kbps channels plus one 16 kbps signaling channel. One channel can be used for voice and one for fax or Internet access, or two can be combined for videoconferencing or higher-speed Internet access. Developed in Europe, ISDN may be available from telephone companies in some urban and suburban areas of developing countries.

Digital subscriber line (DSL): Several variations of DSL technology have been developed that provide data rates from 384 kbps or more downstream over existing telephone lines. This technology is replacing ISDN in industrialized countries because of its greater bandwidth. It can be used in urban areas where copper wire is already installed, but its range is limited to about 1 km from a telephone exchange.

Cable modems: Some cable television systems can also be used for high-speed Internet access via cable modems. Like DSL, cable offers much higher bandwidth than dial-up telephone lines. However, a high volume of users may result in congestion of a shared cable network, and older networks may not be converted easily for two-way connectivity.

Optical fiber: Telephone companies upgrading their networks may install optical fiber for institutional customers such as hospitals, schools, and businesses. The advantage of fiber is its enormous bandwidth, which can be used for high-speed Internet accessing or other services such as videoconferencing. However, the price of access may be prohibitive. Some schools have managed to gain free or heavily discounted access to so-called "dark fiber," excess capacity that has been installed but is not yet in use.

Hybrid fiber/coax: A combination of optical fiber and coaxial cable can provide broadband services such as TV and high-speed Internet access as well as telephony; this combination is cheaper than installing fiber all the way to the customer premises. Unlike most cable systems, this hybrid allows two-way communication. The fiber runs from a central telephone switch to a neighborhood node; coaxial cable links the node to the end user such as a school. Developing countries with such projects include Chile, China, India, and Malaysia.[12]

Other Technologies

Other technological innovations that can be used for educational communication in developing regions include:

Internet telephony (voice over IP): Packetized voice communication can be transmitted very inexpensively over the Internet. Schools with Internet access may be able to use their networks for voice communications as well (regulations vary by country). Using Internet protocols for voice and data is much less expensive than using regular telephone networks.

Community radio: Small community radio broadcasting stations can be important news sources for the community and can be used to broadcast educational radio programs for listening in school, at home, or in community centers.[13] Some school and telecenter projects are combining computer facilities with community radio stations, so that information received via the Internet can be communicated more widely. Portable windup or solar-powered radio receivers are practical for school and community use.[14]

Selecting an Internet Service Provider (ISP)

In addition to choosing a means of connecting to the Internet, it also will be necessary to choose an Internet service provider (some ISPs bundle connectivity with services). Factors to consider include:

Distance to point-of-presence (POP): Ideally, the ISP should provide local connectivity so that long distance calling charges are not incurred. However, in many rural and developing regions, local access is not available. In such cases, it will be important to consider the price charged by telecommunications operators to reach the POP, and whether there are any toll-free or flat-rate options.

Speed and reliability of access to the Internet: The speed of access to the Internet depends not only on the bandwidth available to reach the ISP, but also the number of ports at the ISP and the bandwidth it has available to reach an Internet gateway. In addition to asking the ISP for such information, it is useful to check with other customers to determine whether they experience outages or delays, and whether they have noticed any improvement or degradation in access over time.

Batched and compressed e-mail accounts: Users can save money in telecommunications charges if they can compose messages offline and send and receive e-mail in batches to the Internet service provider (ISP). A batched e-mail service using the compressed UUCP (UNIX to UNIX copy) transfer protocol is four to eight times faster than the standard TCP-IP/POP (post office protocol) used by most e-mail clients.[15]

Web hosting: The ISP should provide Web-hosting capability if another Web-hosting site is not already available in the country. Alternatively, schools can use one of the free Web-hosting services made available by some U.S., European, or Australian sites.[16]

SOFTWARE AND OPERATING SYSTEM CONSIDERATIONS

Software, an essential component of computer systems, enables the hardware to do useful work for users. In this section, the discussion about software for educational computer systems is organized into the following four broad categories:

- operating system (OS) software for client and server computers;

- basic computer application software, including software for word processing, spreadsheets, presentations, and graphics;
- educational software applications; and
- Internet-related and -delivered software, including browsers, Java applications, and interactive tools on Websites.

Operating System Software

Decisions about what operating system software to use on client or end-user computers are usually based on the type of hardware purchased. If Apple computers are purchased, then Apple's OS, which comes with the computer, will likely be used on client computers. If computers with Intel or Intel-compatible CPUs are purchased, the computers likely will come with a version of the Microsoft Windows OS. In contrast, decisions about what software should be used to operate networked computers are not as easy or predetermined as they are with client system software. Basic Apple and Windows operating system software comes with the capability to enable computers to be connected together to manage small networks. However, larger and more robust networks that may need to be managed securely will require special network operating system software installed on the network's server to manage the functions of the network, including links to printers and other peripherals, e-mail, file sharing, security functions, and communication among linked computers. There are different options for network operating system software. For Apple computer systems, two main options are available: Apple's own network operating system and Linux.[17] For Intel-based computers, the three main options are Microsoft NT, Novel Netware, and Linux.

It is beyond the scope of this chapter to present a detailed comparison of these network operating system software options. However, there are several important questions that should be addressed when deciding which network operating system to use, including:

- Is technical support available and what does it cost for the different options?
- What types of network operating system software are most common in schools, businesses, and government agencies in your country or locality?
- What types of network operating system software are used already?
- How much money is available in project and school budgets to cover the costs of installing, maintaining, and upgrading network operating system software?
- Are there local user communities (face-to-face or Web-based) that can be used to access local technical support for different network operating system software systems?
- Is the network operating system software available in a language version to match languages commonly spoken by technicians and users?

Open Source Software (OSS)

One of the most hotly debated topics in educational technology today deals with the question of whether it is better for school systems to use open source software (OSS) or commercial software products for client and server operating systems. There are no simple answers to this question since they involve policy, commercial, technical, and educational concerns. For education systems, the education functions that need to be supported and the needs of students and teachers are the most important factors in making technology decisions. If the software and hardware solutions do not ultimately serve the teaching and learning process, then even "inexpensive" or "free" options can be very costly educationally. If key educational software programs cannot be used on computer systems with "free" OS software, then the "free" solution could become very expensive. Similarly, educational uses and needs for computers are often quite different from corporate needs—and decision making about technology choices for schools needs to reflect these differences.

Linux, part of the family of UNIX-based operating systems, is one of the most popular open source software products used for computer operating system software. Linux has become popular primarily because it is available free of charge and has a large development and user community. Linux is also the first or second most popular operating system software for Internet servers—accounting for about 30% of all Web servers in the world today. It is used only rarely as a client operating system (on the end terminal or PC at the user's desk), however, mainly because few software applications, such as word processing, can be used on computers running Linux. The exception is WordPerfect's and Sun's StarOffice's application suite (the latter is now called OpenOffice, since it was released as an OSS application).

Questions of Benefits of OSS

The technical benefits of operating system and network operating system software generally are discussed in terms of the software's reliability, performance, scalability, security, and cost. A variety of comparisons have shown that servers running Linux crash less often and perform better than commercial and other OSS software. Also, Linux can be used on a wider range of computer platforms than any other operating system and is more secure than commercial OSS. Finally, studies have shown that Linux and other open source software usually have significantly lower initial costs than commercial operating system software.[18]

When Is Free Software the More Expensive Choice?

Proponents of using Linux in educational computer environments often emphasize the fact that Linux is "free," and that the money saved from not having to purchase operating system or network operating system software is a sufficient reason to use it. Unfortunately, this argument is seriously flawed. Operating system and network operating system software only account for about 5% to 8% of the total cost of buying a client computer system. In contrast, the ongoing costs to train teachers to integrate technology into teaching and learning, and to support and keep computer systems running from year to year, can be many times greater than the original purchase cost of the computer and the operating system or network operating system software. In many cases, school systems will spend as much in two years for operating school computers as was spent initially to purchase and install a system that is expected to last five years. Therefore, it is more important to consider the total cost of ownership carefully—acquiring, installing, configuring, supporting, maintaining, training users in, using, and upgrading the software—when evaluating the real costs of using different types of operating or network operating system software. It is also important to emphasize that total cost of ownership studies carried out for corporations cannot and should not be used to justify purchase decisions for educational systems. There are special and critical differences between the needs and uses of computers in education and corporations.

The most important factor in realizing the potential educational benefits of technology is how teachers and students use computers and the Internet in learning activities. Consequently, the most important cost factors in total cost of ownership studies of technology in education are linked to the use of technology and its integration into teaching and learning. Therefore, when evaluating the use of OSS in education, it is essential to assess how different software decisions will affect how teachers and students use technology and how easy or difficult it may be for them to integrate it into routine teaching and learning.

Human capacity development considerations: In Brazil's ProInfo[19] program, for example, more than 40% of the budget was dedicated to initial teacher professional development and training, both pedagogical and technical. ProInfo staff also made significant and continual investments in building teachers' confidence to use computers and the Internet in their teaching, and in developing successful project-based learning strategies that make effective use of computers and the Internet. The value of these investments is several hundred times greater than the initial cost of the computers and several thousand times greater than the cost of the operating system software used on these computers. If the government of Brazil were to develop a total cost of ownership model to evaluate the costs of switching from a Microsoft Windows operating system for client, end-user computers that are currently used in schools to OSS such as Linux, it would have to include the costs of rebuilding the skills and confidence of thousands of teachers across the country to use computers over several years, and the opportunity cost of not having students use computers during those years.

Technical support considerations: Anther lesson from Brazil's ProInfo program is that technical support to keep school computer systems running, and to help teachers implement their learning projects with technology, is essential. A shift from Windows to OSS options would require states, municipalities, and schools to spend thousands of dollars and years rebuilding the technical support capacity essential to making effective use of computers in education. Some countries, such as Namibia, may have greater technical capacity to manage UNIX and Linux operating systems than Microsoft NT, so using Linux could be a more cost-effective decision for them.

Matching skills to needs: Windows is the operating system used on 80% to 90% of all client computers in business, government, and the nonprofit sectors of the economy. If students were to use computers in schools with OSS, some likely would not gain the needed skills and experience with Windows that prospective employers would demand. Therefore, total cost of ownership calculations for education systems considering OSS would need to consider the costs that students and companies would likely incur to train workers to use Windows.

Educational software applications: The lack of educational software applications that can operate on OSS, and the loss of current investment in Windows applications that could not be used on OSS, without using emulation software[20], would need to be considered as well in total cost of ownership calculations. Furthermore, many schools, especially those in developing countries, have very small budgets to purchase additional software for their computer systems. A shift to OSS would make some current investments useless, and replacing the software with versions to run on OSS, if they were available, would drain scarce resources. Also, some critical applications, such as software used in special-needs education, are not available for the OSS operating system, and a shift to OSS could prevent some students and schools from using their computers.

Optimizing Investments

When considering the technical specifications of educational computer systems, especially regarding the use of open source software, it is critical that the primary goals and objectives of such systems—significantly improving the quality and equity of teaching and learning—remain the principal focus of decision making. If decisions to use OSS are made for short-term or immediate cost savings, it is possible that the long-term costs, both financially and educationally, may become excessive. As described above, the development of total cost of ownership models to assist decision making must reflect unique local realities and include the significant hidden costs associated with building the capacity of educators to integrate the use of computers and the Internet effectively into routine teaching and learning.

Basic Computer Application Software

All computers in schools require a basic set of software applications to be useful for computer literacy programs and to be integrated effectively into routine education programs. These applications generally include software for word processing and manipulating numeric data such as spreadsheets, presentation software, and graphics software, and the increasingly important software to create Websites and HTML documents. As with operating system software, commercial and public domain options are available. Major commercial applications often are purchased because they are the types of software used in businesses and government offices, and it is often important to prepare students to use computers and applications that are common in the workforce.

Where funding is a constraint, schools have the option of using Sun Microsystems public domain software application suite, called OpenOffice. It includes an integrated graphical interface similar to MS-Office and WordPerfect and comprises word processing, spreadsheet, and presentation applications. StarOffice also has support for AutoPilot Web page design software, 3D graphics, diagrams, HTML editing, and calendar, newsgroup, browser, e-mail and scheduler, photo editing, and other applications. This software is also available in a variety of languages and can be downloaded for free from the Internet.[21] There are versions of StarOffice for Windows and Linux operating systems.

Educational Software Applications

Thousands of software applications have been developed over the years, many for free, to meet specific educational objectives, including:

- strengthening subject matter competence;
- providing drill and practice activities for different subjects;
- enhancing logical thinking and problem-solving skills;
- enriching research and writing activities;
- simulating complex or dangerous processes that enable students to change variables and visualize how processes are changed; and
- providing opportunities for students to extend learning beyond the scope of classroom activities.

As with all uses of computers to enhance and improve teaching and learning, the key to success is not the type of educational software that is used, but how teachers use the software and integrate it into their teaching programs. For example, research has shown that when drill and practice software is used without active teacher participation, performance on standardized math tests can go down. In contrast, when this type of software is integrated into a comprehensive set of activities and actively facilitated by teachers, performance on standardized tests can improve.

It is commonly believed that the best educational return on investments in computer systems in schools comes from using specialized educational software. This assumption is not valid. Significant benefits to teaching and learning can be achieved without using any specialized educational software. However, when used effectively by teachers, many excellent educational software applications can enhance the use of computers in education. Achieving these benefits is not guaranteed, and the costs of purchasing often very expensive software must be considered carefully. Selecting software should not be done based on the publishers' promotional materials. Rather, schools and teachers should seek out evaluations of software from other educators to learn the benefits of and possible problems with the software. Numerous Websites can provide evaluations of educational software. Also, publishers often will provide evaluation copies of software that teachers can use to test the products before the school decides to purchase them. When evaluating educational software, teachers and schools need to develop evaluation criteria so that purchase decisions are based on objective and subjective measures of educational quality.

Internet-Related and Delivered Software

One of the most important benefits of Internet- and Web-related software is that most of it can be used regardless of the hardware and software installed at schools. The "platform independence" of the Internet reduces the costs involved in using the Internet in education and enhances its benefits. One key area of Internet use is access to a variety of Internet and Web-based software applications, much of it freely available in different languages that can be used by teachers and students in a variety of ways, including:

- browser and search software that enables students to carry out research on the Internet and engage in

enquiry-based learning activities using the millions of Websites on the Internet;
- e-mail software that allows users to send and receive communication from other learners and Websites;
- listserv or e-mail distribution software that allows groups of users to form and communicate easily by e-mail;
- Web-based discussion forum software that allows users to engage in ongoing dialogues in which the topics or themes are linked to form discussion threads;
- interactive Web-based publishing tools that allow students and teachers to publish their thoughts, comments, experiences, pictures, suggestions, etc., instantly on Web pages;
- Internet- and Web-based chat and instant messaging software that allows users to engage in live text-based discussions;
- easy-to-use Web page construction and publishing tools;
- voice and video software applications that allow teachers and students to participate in synchronous audio- and videoconferencing, if sufficient bandwidth is available; and
- file storage and retrieval software that allows users to share digital files easily, including documents, presentations, images, data, and music, with other users.

The existence of these online or Web-based software applications that enable users to communicate at a distance has given rise to opportunities for collaborative and project-based learning that were not possible before the Internet. Since learning is very much a social activity, the ability to link students and teachers together to form learning communities can significantly enhance learning outcomes and opportunities to develop lifelong learning skills.

Another important category of Internet-related software includes applications, many of which are freely available, that enable teachers and students to construct and publish Web pages and HTML documents on the Internet. In addition, the Internet's "platform independence" helped give rise to a variety of software applications, including JAVA, FLASH, and Shockwave, which can be used to create learning applications that simulate simple and complex processes and concepts. These programming languages can be used by teachers, students, and mediated learning specialists to create simulations that can accelerate understanding of complex concepts and demonstrate scientific activities that normally would need to be carried out in expensive labs. (For a full description of these authoring tools, see chapter 7.)

CONCLUSION

As mentioned at the beginning of this chapter, no "off-the-shelf" configuration solutions meet the diversity of needs and conditions of different schools around the world. Carrying out an assessment of needs, physical conditions, constraints and opportunities, and weighting factors, according to their importance, will contribute greatly to deciding which type of configuration optimizes resources against needs. It is also important to examine the capacity of local markets to support different options, especially new, innovative, state-of-the-art technologies. Throughout the information-gathering and decision-making process, it is important to evaluate options and alternatives against the ultimate objective of all school computer systems—to enhance teaching and learning.

ENDNOTES

[1] This chapter does not address the use of computers and Internet technologies in school management or in building school community partnerships.

[2] In this chapter, computer configurations refer to how computer systems are distributed, arranged, connected, and used in a school, and the supporting infrastructure needed to power school computers systems and link them to the Internet. The chapter does not discuss the technical configuration of how software is installed or how individual computers are prepared for use.

[3] From *An Educators' Guide to School Networks* (1997-1999). Florida Center for Instructional Technology, College of Education, University of South Florida. Available at: *http://fcit.coedu.usf.edu/network/*.

[4] Molta, D. (June 28, 1999). For Client/Server, Think Thin. IT Papers.Com. Available at: *http://www.itpapers.com/cgi/PSummaryIT.pl? paperid=13855&scid=154*.

[5] The most common standard for wireless LANs today is 802.11b, which transmits data up to 11 Mbps (the rate of transmission is affected by distance, walls, and radio frequency interference) 30 to 500 meters. A more recent standard, 802.11a, can transmit data up to 33 Mbps.

[6] International Telecommunication Union (1998). *World Telecommunication Development Report*. Geneva: ITU, p. 53.

[7] Kayani, R., & Dymond, A. (1997). *Options for Rural Telecommunications Development*. Washington: World Bank, p. 48.

[8] See, for example: *www.schoolaccess.net*.

[9] See: *www.worldspace.com*.

[10] See: *www.vita.org*.

[11] It should be noted that copper wire is prone to theft in some countries: Telkom South Africa reported more than 4,000 incidents of cable theft in 1996, at an estimated cost of R 230 million (about US$50 million).

[12] ITU, op cit., p. 57.

[13] See, for example, Latchem, C., & Walker, D. (eds.) (2001). *Telecentres: Case Studies and Key Issues*. Vancouver: Commonwealth of Learning.

[14] See, for example, Freeplay Energy at: *www.freeplay.net*.

[15] Jensen, M., & Walker, D. Telecentre Technology in Latchem and Walker, op cit.

[16] See, for example: *www.geocities.yahoo.com* or *www.tripod.lycos.com*.

[17] Linux is a public domain operating system software based on UNIX. Linux can be downloaded from the Internet free of charge.

[18] See: *http://www.dwheeler.com/oss_fs_why.html*.

[19] Started in 1997, ProInfo is a national program in Brazil that works in partnership with state and local authorities to establish a network of teacher training and technology resource centers across the country, build computer labs in public primary and secondary schools in all states, and train thousands of trainers and teachers to integrate technology into all aspects of the curriculum.

[20] Emulation software enables Windows applications to operate on computers running the Linux OS. Unfortunately, not all Windows applications will run under emulations software, and, when emulations software works, the application will run more slowly.

[21] StarOffice can be downloaded from the Sun Microsystems Website at: *http://www.sun.com/software/star/staroffice/5.2/index.html*.

7

DEVELOPMENT OF MULTIMEDIA MATERIALS

Cesar A. A. Nunes
Edmond Gaible

INTRODUCTION

Many nations are increasing their investments in education and education technology[1] to support the transformation of teaching and learning. Yet, not enough attention is given to the development and availability of instructional contentware that makes the investments in hardware economically useful and educationally meaningful. One possible reason is that equipping schools with radios, televisions, and computers and connecting them to the Internet is simple compared to developing corresponding instructional materials.

For a visual artist about to create a new work, the choice of medium is a question of supreme importance. Each medium carries within it a certain relationship to the gesture, a demand for restraint, limitations of texture, hue, value, plasticity. For the educationist, the term, "multimedia," has become much more definite. It signals high cost, a simplistic blend of visual and aural information, and low return. Today multimedia as a means of learning is equated with tightly structured content built by a commercial vendor—a developer. It is a product, not a possibility. The excitement of choice, of trial, of process is absent.

Yet, multimedia in its broadest sense is among the most effective and egalitarian of computer-based resources available. By establishing the potential for the artful interaction between learners and content—intertwining information, skills, and even the synthesizing vision that is so important to comprehension—multimedia "contentware" is effective across the wide range of circumstances. Multimedia can be designed to:

- enhance learning in different locations and in schools of diverse quality;
- present opportunities for students working at different rates and levels;
- provide (tirelessly, without holding up other students) repetition when repetition is warranted to reinforce skills and learning; and
- compensate, in the short term, for high student populations and limited numbers of trained and experienced teachers—in combination with robust teacher development initiatives and improvements in teachers' working conditions.

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In dynamic fields, such as astrophysics, genetics, or political geography, updates to contentware can ensure that teachers and students encounter and have the chance to work with current and even cutting-edge knowledge. Such encounters tie learning to the most important events of our time and underscore the general idea that knowledge itself is not fixed and finalized, that there is a universe of discoveries and a library of analyses that can be available to students.

Finally, computer-based and Web-based multimedia contentware is itself dynamic, built of bits and bytes, using software development tools that combine, in some cases, the power to create with the simplicity of use. Unlike textbooks or library-based resources, contentware has the potential to engage all stakeholders in the education system—from software developers to ministry personnel to education researchers to teachers and students—in the development of multimedia learning resources.

In this chapter we present multimedia as a tapestry of possibilities—for creation, experimentation, and communication—that is woven by students, teachers, researchers, and professionals, working with different tools across the range of media. We address:

- the context for multimedia development;
- the nature and modalities of multimedia;
- the authors of multimedia resources;
- environments and tools for multimedia development; and
- ensuring quality in multimedia.

THE CONTEXT FOR MULTIMEDIA DEVELOPMENT

A decade and more ago, national efforts to introduce ICTs in education anticipated increases in efficiency,[2] without attending to the nature of learning and cognition, or to the distinction between skills mastered in abstraction and knowledge built to be used, expanded, and eventually transcended.

To build resources that enable learners to build knowledge, we must broaden our perspective beyond building skills and memorizing facts in the abstract; if these are our educational goals, technology will prove neither cost-effective nor effective in absolute terms. If our goals include enhancing analysis, synthesis, communication, and the grasping of interrelationships in the ways in which we represent our world, we will find that technology supports and empowers all of our efforts along these lines.

The use of multimedia as engines of learning is conditioned by several dynamic contexts, including our evolving understanding of cognitive factors with direct bearing on learning and changes in school environment ranging from infrastructure to resources to teacher development.

The Cognitive Context

The emergence of technology as a change factor in education coincides with the sweeping influence of cognitive science and brain studies as a factor in the transformation of teaching and learning.[3] The influence of both of these forces has increased with the recognition of globalization, the concomitant demonstrations of the value of innovation, [4] and the prevalence of strong "knowledge-work" sectors.[5]

The Committee on Developments in the Science of Learning of the National Research Council[6] identified five themes that changed the conceptions of learning: memory and structure of knowledge; analysis of problem solving and reasoning; early foundations; meta-cognitive processes and self-regulatory capabilities; and cultural experience and community participation.

Beyond thinking skills, thinking dispositions are important—students must have sensibility to know when and how to apply their skills. Development of such competencies can be fostered by the creation of a culture of thinking in the classroom.[7] In this way students are able to develop successful strategies to transfer their learning to other situations.[8]

From these concepts about learning, and more recently from discussion of the skill sets needed in the "global, knowledge economy,"[9] new pedagogical rubrics have emerged that include cooperative learning, collaborative learning, active learning, project-based learning, problem-based learning, situated learning[10] and, most recently, "learning by doing." These approaches all aim at a transfer of emphasis away from rote-based methods and assessment, and the teacher as the "producer" of knowledge. Instead, they emphasize the roles that analysis, synthesis, and other higher-order cognitive skills play in learning, with particular focus on learners building their own knowledge.

Expanding our view of multimedia must also take into account multimedia examination formats.[11] Students and faculty feel that incorporation of rich media in assessment can provide additional support for learning and teaching.[12] Advances in technology, cognitive science, and measurement also show the need to reinvent large-scale assessment,[13] and this process of reinvention may stand to benefit from incorporation of multimedia.

Dynamic stimuli, such as audio, video, and animation, may make performing such tasks as problem solving more relevant to student experience.[14] To accomplish this objective, multimedia development must consider cognitive complexity, sensitivity to instruction, meaningfulness, reliability, fairness, and linguistic appropriateness.[15] Multimedia material produced for teaching and learning must be produced for assessment as well, with compatible goals, similar depth, and equal quality.

The Instructional Context

When developing educational multimedia resources, it is important to take into account objectives at the level of the individual learner, the school, and the state. Each has different characteristics, expectations, and needs, and the means to fulfill them are all interrelated. For this reason, development of learning resources is linked, strategically, with processes of educational reform and the transformation of teaching and learning. Thus, we suggest four points of focus for planning the development of multimedia educational material[16]:

Learner-Centered

- What kind of approaches and materials would be flexible enough to consider students' previous knowledge, cultural practices, and beliefs while connecting them to academic tasks?
- How can the processes of teaching and learning benefit from each student's special interests and strengths?

Project-based learning activities[17] are just one way to achieve these goals. Technology also may enable us to support these goals through a combination of preauthoring (i.e., design) tools, classroom work, portfolio-organization systems, publication systems, and collaboration tools. In such an environment, the most useful multimedia material might be small bits and pieces of software that are plugable and insertable in student's pages and projects (applets[18], Flash and Shockwave files, video clips), perhaps allowing user customizations. Examples of this combination of a tool-based learning environment and preexisting content can be found in "microworlds," often written in Java, such as *Proyecto Descartes* (*http://www.descartes.es*). In this environment, students are motivated not only by the drive for visual quality in their work, but by the opportunity to use and discuss material that they, working independently in the classroom-based learning environment, would be unable to produce on their own.

Knowledge-Centered

- How can we design curricula to promote understanding instead of the acquisition of disconnected sets of facts and skills?
- How can we develop in students the ability to think and solve problems by accessing appropriate knowledge?

Multimedia may help in making accessible themes that would be very hard to understand or to connect to reality—as demonstrated by the site, Physics 2000 (*http://www.colorado.edu/physics/2000*). It also can help in enabling learners to reframe knowledge. They may use conceptual maps linked to Web pages[19] that highlight different aspects of a content domain: how knowledge is acquired by experts; how problems are solved; what language is used in that domain; the current pathways of deepening knowledge; and the different possibilities of presentation for different publics of different ages.

Multimedia also can broaden the scope of school learning environments by enabling experiments that otherwise would be too dangerous, too expensive, or take too long. (There are already some excellent CD-ROMs available in this niche.) And visualization and modeling tools give students the opportunity to enter into much more complex knowledge-contexts (so many of which are now necessary in our world than ever before), while continuing to build their comprehension of the core knowledge of those domains.

Assessment-Centered

- How can we provide opportunities for students to revise and improve the quality of their thinking and understanding?
- Technology can help facilitate self-assessment and other meta-cognitive activities in students, in part by giving frequent feedback. Collaborative tools and communication tools may promote reflection and learning as a social activity, enhancing the potential for conceptual change.

Interactive multimedia can play a crucial role in helping students overcome misconceptions in other ways as well. Students can be enabled to develop their hypotheses as far as possible, aided by the capabilities of well-planned multimedia.[20] At that extreme point of development, visual feedback can intervene, providing alternatives or deconstructing their beliefs. It is possible to produce simulations and animations that feature embedded "expert-systems examples," demonstrating how experts have addressed the same problems or arrived at true conclusions, only after students tried the simulations on their own.

Community-Centered

- To what extent are students aware of the differences in learning in school and in their social environment? Do they identify the building blocks of knowledge, and what knowledge they already have is applicable to real-world problems?
- How can students become aware of their role in a globalizing world and understand the importance of formal education in that world?

Technology can play a crucial role in connecting schools to professionals in their communities and around the world, and by allowing the school to develop ideas and positions and make them public. What types of multimedia material support more community-centered environments? People need to see and reflect on real and very often dramatic situations. Discussions can be sparked by showing videos. It may be useful to begin with small problem sets, in which only the most relevant variables are shown; then other variables can be inserted step by step. All of these features can be implemented in well-planned simulations.

Many students are motivated to include high-quality material in their projects and pages. With access to appropriate databases of educational and multimedia resources they can search, modify, and combine such material to use in their presentations and explanations.

Clearly, there are no boundaries among these four focal areas. When we construct an assessment-centered learning environment, we create elements of a learner-centered environment. When we build a community-centered environment, we satisfy our criteria for a knowledge-centered environment. Well-designed systems combine characteristics of all four.[21] One way to ensure the interweaving of characteristics of all such environments is to ask what resources would be required for "hands-on, minds-on, and reality-on" learning activities (*IVEN project design—http://www.rived.org*).

THE NATURE AND MODALITIES OF MULTIMEDIA

Modes and Instruments

Content can be presented to learners using tools ranging from books and lectures to the Internet or even handheld computers. Each different instrument—whether a book or a handheld—communicates its content in one or more modes. A book, for example, readily accommodates text, of course, plus images that can range from line drawings to schematics to maps to photographs.

These modalities and instruments offer different "affordances" (or features that facilitate a specific type of interaction). Text, as a mode for content presentation, can present complex information, although it requires literacy, analytical, and mnemonic skills. As an instrument for text-based content presentation, books are portable and easy to read, guide sequential reading, and do not require electricity (although they do require light of some sort). They offer a balance between their ability to present large quantities of content—through both text and images—and the reader's ability to build an overview of the entire body of content—based on indexes, chapter headings, and other explicit structuring—to discover the most relevant material. A Web page, which also presents information via text and images, is easier to modify and can be linked to many other pages to provide different pathways through the text.

Of course, each instrument has its limitations as well: books are difficult to modify, and many learners find it difficult to break out of their linear pathways, and Web pages are tiring to read, require electricity and connectivity, and may divert readers far from their target objectives.

Each modality and instrument offers specific affordances in combination with specific limitations. In addition, factors such as design, construction, development, and support vary among specific resources of a given type. In addition, external factors, such as a region's technical infrastructure, its climate, overall education system, and even the health and nutrition of individual learners, will determine the degree to which a resource's affordances are realized and its limitations minimized.

Current major modalities for content presentation are text, images, audio, video, and simulations. (Simulation, as used here, includes animations that present specific content, such as Earth's travel through space, and interactive simulations that offer the learner the opportunity to change variables and observe results, as might be used to present angular momentum.) Each of these modalities can be presented via many instruments. Table 7.1 describes some of the major instruments, their affordances, and their limitations. The information presented is intended to provide an overall picture of modalities and instruments only, not to enable absolute rankings. Specific designs and implementations should be analyzed relative to the objectives they are intended to support and the environments in which they will be deployed.

Affordances can be optimized and limitations minimized for a given instrument in a specific implementation through appropriate design and development. In a multiplatform environment, for example, in which early- and late-model PCs are mixed with Macintosh computers (as in U.S. schools), interactive simulations can be written in Java to provide multiplatform interoperability. In low-bandwidth environments, requirements for plug-ins such as Flash Player can be avoided, or CD-ROMs can be used as the primary delivery instrument.

Multimedia offers the opportunity to combine instruments and modes to radically enhance the effectiveness of learning resource development efforts. Educational publishers frequently "bundle" CD-ROMs with textbooks, providing additional resources, updates, and other information. Interactive simulations are often "wrapped" with text addressed directly to learners, providing contextualizing information, and with text addressed to teachers guiding them in facilitation of classroom activities, questioning strategies, and assessment. In this sense, supporting radio broadcasts or audiocassettes with print-based workbooks comprises a multimedia combination of different instruments. In all of these combinations, not only are limitations mitigated, but the strengths of each instrument are also magnified beyond the potential of any single instrument deployed in isolation.

That above characteristic implies a fundamental goal of multimedia design—to combine instruments in ways that best address the requirements of a specific content domain, the abilities and deficits of targeted learners, and the infrastructure and systemic conditions of the prospective learning environment to achieve results beyond what is possible with individual instruments and isolated media.

The Internet and CD-ROMs, of course, have the potential to serve as platforms for the full range of modes—text, images, audio, video, and simulations. To this potential, the Internet adds the possibility of frequent updates, collaborative or participatory solutions, and near-infinite scalability. Bandwidth and platform constraints, however, continue to pose limits in most circumstances. In all instances, effective design and development processes are required to arrive at a creative, effective, and appropriate implementation that addresses specific parameters.

Technology Choices

Educational gains can be maximized for every situation when the most appropriate tools are used. It is not possible, however, to give recipes for what technology tools to use or when to use them. Each case is distinct. But we can try to identify situations where the use of certain instructional multimedia material regularly achieves success. In such cases, it is also important to keep in mind the infrastructure or pedagogical constraints that may impede effective use of such multimedia. Below, we focus on the use of video, sound, simulation, and animation, and explore considerations that affect their development.

Video

Videos motivate students by showing real-life situations, in ways that are often superior to a teacher narrating them or a text describing them. Videos can be used when

TABLE 7.1 • AFFORDANCES AND LIMITATIONS OF MODALITIES

MODE	INSTRUMENT	AFFORDANCES	LIMITATIONS
Text	Books/ magazines	> Portable > Durable > Can present complex information > Sequential structure guides learner > Little eyestrain > Moderate cost of development	> Difficult to modify (as in localization, updating, etc.) > Requires literacy plus higher-order thinking skills > Content is difficult to extract for use in other resources > High per-unit cost of publication
	Web page	> Dynamic and easily modified > Hyperlinks enable nonsequential navigation > Low cost of development and very low publishing costs > Supports interactivity (e.g., navigation, user-entered information, etc.) > Can support assessment	> Nonsequential structure may obscure critical information or cause confusion > Reading may cause fatigue > Requires PC, electricity, connection > Potential additional system requirements (e.g., Java, plug-ins)
Images	Printed photos, maps, and schematic drawing	> Concrete, specific, detailed information > Appropriate for learners with "visual intelligence" > Engaging and motivating for many learners	> Low information value relative to text > Resistant to reuse by learners > "Visual literacy" skills required for best use > High cost of reproduction
	Digital photos, maps, and schematic drawings	> Affordances similar to printed photos > Easily copied, shared, and used > Low costs for reproduction and publishing > Can be data-based or Web-served for delivery to handheld computers and other "anytime, anywhere" devices	> Limitations similar to printed photos > Require PC and electricity, possibly an Internet connection
Audio	Radio	> Can present contemporary and topical information easily > Highly accessible and potentially engaging format (no literacy skills required) > Widespread adoption in developing countries > Moderate production costs > Highly scalable > Low-cost hardware	> Information is not durable; learners can't "review" a broadcast > Poor presentation of complex concepts > No visual component (e.g., schematics, maps, photos) > Synchronous form requires system-wide coordination (e.g., announcements, class schedules, etc.)
	Audiotape	> Wide adoption, low-cost hardware > Information persists (tape may be reviewed many times) > Moderate production and reproduction costs > Highly accessible > Supports asynchronous presentation > Sequential structure guides learner	> Poor presentation of complex concepts > Medium is not durable, especially in extreme circumstances > Studio recordings not easily modifiable or well-suited for current events

MODE	INSTRUMENT	AFFORDANCES	LIMITATIONS
Audio (continued)	Digital audio (Web- and CD-based)	> Can present contemporary and topical information easily (Web) > Information is durable (e.g., it can be reviewed many times) > Medium is durable > Moderate production costs > Low reproduction costs; easily scaled > Easily catalogued and reused (by developers and users) > Can be indexed or catalogued to enable nonsequential access	> Requires robust PC and/or high-speed Internet connection > High storage "overhead" (in terms of hard drive capacity) > May not support presentation of complex concepts
Video	Analog	> Highly accessible and potentially engaging format (no literacy skills required) > Sequential structure guides learner > Concrete, specific, detailed information > Appropriate for learners with "visual intelligence" > Engaging and motivating for many learners > Moderate hardware costs	> High production costs; moderate reproduction costs > Complex information may be difficult to present effectively > Information may prove difficult for some learners to analyze/synthesize
	Broadcast	> Same as analog video > Can present contemporary or topical information easily	> Same as analog video; however, costs may be higher
	Digital (Web- and CD-based)	> Same as analog video > Can present contemporary or topical information easily > Easily catalogued and reused (by developers and users) > Can be indexed or catalogued to enable nonsequential access > NOTE: "moderate hardware costs" is not applicable	> Same as analog video > Requires robust PC and/or high-speed Internet connection > High storage "overhead" (in terms of hard drive capacity)
Simulations	Interactive (Web- and CD-based)	> Same as noninteractive simulations > Active-learning characteristics engage learners via several paths to reinforce concepts > Quantitative elements are supported (and reinforce conceptual learning) > Engaging and motivating for many learners > Can support assessment	> Requires robust PC and/or high-speed Internet connection > Potential additional system requirements (e.g., Java, plug-ins)

introducing a new theme to motivate and contextualize learning, after a topic has been addressed in a few class periods to aid students in applying the knowledge they acquired, or after an entire module is completed to show connections to other subjects and disciplines.

Video production is not easy. If a video is intended for widespread use or for broadcast, required resources and resulting costs mount quickly. Professionals should be involved in production of good storyboards, lighting and shooting the video, and editing and postproduction. Beta-format equipment should be used, rather than VHS, to ensure high quality. Videos produced for viewing on computers are somewhat different; resolution can be low, and it should be low for most platforms currently in schools. Such videos may be displayed to large groups via multimedia projector, or individually or in small groups on individual computer workstations. The Digital Video Disc (DVD) format brings benefits to schools in terms of storage and durability; however, most schools do not have DVD players, and care must be taken in all cases to ensure compatibility of disc formats and players.

Short videos present a whole new arena. High-compression formats such as MPEG, RealVideo, ASF, and QuickTime are suitable for delivery over the Web or by CD-ROM, and plug-in players for these formats are available as free downloads from the Internet. Short videos can be integrated into computer activities in labs or computer-equipped classrooms. They can demonstrate dramatic effects or experiments that are too costly or dangerous to be performed in schools. Production of Web- or CD-ready videos can be accomplished through relatively low-cost processes, in labs or in the open air using a camcorder, with a robust computer workstation equipped with a video card, used for editing. Specialists are not necessary.

What could limit the wide spread of video? Even short videos are stored as very large files, and Internet bandwidth (contingent on national infrastructure, Internet service provision, and school hardware) is a key factor for transmitting them. In addition, storage space and storage media can be problematic. Older computers, especially, may lack both hard drive space and processing power to run videos—and student workstations of all vintages generally lack hard drive space sufficient to store videos in any quantity. Complementary distribution of videos, via DVD, CD-ROMs, or VHS tapes, can address Internet- and computer-related problems. It can be effective to integrate time-sensitive information—such as news, student work, and so on—with large media resources, such as videos, distributed on fixed media.[22] Some multimedia authoring tools, such as Macromedia Authorware, facilitate creation of integrated online and offline media solutions.

Sound

Audio technology has been used widely with tape recorders and radio programs (see chapter 9). Some uses do not depend on the production of material, but stem, instead, from good infrastructure. For instance, students can progress rapidly in language studies if they interact with students from other places; they can hear specific and authentic dialects and languages. Advanced consumer tools that support these activities include Internet Protocol Telephony (I.P. Phone), CUseeMe, and NetMeeting. In addition, the explosive popularity of various techniques for exchanging music over the Internet has already led many students to explore the power of information exchange via Web-based and peer-to-peer collaboration.

Many students are eager to produce and publish their own sound files. It is easy to channel such motivated activity toward production of materials that also have educational value—for the creator. Again, resource considerations may pose limitations: although software is not too expensive, it is necessary to have a good sound card, a good processor, and sufficient RAM (random access memory) and storage capacity.

Maybe the most interesting materials that can be produced are those that explore sound and image at the same time. For example, we could develop an applet that explores the overlap of two sounds of equal or very close frequencies; in addition to producing the sound of both frequencies, the applet can display images of the wave superposition. Such kinds of image/sound are very effective for learning about topics that students usually find difficult. By making analogies, a teacher could guide the class through discussion and research on electrocardiography, or the differences between AM and FM transmissions. Soundry, an award-winning ThinkQuest entry, includes such an applet as well as others, like the one that shows wave fronts generated by a plane crossing the sound barrier. Other useful mixtures of sound and images might address resonance; intervals in musical tones and the analogous harmonic vibrations in nature; codification of fractals or other repeating patterns using sounds; and discussion of minimalist changes, adaptation, and rupture. And, of course, well-designed applet-based sound-and-image combinations can benefit the study of languages.

Sound files can be kept small, and the most recent Internet browsers play all common formats. For more sophisticated formats, there are free players. Simple sound cards are not expensive. So, with reasonably current hardware, technology is not a barrier to the use of audio resources.

Simulations

The most remarkable aspect of simulations is interactivity, or the opportunity for the learner to change values or conditions and see what happens. This capability motivates students to formulate and test hypotheses. Simulations represent the temporal dimension visually and experientially, making them different from images, text, sound, and video. In some cases, they can enhance experiences gained in real school science labs by allowing virtual experimentation in ideal conditions. The realism of these conditions can be increased gradually. Simulations also can enable experimentation with concepts that cannot be experimented with in actual school-based labs.

With so many possible uses for simulations, it is wise to consider each simulation's intended use before designing and developing it. Will the simulation be used to motivate students during introduction to a subject? Such cases might call for beautiful graphics or intricate outputs. Will the simulation be used in inductions, deductions, experimentation for the testing of a hypothesis, demonstration of a complex concept, or application of knowledge the learner has already gained? Each potential role has its own parameters and requirements.

Which technology should be used in developing simulations? Java and Shockwave are extremely popular with developers—so much so that recent browsers do not even require plug-ins to run code developed in these formats. And because Java is object-oriented, it facilitates the reuse of code. This characteristic has led to compilation of libraries of free applets and codes that can be downloaded over the Internet. Applications such as Macromedia Flash and Macromedia Director (with Shockwave output) are simple to use, making it quick and easy to produce simulations and integrate other media, such as sound and video.

Care must be taken, though, when the simulations become too elaborate or complex, as when they are asked to treat several curriculum topics. They can strain schools' hardware resources or prove ineffective when teachers do not receive adequate guidance or professional development. In particular, development of CD-ROM-based stand-alone suites that use interactive simulations as substitutes for school science labs tends to lead to overly complex and machine-straining products, although worthy exceptions do exist.

What kinds of delivery configurations are possible? One easy means of presenting simulations to students is to position them on "html" pages that can be served to the Internet. All computation then runs in the browser, making the simulation itself generally easy to run on any recent combination of hardware and software. However, some Java-based simulations are large and memory-intensive and cannot be run on older machines with limited processor speed and memory. It is possible, when these situations are anticipated, to run calculations in the server and transmit only data to the browser—although in these instances, bandwidth constraints and network configurations simply shift the problem to another area. Flash and Shockwave output is easy to create and often "runs light"; however, their programming languages are not as robust as Java, and these files may not run across a range of platforms.

Among the difficulties with CD-ROM-delivered simulations is cost, which may be high, based on the number of licenses required for an entire class or lab. Problems also can arise from complex or time-consuming installation procedures, complex design, and lack of technical and pedagogical support. Again, solutions to some of these challenges involve centralization of computing power and administration through client-server systems based at the lab, school, or district level.

Animations

For our purposes, animations stand in contrast with videos and simulations: they do not use real images, nor do they enable interaction with the learner. Despite these significant constraints, animations are very powerful, especially as a means of enhancing otherwise static images—whether in textbooks or on Web pages. As with other examples discussed above, animations can be used to motivate learning, demonstrate concepts, and, as tools, emphasize particular details or aspects of complex phenomena. Animations often may be the best tools for highlighting the path between modeling and reality. It is possible to create a sequence of visualizations with increasing degrees of sophistication, enabling student understanding to go far beyond crude and simple models.

Animations are created by digitizing and sequencing hand-drawn images, or directly through the use of 3-D and other software. As we have seen with other media, older computers with limited memory and slow processors have problems with animations generated by 3-D software because these are usually large and heavy.

WHO ARE THE AUTHORS OF MULTIMEDIA RESOURCES?

Over the course of the last decade, ICTs have reshaped the contours of production profoundly in all sectors. Changes in the development of materials for teaching and learning have occurred most visibly in an expanded range of available modalities—with interactive CD-ROMs, Web-based simulations, and intelligent tutors among the array of new resource types presented to educators and policy makers. However, the more profound shift in creation of educational resources centers on the changing identity of the authors of learning resources, and on changes in the relationship between authoring itself and learning.

Before the widespread adoption of ICTs in universities and schools, educational resources were generated largely by private-sector publishers or centralized government-operated organizations. Textbooks, instructional audiotapes and videotapes, and broadcasts require substantial investment in content development, and in the capital equipment required to make that content available at scale. University faculty and, at times, schoolteachers are engaged as subject-matter and pedagogical experts. But the production, marketing, sale, and delivery of resources to the education sector generally remains solidly under the control of a single organization—whether a ministry of education or a private vendor. For this reason, it is the organization—not the individual educators engaged by the organization—that retains ultimate control over the evolution of the learning resource. Whether the target client is seen to be a ministry-level decision maker, the head teacher of a state school, a teacher in the classroom, or the operator of a private school or tutoring business, it is most often the publisher developing a product who determines the scope of the resource, its requirements, and the kinds of learning opportunities it affords its users.

In some instances, centralized developers have achieved stunning successes, especially when their efforts are focused on innovation, and when such innovation is fueled by the results of research and experience.

Institutional Developers

Institutions—universities, government- or privately funded research facilities, and international agencies—may be effective developers or sponsors of multimedia resources, initially free of cost, and market considerations that may limit development in the private sector. Successful resources or approaches may be transferred later to the private sector for support and elaboration, however. In Turkey, for example, the technology research agency, Tubitek, successfully transferred its research results in education to a start-up private-sector company, Sebit (recently acquired by another Turkish firm, Vitamin), which has released a comprehensive set of interactive test-preparation tools, with efforts underway to localize these for schools in the United States and China.

Alternatively, institution-based development may provide the benefits of scaffolding projects, experiences, and innovations. The *Red enlaces* (or Enlaces Network, *www.redenlaces.cl)* of the Chilean Ministry of Education was begun in 1992 as a 100-school pilot project to assess the potential benefits of computers in education. Enlaces has evolved and expanded to keep pace with new technologies, ranging from multimedia[23] to e-mail to the Internet. Enlaces currently reaches more than 100,000 students and 10,000 teachers—including a majority of those in rural schools.[24] As a result of the program's success, Enlaces is one of two Internet resource sites, along with *Internet Educativa 2000* of the Fundación Chile, that form the backbone of the Ministry's new mega-portal, Educarchile (*www.educarchile.cl*).

Nongovernmental and nonprofit organizations have been in the forefront in linking students in innovative and effective ways. The International Education and Resource Network (iEARN, *www.iearn.org*) began in 1988 to promote project-based collaborative learning and remains among the leaders in global, Internet-based education. With a global scope that is now approaching that of iEARN, ThinkQuest (*www.thinkquest.org*) integrates knowledge-building projects with Internet design, furthering the technical skills of national and international collaborative teams.

Both the institutions and the roles they play in development of multimedia resources may vary considerably. In this section, we profile the approaches of three different initiatives.

KRDL Learning Lab

Singapore's Ministry of Education has adopted a centralized approach, sponsoring and implementing resource development by the Kent Ridge Development Laboratory (KRDL), a research lab funded by state and corporate sponsors. Private-sector development of education software in Singapore focused throughout the 1990s on resources that supplemented mastery of the K-12 (school) curriculum in preparation for the university entrance examination. Based on its consultative relationship with the Singapore Ministry of Education, the KRDL learning lab has developed, in contrast, Internet-based environments and tools that support the ministry's vision of a shift in learning from mastery of facts and skills to building knowledge. These resources include:

- *Infrastructure for Collaboration*—Support for 700 simultaneous, persistent, project-based groups of two to five students each, specifically targeting learning-based collaboration learning
- *Shared Mindtools*—Development of 10 commonly used multimedia tools for use in two- to five-student collaborative groups

- *iASSESS*—Development of a Web-based, client-server software infrastructure for providing intelligent assessment services that can be externalized to allow students to realize their strengths and weaknesses
- *HistoryCity*—Built on NetEffect technology, a networked 3-D virtual environment for children aged seven to 11, using communication, collaboration, and construction to teach children about Singapore's National Heritage

Seen together, the KRDL projects address core objectives in educational transformation outlined by the Ministry of Education, with ICTs seen as playing a crucial role. Again, the circumstances that have led to the Learning Lab's success are distinct, in that development is paired with a ministry-level vision, resource allocation is high, and the lab itself is less bound by market pressures.

RIVED (or IVEN)

In RIVED—*Red International Virtual de Educacion, http://www.rived.org* (known in English as the International Virtual Education Network, or IVEN)—several Latin American countries have contributed expertise and funding to the collaborative development of educational modules. These are intended for use in math and science education at the secondary school level, incorporating well-defined and contemporary processes into the teaching of these disciplines.

In the first phase, all participating countries—Argentina, Brazil, Colombia, Peru, and Venezuela—mapped their curricula into modules to be developed, with roughly four to eight teaching periods included in a module. Modules that were common for all countries were divided for production among them.

Modules are composed of elements (videos, animations, simulations, text, exercises, etc.) that can be combined flexibly, and are accompanied by a teacher's guide suggesting how to use the modules. The flexible use of various elements enables satisfaction of country-specific requirements, and at the same time allows reuse and linkage among disciplines and topics.

To satisfy country-specific educational priorities and the project's objectives concurrently, each country provides a production team with two or three specialists in each discipline (physics, biology, mathematics, and chemistry), one instructional designer, one Web designer, one programmer, and one information technology (IT) technician. These production teams are trained to work as multidisciplinary teams, with coordinated development processes supporting the projects' educational objectives and improving efficiency. A production manual guides the teams through the different steps of development and testing in adherence with the teaching and learning objectives established by the project.

Each module proposed for development is published in a first round for comment by other countries. In this way the acceptance and necessary adaptations are decided a priori, and new ideas for adoption or adaptation of existing material are coordinated with the development process. Production teams present a general design with specifications of content and technologies to be used (a blueprint of the module). They receive initial feedback on their modules from the teams of the other countries and from an expert panel charged with ensuring the quality of the modules. Across several reiterative stages, modules are tested for content, ease of use, and efficiency. Other testing and feedback rounds take place when production is completed. This process guarantees efficiency, sharing of expertise, and collaborative engagement.

EDUCAR

The educ.ar portal (*http://www.educ.ar*), the official education portal of the Ministry of Education of Argentina, aggregates resources for all educational levels and is representative of the many national education portals now emerging in Latin America. Educ.ar incorporates a dynamic database that is updated very efficiently. It has information on events, training information for teachers, and information on adventures and contests for students. The portal also features chat and translation.

The involvement of specialists in writing units of practice that use existing Web material, or material produced on demand by Educar's team, guarantees the development of expertise in the country. The specialists of all areas are also responsible for selecting and cataloging resources and software following a catalog system compatible with IMS (discussed later in this chapter). A multidisciplinary team of developers, discipline specialists, and instructional designers works together in the same building, increasing efficiency and sharing expertise. The work of this team is tightly coupled with teams responsible for teacher development targeting technology use nationwide.

LINKS

Project Links (*http://links.math.rpi.edu*), funded by the U.S. National Science Foundation (NSF), has as its aim the production of a library of interactive learning materials that highlight mathematics for science and engineering. The learning materials are intended for integration into existing courses and follow a predefined structure of navigation and instructional design. Each module requires one to three class periods.

Content creators in Project Links follow a process that involves completion of a module design questionnaire, detailed module storyboards, and applet storyboards. The technical manager and other authors review these materials, and a subject-matter expert reviews the module's content independently. The modules are alpha- and beta-tested in-house, then tested for usability, and finally pilot-tested in classrooms. After each step, the module is changed and improved. When this process is completed, the module is used in all participating courses. Five institutions currently participate as content creators; technical development is done at the Rensselaer Polytechnic Institute, with evaluation teams at two other universities.

Private-Sector Developers

Private-sector activities in multimedia development can also be extremely varied. Whereas private-sector activity for much of the 1990s focused on development of CD-ROM-based multimedia, with mixed results in terms of both educational and financial success, more recent activity has explored a range of models involving the Internet.

As early as 1995, a Rand Corporation study for the U.S. Department of Education linked the poor quality of CD-based education software to a fragmented and difficult-to-reach market.[25] Innovation has come, sporadically, when smaller companies have launched products that have focused on student creativity (e.g., HyperStudio), and when they have based development on a solid foundation of learning research.

Cognitive Tutor

The Cognitive Tutor math products of Carnegie Learning, Inc., exemplify an approach to multimedia development that is grounded in cognitive science, computer science, and hands-on teaching and learning. The product line addresses algebra and geometry at the secondary level in the United States. Drawing from the efforts of John R. Anderson[26] of Carnegie-Mellon University in cognitive theory and intelligent tutoring, the products:

- present math problems in the context of real-world situations and experiences;
- facilitate inductive learning;
- enable collaborative learning and peer mentoring; and
- provide in-class curriculum activities.

Centralized production, in this case by a private-sector developer, yields a learning resource that integrates a range of pedagogical attributes and spans an entire semester's curriculum. In this instance, a private-sector spin-off from academia has led to the development of a single, comprehensive, innovative resource. However, it is critically important to observe that this product has emerged within a competitive and mature education software market, one that places a premium on product differentiation. And within the decentralized U.S. education system, where purchasing decisions are made on a district-by-district basis, marketing costs are staggering, and the success of the product, and of the company that developed it, is far from certain.

Private-Sector Portal Development

In countries in which institutional or national organizations have not yet established education portals, private companies have rushed to fill that gap. In the United States, bigchalk.com has emerged as the premier aggregator of education resources and services, offering a catalog of lesson plans, productivity resources for students and teachers that include professional Web-construction tools, career and professional development resources for teachers, and a host of other resources. Because many of the lesson plans and student projects have been developed outside of the bigchalk organization, these tend to be heterogeneous, although efforts have been made to cover broad areas of the common curriculum in the United States, and to ensure that resources meet bigchalk's standards of quality.

In contrast, in Turkey, where education is highly centralized under the Ministry of National Education (MONE), portal services nonetheless have been designed and developed by a private company recently purchased by Koç Systems, the country's largest holding company. The Elma portal (*elma.net.tr*) also aggregates resources from a select group of other sites (see below). However, a combination of professional or volunteer staff, directed by a central management team, develops the bulk of the materials available on the site. In addition, Turkish educators contribute lesson plans directly to the site. Elma also offers a "homework help desk": students e-mail questions and challenges arising from homework problems, and they receive personalized responses from a staff of volunteer teachers. With the permission of the inquiring student, both questions and responses are publicly available on the site and are archived and searchable for later reference.

Challenges to Private-Sector Authorship

When private-sector development of effective CD-ROM-based educational materials has been successful, as in the case of the Cognitive Tutor, success has come despite structural factors, chiefly economic, that have tended to limit the effectiveness of resources created by centralized development. It may be instructive to review those factors historically and their effects, in part to determine their continuing effect on centralized development—for both CDs and the Internet. Chief among these factors, of course, is the persistently high cost of software development, with an average for educational CDs reported to be US$400,000 in 1994.[27]

In the United States, private-sector development of education software remained a struggling industry throughout the 1990s, despite high levels of market and venture capitalization in the technology sector and an increasing influx of technology into the schools. By the late 1990s, high development and marketing costs and low profit margins led to the consolidation of the industry in software clearinghouses, chiefly Softkey, Broderbund, and the Learning Company. By 1998, these three companies had been consolidated further through merger and acquisition, and then were acquired for US$3.6 billion by Mattel, Inc., with disastrous consequences.[28]

Pressures of this sort force private-sector developers to design education products for the broadest possible audience, including not only teachers and students in state schools and private schools, but also families, students using computers at home, and, in some cases, private test-preparation and tutoring companies. The nonschool segments of the developers' market base may prove to be larger and more easily reached by marketing efforts, and the decision to purchase may be made more easily. However, the various learning environments—school labs, after-school labs, and homes—provide learners with radically different circumstances. The one-learner/one-computer configuration implied in the design of most commercially produced education software is rarely provided in a school classroom or lab. And these designs fail to support—and may actually interfere with—the essential social aspects of learning.[29]

With low profit margins and little incentive to develop "school-only" titles, developers have little reason to assume the risks of innovation. As evidence, the Cognitive Tutor product line was recognized in 1999 by the U.S. Department of Education as one of only five of 61 available math software products as "exemplary"—after more than 10 years of multimedia development by the private sector (Eisenhower National Clearinghouse). In 1999, the Turkish Ministry of National Education rejected all bids from software developers to a tender that was part of its Basic Education Project, spanning 8,000 schools, because none of the products met their requirements.

Teacher Developers and Collaborative Efforts

Due in part to the challenges confronting private-sector developers—and in part to changes in pedagogical approaches—teachers in many countries have been seen as partners in and even drivers of development of technology-based learning resources over the past 10 years. During the early years of multimedia development in the United States, classroom teachers drove the start-up of education software companies such as Minnesota Educational Computing Corporation (MECC), Sunburst, the Learning Company, and many others. Currently, former teachers are heading companies ranging from bigchalk.com (*www.bigchalk.com*) to smaller, leading-edge businesses, including Carnegie Learning and Learning in Motion. Although its tools are solidly grounded in cognitive science, Carnegie Learning has incorporated the results of extensive field trials of its Cognitive Tutor line conducted by William Hadley, 1995's U.S. Math Teacher of the Year. Although these companies benefit from the teachers' experience and knowledge, they are constrained by market-based pressures.

New tools and new understanding of the value of the teacher's experience have combined to generate new processes to develop multimedia learning resources. Apple Computer's 1984 introduction of HyperCard gave perhaps the first promise of software learning resources developed by working teachers, and today we see teachers developing Web-based resources. Three projects initiated in the late 1990s explore teachers' potential as collaborators in resource development:

- The Educational Object Economy (EOE),
- Multimedia Educational Resource for Learning and Online Teaching (MERLOT), and
- Educational Software Objects of Tomorrow (ESCOT).

The Educational Object Economy (EOE)

The EOE emerged out of a 1993 NSF grant to the East/West Authoring Tools Group, a coalition of universities and publishers anchored by Apple Computer's Advanced Technology Group. The initial objective of the grant was to sponsor development of menu-driven "end-user" authoring tools that could reduce the high cost of multimedia CD-ROM development. However, the project met with unanticipated difficulties with the repurposing of university-built tools for commercial uses. At the same time, the emerging dominance of both the Internet and Sun's Java scripting language pointed to the decreasing importance of CD-ROM-based delivery.[30] The success of subsequent efforts to enable authoring tools to generate Java output led to a crucial realization—without coordinating mechanisms, a proliferation of authors and authoring tools leads to redundant development of the "low-hanging fruit" of software resources.[31] In 1997, the Educational Object Economy (*www.eoe.org*) launched a dynamic, database-served Website as a place where users could post interactive simulations constructed as Java applets. These small, Web-delivered simulations generally enable learners to change variables and see the results of their changes graphically and quantitatively.

Lifted by waves of interest in both Java and the Internet, and in open-source development models, the EOE now features over 2,000 Java-based simulations for education. Applets have been developed and contributed freely by teachers, students, programmers, and education researchers, with metadata that include reviews, comments, and curriculum-based activities, as well as catalog information based on an early version of the Instructional Management System (IMS) model. In roughly one-quarter of these applets, Java source code is available for modification and localization.[32]

For many reasons, the EOE has not had significant impact on education in the United States.[33] Key factors include:

> the diversity and scale of the U.S. education system;
> competition from a mature private sector; and
> limited Internet access in schools early on in the project.

In particular, as the EOE collection has grown, limitations in the catalog design have become apparent, complicating resource discovery and qualification by teachers. Because the EOE repository stores only the Uniform Resource Locator (URL) for each applet, maintaining the catalog becomes significant as addresses and posting changes occur on host servers.

However, since 1998, the EOE has begun shifting its focus to education systems in emerging economies, where multimedia development for education is beginning. In a three-week workshop outside of Delhi, India, teachers and students designed and developed interactive simulations targeting Indian science and math topics.[34] Most notably, the Turkish education portal, Elma, now mirrors the EOE repository, with Turkish-language learning activities, and several Turkish educators have now contributed Turkish-language applets to the EOE repository.

MERLOT

Based on the EOE model, and seeding its repository with EOE applets, the Center for Distributed Learning of California State University has established the MERLOT project (*http://www.merlot.org*) as a community focused exclusively on resources for higher education. The project has made several significant changes to the EOE model, including:

> collecting all learning-resource types (text, image, audio, etc.), in addition to Java applets, and
> providing dedicated programming services to faculty.

The results have included rapid compilation of more than 10,000 "learning objects" across the California State University system—many available at no cost—and increased adoption of technology by faculty. Dedicated Java programming has enabled a wider range of faculty to participate as developers, contributing interactive objects to the repository, and has led to more sophisticated Web-based support for learning in specialized fields such as health services and business education. Within the last two years, universities outside California have begun sponsoring domain-specific online communities (biology, business, physics, teacher education) as part of the MERLOT system; domain-specific search engines are planned to address issues of scale that have arisen in the MERLOT catalog as they did earlier in the EOE.

As in all community-developed repositories, quality assurance presents a significant challenge. MERLOT has introduced a system of peer review—necessary to establish the quality of the MERLOT "brand" and, in theory, to position publication in MERLOT as a tenure-track milestone.[35] Contributions to the collection are reviewed by a formal panel within the appropriate discipline and, once posted to the collection, are also open to review by the user community at large. The formal review is conducted by at least two faculty members, currently from 12 discipline-specific communities. The individual reviews are combined in a "composite review" that is posted to the MERLOT Website after sending it to the author and getting his or her feedback and permission to post. Reviewers follow a standard in their evaluation, considering separately three dimensions: quality of content, potential effectiveness as a teaching tool, and ease of use. The evaluations are expressed in written format as well as a rating using one to five stars for each dimension. The "MERLOT Review Panel" signs the reviews, and a list of the panel members is posted on MERLOT.

Additional challenges to the MERLOT model arise generally from the problematic relationship that surrounds faculty authorship, control of intellectual property, and commercialization of online higher education. Dedicated programming services increase costs in step with sophistication, with those costs often shared among several university departments. However, faculty members working with publishers arrange to bundle their MERLOT-developed online resources with textbooks.

ESCOT

In another NSF-funded initiative, the ESCOT project (with principal investigators Roy Pea, Jeremy Roschelle, and Chris DiGiano) has created a collaborative test-bed of software developers and secondary school teachers to develop small, interoperable tools to create mathematics simulations. Working with five exemplary and widely adopted math curricula, the teachers contribute both design requirements *and* learning activities. The involvement of teachers as co-designers is intended to ensure that the (again, Java-based) multimedia resources will be readily adopted in the classroom. Pairing teachers with developers for short-term development projects is intended as a model for increasing teacher participation in authoring—compared with providing the teacher with end-user authoring tools.[36]

ESCOT—like the EOE and MERLOT—addresses the high cost of multimedia development, seeking to implement one of the most promising of emerging engineering processes—integration of reusable software components. Components (also called "objects") are discrete units of software code that can be combined (or integrated) to create usable software. In ESCOT's collaboration with the Math Forum (*http://www.mathforum.org*), components are shared among 12 "integration teams" under a licensing scheme that protects attribution and intellectual property rights even after modification of a component's source code.

Benefiting from the teachers' contributions, ESCOT simulations generally are designed to be simple and easy-to-use—making them readily grasped in classrooms and computer labs. The initial ESCOT partnership with the Math Forum involved development of 48 electronic Problems of the Week (ePOWs) focused on 12 component-based simulations targeting middle school mathematics students.

In addition to the significant challenges of software reuse in educational development,[37] ESCOT faces challenges in improving its design processes and outcomes.[38] Future objectives include efforts to *increase* the role and effectiveness of teachers participating in ESCOT integration teams.[39] To address this, ESCOT researchers have proposed a very promising approach, including international participation: if funded, the TRAILS project will create ESCOT-style integration teams comprising graduate-level students in schools of education and computer science departments. The project will link participants in several countries (e.g., India) to address specific areas of the mathematics curriculum.

Student Developers

Over the past decade, many cutting-edge uses of ICTs in education have been guided by the confluence of "active learning"[40] and the emergence of new, easily mastered applications for multimedia development. Input devices, such as digital cameras and video camcorders, have dropped in price; video and sound editing can be accomplished on desktop computers; and Web pages and even Web animations can be built by anyone with access to a computer and the ability to read and comprehend a manual.

Over the course of this same period, schools and school systems have increasingly—although in many instances not systematically—incorporated active-learning pedagogies that engage students in synthesizing information derived from research across a range of sources, and in using information as the basis for alternative presentations, ranging from original plays and musicals to literary magazines to real-world experiments in physics, chemistry, and other fields. As computing power has become available in schools, computers have been deployed as the tools of resource creation.[41] In some cases, active engagement in design processes has been linked with helping learners to build "ownership" of problems, leading to knowledge creation, integration, and dissemination.[42]

In the best cases, this combination of active learning and the emergence of new, easy-to-use tools for design and development have revolved in a "virtuous circle" of multimedia resource creation. Students, themselves, now use professional or near-professional toolsets to build conceptual understanding, express ideas, and create new resources. In this section, we begin by exploring student use of the simplest tools and follow that with discussion of more sophisticated tools and their impact on development and computer use in schools.

A Scaffolded Approach to Student Authoring

To demonstrate (and build) understanding, students must organize their knowledge in rich and coherent webs.[43] Such organization has traditionally stimulated creation of concept maps. New tools now make it possible for students to perform concept-mapping activities through the creation of hypertext webs. The latter case affords students several advantages, as they use their knowledge in authentic ways, demonstrating ownership, autonomy, and effective use of symbols, and making considerations about both the audience and context. Their constructions, then, can be considered a legitimate demonstration of understanding.[44]

Concept mapping is a valuable form of learning, because formation of rich and coherent webs is not done instantaneously. Concept webs are built step by step, through working out new concepts and relationships. Very simple computer systems—supporting only a text editor and a browser—can support student use of hypertext and other media to develop their webs. Students can use familiar tools, such as a text editor, to write concept names and descriptions, and then save their work as HTML. After this step, they can insert navigation links (or hyperlinks) and open the text in an Internet browser accessing their computer's hard drive. When they are asked to return to this text, after completing other work on their project, they can then update the hyperlinks connecting both texts and start building strong and eloquent connections. Continuing this process, students link their texts to the texts of their colleagues and to their own texts produced in other disciplines; through this process, they can build their command of rich, coherent webs of understanding. In mastering this process, they also experience spontaneity in learning and the evolution of concepts.

To realize the potential in HTML-based concept mapping, file management is essential. Fortunately, network tools for schools—such as Encarta Class Server and Powerschool—have advanced to the point that such management is relatively easy. However, for schools with more limited resources, configuration of such environments without commercial tools is also feasible. For the LabVirt project of the University of São Paulo, an intranet was configured in each participating school, using Linux for the server and Windows (95 and 98) for the workstations.

When students who are rendering their work in hypertext learn how to insert images and animations, they become even more emotionally involved—they are proud of it and express their desire to advance to better tools to edit their "site." Simple visual text editors show the structure of links among arrays of pages, helping students to solidify their conceptual connections. Several projects, including LabVirt, Por Mares *(http://educom.fct.unl.pt/proj/por-mares<insert>)*, and many of the collaborative projects created through iEARN (*www.iearn.org*) point to the success of such approaches.

It should be noted that this approach goes beyond student development of PowerPoint presentations in several ways. The simplicity of HTML-based systems allows students to work comprehensively on longer-term projects without making files prohibitively large and difficult to manage. Also, the greater flexibility of hyperlinking in HTML affords students the ability to create intricate and organized networks that more accurately reflect their ideas and associations.

Harel[45] has shown that students also learn when they are engaged in design. Students who designed fraction software for other students, using the Logo computer language, learned fractions better than students who were taught fractions using conventional methods. In addition, students who used Logo to design software learned Logo better than students who received Logo programming instructions only.[46] Derivatives of Logo, including StarLogo and MegaLogo, now offer a wider range of possibilities for multimedia development by young students. Although work along this line is promising, care must be taken because students are different. While some love to develop programs, other students with different skills may prefer to frame ideas or work on refinements.[47] Collaborative teams can be structured to take advantage of these differences, but it is critical that, over the course of the curriculum, students have the opportunity to build skills in all areas.

The tools used should allow students to express themselves using symbols that are compatible with the field in question, and to test their products much like experts in a given field would. In this sense "Boxer," developed by Andrea diSessa and his team at University of California, Berkeley, is an exemplary software tool for student use.[48] One of Boxer's main characteristics is that it permits, even in very specific areas, the treatment of open problems in ways that are critical to the development of higher-order thinking skills.[49]

Students Catch Up with the Pros

The availability and ease of use of the tools mentioned above enables students to inch closer to professional developers. With these tools, students are able to develop Websites that approach the quality of professional sites (*www.thinkquest.org*), while enhancing their learning.[50] Students usually develop pages or presentations that are static or contain simple movements; however, as we mentioned, the use of Flash is changing the pattern. (There are sites that aggregate many examples and tricks [e.g., *www.flashkit.com*].)

It is not necessary for students to achieve a final product. The act of designing a Website or an animation can provide enough motivation to engage the student. And communicating the concept and parameters of a design that itself represents a specific phenomenon or principle can build fundamental and deep learning. This line is explored in the LabVirt project.[51] In this project, high school students focus on creating designs, which are then produced by university students under supervision of researchers (see Box 7.1).

Tools that might be classed as "end-user authorware," however, are making it easier than ever before for students to create and manipulate dynamic objects on the Web. Stagecast affords students the capability of programming objects by example. Students "show" to objects the behavior they want; the behavior is then recorded by the object and enacted when the object encounters identical situations. Using this simple technique, it is possible to create scripts, and even entire "worlds" of objects, interacting with one another—and the tool makes it possible to publish the results of development directly on the Internet and to access and use libraries of previously published Stagecast worlds.

Although the rudiments of programming are integral to the use of Stagecast, the tool's ease of use ensures that other

BOX 7.1 • THE *LABORATORIO DIDATICO VIRTUAL*

The *Laboratorio Didatico Virtual* (LabVirt) project of the *Universidade de São Paulo* (USP) asks secondary physics teachers to guide students, most from underprivileged neighborhoods, in project-based approaches to specific topics in the physics curriculum. These projects—in which students approach physics *inductively*—culminate in the posting of student-created designs for interactive simulations. Using LabVirt technical solutions to overcome infrastructural obstacles, students forward their designs to coordinators at USP, who facilitate both the refinement of the designs and their development by USP student programmers. At the university, a specialist analyzes the accuracy of the way physics is represented in the students' designs. (The template is informal, but the physics formulas and processes are described in a rigorous way.) The designs are then realized in the Java language, making them Web-ready and relatively interoperable across the range of hardware (486, Pentium I and II, etc.) installed in São Paulo's schools.

After development by the student programmers, a simulation is tested again for correctness. The simulation is then cataloged in the LabVirt database and sent to the school, where the student uses it. Secondary school teachers, who have the opportunity to use the animation in their classrooms, judge the educational value of a simulation.

higher-order cognitive activities may take precedence. The Stagecast site (*www.stagecast.com*) provides examples of successful student use from grade 2 to university-level computer science. Using Agentsheets (*www.agentsheets.com*), students are also able to produce elaborated animations, in this case by combining existing scripts (behaviors) visually and attaching them to graphic objects. The final products can be exported as Java to Web pages. Agentsheets "Object Exchange" aggregates the collective results of development, making object behaviors available for use by others. The educational possibilities are unimaginable, with many fine examples of Agentsheets' use, including analysis of historical information.[52] One other possibility is to use Java applets that are not closed. These provide "microworlds" that teachers and students can explore, changing parameters to generate their own applications and inserting them into Web pages. A remarkable example of this class of applets is Descartes (*http://www.cnice.mecd.es/Descartes/descartes.htm*).

ENVIRONMENTS AND TOOLS FOR MULTIMEDIA DEVELOPMENT

For professionals (and advanced students), many new developments in authoring tools have focused on increasing the dynamism and interactivity of Web-based resources. By consolidating several multimedia-authoring functions, enabling one or two developers to complete a resource, these tools not only cut the cost of authoring, but also enhance the potential of the Internet as a delivery pathway for contentware. Other new developments have addressed resource reuse, through compilation of searchable repositories, creation of combinable software components, and new protocols that attempt to ensure that resources—whether recombined components or integral wholes—are discoverable, modifiable, and interoperable. The longer-term implications of these protocols, such as Extensible Markup Language (XML), have yet to emerge. The overall trend, however, is toward increasing reliance on the Internet, more powerful "on the fly" assembly and modification of content based on a learner's profile and needs, and the ability to develop contentware for implementation across many languages, platforms, and cultures.

New Developments in Professional Authoring Tools

As mentioned above, there has been notable progress in development of professional authoring tools, allowing non-specialists to work in areas previously unavailable to them. In the past, in private-sector professional situations, a graphics designer would not engage in coding or in including his or her works in Web pages. A programmer would not incorporate a sophisticated visual design without collaborating with a graphic designer, and both might then rely on a Web designer to design a site's "architecture," decrease image sizes, and render pages across different platforms and browsers. Today, visual or menu-driven tools perform these functions. It is easy to import and format images, test pages on target browsers, and adjust fonts, color, and size for appropriate rendering. There are programming tools that use time lines and preexisting scripts (behaviors) that can be inserted into an animation simply by dragging them to the objects on the screen. Visual editors contain tools to guide the producer in connecting items in databases, which is necessary to generate dynamic pages and to manage very large sites. And—just as important—software tools that earlier produced incompatible output now enable seamless interoperability and file conversion.

If we compare the appearance of older Web pages to new ones, we can see that many of the newer pages include graphical objects that move in a synchronized way. These objects describe defined trajectories, encounter other objects, or allow interactivity via mouse clicks or numerical parameters. Even pages with these elaborate effects are not, today, the work of experts or professionals. Dynamic Hypertext Markup Language (DHTML) is a standard that allows objects to move within pages. DHTML and other technologies, coupled with the latest versions of Internet browsers, include Java machines and plug-ins such as ShockWave that make creation of sophisticated animations and simulations feasible for any technically competent Web author. Macromedia's Flash, for example, with its graphical metaphor of a temporal line and movie clips, makes it possible, without writing code, to adjust objects and actions that happen on the Web pages. Other tools, such as Photoshop, Fireworks, Dreamweaver, and GoLive, have greatly facilitated publishing and maintenance of Websites in the professional world.

The expanded possibilities of this new generation of Web tools engenders situations in which one professional may assume the roles that previously might have required two or three people working in a team. Of course, the tools themselves do not substitute for the training and knowledge that a professional graphic artist, for example, brings to bear on a problem in visual design, or that a programmer uses to create a spectacularly elegant solution in code. But creative professionals and other experts are empowered to realize more complex ideas in educational multimedia than ever before, without assistance.

Most simulations that appear in Web pages are created using Java, a language for programmers that has not been opened significantly to nonspecialists. However, while it is difficult to produce Java applets, it is not difficult to insert them into Web pages. And there are repositories (e.g., *www.javaboutique.com*) that make these resources available and facilitate their inclusion in new Web pages, by making it possible to download the necessary files and copy only two or three lines for insertion into existing HTML pages.

New Systems for Cataloging and Collaboration

The first wave of the Internet boom (1994-1997) involved the spontaneous, enthusiastic participation of many professionals. University students and faculty seized on the new medium as a way to share ideas. The idea that anyone could have access to specialized knowledge took hold, followed by the idea that anyone—even without technical skills—could publish significant new ideas and work. The concept of "net gain" was used to predict the exponential growth in value of networks of people and resources.[53] Fueled by this enthusiasm, new phrases appeared describing the tremendous change that access to information and information tools would create: An "Information Superhighway" transporting us to a "Knowledge Economy" that would usher in an "Information Age."

The freedom to access information and to publish has proven to be very positive. However, we find ourselves facing new problems: with every query, our search engines overwhelm us with too many URLs. For the educator, working within the constraints of poor infrastructure and limited time, it is extremely difficult to separate relevant material from the rest. So we have invented new phrases, such as "information overload" and even "drowning in information."

Content generators face these same difficulties and require processes to optimize production. For instance, an online course developer must combine high-quality text (written specifically for online media), images (with the trade-offs of quality and size), animations, simulations, and assessments to create an integrated, seamless experience for the learner. Weaving these different strands together is facilitated when existing material is easy to find, of course, but it is also critical for the developer to know the technical and pedagogical characteristics and the conditions of use for each component resource. With such information, developers can make decisions about acquisition, reuse, or creation. Ideally, such information, conforming to established standards, will make it possible to integrate resources built with different toolsets by different developers, or made available by different vendors.

The Emergence of Standards

Concerned with both aspects, excess of information and integration of resources, the education community has organized initiatives defining standard sets of meta-data, or data about data, to enable resources to be searched, evaluated, acquired, and combined. With minor differences among them, each meta-data definition contains:

> general aspects that are useful for everyone (e.g., the title and a general description);
> technical aspects that are useful for developers and integrators (e.g., the technology used, resource size, prerequisites); and
> pedagogical aspects useful for teachers, educators, and integrators (e.g., the target audience, estimated use time, taxonomy path).

In principle, attaching meta-data to a resource (or "learning object") ensures that the user has enough information before looking at the resource to know whether it is desirable and possible to integrate with other resources. For educational users, for example, it is critical to know if a resource is appropriate to use within a certain amount of time with students of a defined level.

Among the most influential and widely adopted meta-data standards are the Instructional Management System (IMS, *http://www.imsglobal.org/metadata/imsmdv1p2/imsmd_infov1p2.html*), the European Union's Ariadne (*http://www.ariadne-eu.org*), and the IEEE Learning Technology Standards Committee's (LTSC) Learning Object Metadata Working Group. Projects that aggregate large numbers of educational resources, such as EDUCAR (*http://www.educ.ar*), use the IMS specification to ensure that their resources are "discoverable." Leading vendors of online course management software, such as Blackboard (*http://www.blackboard.com*), also comply with IMS specifications.

Internationalization and Localization

Globalization affects every sector involved in education development; from the largest education portals (e.g., bigchalk.com) to private and even homespun efforts. Successful sites, like the Physics 2000 project—intended to introduce modern physics in high school—often are translated into several languages (*http://www.colorado.edu/physics/2000/*). Distinguished and widely recognized personal initiatives, such as the collection of simulations developed by Walter Fendt (*http://home.a-city.de/walter.fendt*), may be translated and mirrored (or duplicated on additional servers) to make them available to broader audiences. It is common to find big universities offering their online courses elsewhere, or software vendors localizing their software for other markets. Again, internationalization is most effective when it is planned in advance, and when the foundation for translation and localization is included in development frameworks and processes.

What about collaborative projects, such as the International Virtual Education Network, a joint effort of Argentina, Brazil, Colombia, Peru, and Venezuela? How does one prepare for localization into several languages and language variants at one time? In principle, everything that is text-based is easily translated. Problems occur, however, with text contained in images, animations, and simulations. In these cases, not only the translator but also the designer or programmer must participate in implementing a translation. However, newly available tools and technologies enable textual elements, such as component labels in the graphical user interface, to be stored outside the source code and retrieved dynamically. The same can be done for culturally dependent data such as dates and currencies and even images. When the simulations and animations are Java-based, the Sun specifications for internationalization can be used.[54] A very remarkable implementation of these specifications is Hwang's NTNU Virtual Physics Lab (*http://www.phy.ntnu.edu.tw/java/index.html*). This site is well known among physics teachers and contains many Java applets. Translating strings in the HTML page where a simulation is inserted is all that is necessary to reformat the simulation to run in a different language; there is no need to change the source code and then recompile the applet.

To the extent possible, private-sector and institutional developers should plan for internationalization of their products. Simple processes, such as maintaining repositories of original graphics files (with their layers intact), text files, and software components, may speed translation and localization. Such preparation also will reduce the cost of subsequent updates and modifications.

A remarkable advance is expected from the wide adoption of XML, which enables Web pages to be generated dynamically. In other words, when a page is requested, the server constructs it "on the fly" from a database of elements that can include text, graphics, video and sound, and even simulations. This new development means that one server can store and assemble elements that enable core resources—such as a video or simulation—to be embedded in Web pages in many different languages or pedagogic contexts. Popular multimedia authoring tools, such as Director and Flash, now support scripts that parse XML documents. Thus, XML and related technologies have the potential to support new architectures for internationalization of educational multimedia.

To summarize, classification and preparation of multimedia for reuse in many different national and international contexts is important in a globalized world pressed by the excess of information, high development costs, and complexity of managing information and knowledge. Without adequate planning, costs in relation to benefits for translation and cataloging of multimedia resources can be very unfavorable, limiting developers' abilities to derive revenues from international markets.

Regulating Reuse and Protecting Intellectual Property

If a content creator—student, teacher, or professional—identifies existing material that would be useful to include in his or her own resource, copyright issues must be addressed. Regardless of whether or not copyright notice is included, the content creator must contact the author or publisher of text, images, software code, or other resources and secure written permission to reproduce the resource. Exceptions are made for resources that explicitly state they are in the public domain. Also, in specific circumstances, resources may be reproduced for "fair use," whereby parts of a copyrighted work are reproduced to critique or discuss the original. (The "fair use" concept does not apply in many countries.)

Particular attention must be paid to projects that involve students as principal content creators. Even in the primary grades, students should be introduced to the need to cite the sources they are using, to teach them how to use other sources responsibly without plagiarizing or infringing on copyright. The ThinkQuest Internet Challenge competition is exemplary in this regard. Each year, teams of students under the guidance of a coach collaboratively develop Websites that address science, humanities, social science, and interdisciplinary subjects. The project has been attaining extraordinary results. ThinkQuest provides resources to assist teams working with copyright, avoiding plagiarism, and citing references (*www.thinkquest.org/resources*).

For large-scale projects that involve collaboration among many individuals and institutions, establishing procedures and policies with regard to copyright and licensing is a crucial step to ensure that all parties involved understand who will control completed resources and how available these resources will be for reproduction. When the materials are completed, licensing agreements inform end users of educational software about prohibitions against sharing, copying, or changing software code.

There are, however, licenses designed to provide incentive for further development. Open-source licensing of the Linux operating system, for example, has resulted in versions developed in more than 50 languages, a wide array of system tools and extensions, and overall improvement of the operating system as a result of contributions by thousands of programmers around the world. Linux, Apache server software, and the most recent release of the Netscape browser have been developed under the GNU General Public License (GPL, *www.opensource.org*) or a similar agreement, Mozilla. "Open source" means that the source code, which is proprietary information in the case of the Windows operating system and most other software products, is open for access and modification.

Open-source licenses allow code use, reuse, modification, and commercialization, with the condition that the modifications are made known and accessible—returned to the public domain—and that the derived work is also licensed as open-source. Under such conditions, many developers participate in the development, thereby establishing a large base of test users, decreasing costs of development, and increasing efficiency.

Many governments have identified strategic areas where software development should receive incentives, involving even private software development firms. Special attention must be paid to ensuring the widest possible dissemination of innovation, without barring firms from including the outcomes of development in commercially marketed products. In cases where the GPL might *inhibit* development by removing commercial incentives, it may be advisable to implement the Lesser General Public License (LGPL). Under the LGPL, specialized code that can be instrumental in the production of other software, such as an open library of math software, is licensed separately for use in commercial and noncommercial products. All modifications and additions to existing code must be returned to the open library, but the end product is not included in the library and can be protected under a different and a more restrictive license.

The PROTEM line of funding *(http://www.cnpq.br/areas/sociedadeinformacao/protem-cc/index.htm)* administered by the CNPq—the national agency for science and technology in Brazil—offers an example of a case in which release of software under the LGPL *could* spur increased development. The funding requirements state that three institutions, private or public, should be involved in each collaborative project, and that each project must include computer science, pedagogy, and psychology. Twenty projects have been supported to date, many of which involve the use of intelligent agents to collect individual cognitive characteristics of students navigating through course material, and then deliver personalized content and present feedback on heuristic strategies for problem solving. The intelligent agents are sophisticated artifacts derived from concepts in Artificial Intelligence. Further development could be fostered if the existing agents follow standards for specification, reuse, and integration—as in the LGPL—and if developers were able to integrate them to develop commercial and noncommercial dynamically adaptive educational products. (Such products would include software and course material that adapt automatically to personal characteristics, infrastructure, special needs, and other factors.[55])

Open-source educational software is available on the Internet, much of it in the form of Java-based simulations. However, in some instances, projects have begun in very open modes and then have found it necessary to restrict use and access to achieve sustainability or increased control over the use of resources. The ExploreScience and ExploreMath sites (*www.explorescience.com* and *www.exploremath.com*) are wonderful examples of the use of simulations to foster learning. In the early stages of these sites, visitors to them could download simulations onto their hard drives for use offline—a necessary feature in many schools with poor

Internet access or other infrastructure limitations. New resources developed for these sites, however, can only be run over a "live" Internet connection, although it is still possible to follow links to a classic version of the site that offers older resources in compressed, downloadable versions.

There are other examples in which restrictions have been applied after projects have been launched. The Links Project (*http://links.math.rpi.edu*) is an exemplar project that connects math learning to the use of math in science and engineering. The site provides examples and templates that allow participation of teams of content and technical developers, while ensuring a uniform "look and feel" for all resources. Early versions of the applets produced in this project were accessible and were excellent examples of good coding. However, the code for these resources is no longer available. This is a typical case of noncommercial use that could very well benefit from a GPL license.

Many educational portals have begun by offering free access, and then have shifted to fee-based access. Biology Labs Online (*http://www.biologylab.awlonline.com*), which contains interactive, inquiry-based biology simulations and exercises, started by offering free access to the first labs. Now, however, visitors to the site receive three days' free access, for trial purposes, after which a subscription is required.

ENSURING QUALITY IN MULTIMEDIA

As the list of potential multimedia authors grows to include students, teachers, and academics, evaluation and quality assurance become critical. In specific circumstances, such as acquisition of commercial software products, any of the widely available evaluation frameworks will yield acceptable results, including:

- California Information Technology Clearinghouse (CITC) (*http://clearinghouse.k12.ca.us*)
- American Dental Association (ADA) Guidelines for the design of educational software (*http://www.ada.org/prof/prac/stands/index.html*)

Of these and others that are used widely, the ADA framework is surprisingly comprehensive and easily applied. Its major categories include:

- pedagogical issues (e.g., instructional methodology),
- subject matter (e.g., information accuracy),
- language and format (e.g., appropriateness, presentation),
- surface features (e.g., interface design),
- questions (e.g., assessment),
- feedback (e.g., meta-cognitive support),
- invisible functions (e.g., record keeping, security), and
- formative evaluation (e.g., testing and evaluation during development).

It is important in applying any framework of evaluation, however, to bear in mind strategic educational objectives as well as the overall context of software support for education. It is equally important to be prepared to recognize the strokes of creativity and innovation that may fall outside the range of existing frameworks, but that distinguish excellence from the norm.

However, as we broaden our understanding of authoring to include the contributions of teachers and students, the parameters of evaluation shift. When students are engaged in design-related activities, for example, our strategic goals may include maximizing participation in both creating and evaluating multimedia, in addition to factual accuracy, clarity of presentation, and effectiveness. When teachers and university faculty, taking advantage of the powerful new tools at their disposal, assume the role of designers or developers, software evaluation and quality assurance again must be approached with a degree of creativity. The effort to build participation in multimedia development throughout the educational community may require incentives—such as those provided by peer review—and safeguards of field templates, testing, and other measures.

Evaluative Methodologies

Four projects that have been introduced previously exemplify different evaluative processes:

- *LabVirt*—A university specialist analyzes students' simulation designs to determine that physics is represented accurately; completed applets are tested; using the applet in their classroom, teachers evaluate its educational value.
- *RIVED*—Different phases of development of multimedia modules are posted and reviewed by country-based teams and an expert panel; each module is tested for implementability; the whole course is implemented and evaluated in pilot schools.
- *Project Links*—Initial designs are reviewed by a technical manager, other authors involved in the project, and a subject-matter expert; modules receive technology testing in-house, followed by usability testing and pilot implementations.
- *MERLOT*—Formal peer review, involving two or more appropriate faculty, is conducted on contributions to the repository; peer review addresses content, effectiveness, and ease of use; once posted, resources are also subject to "open review" by all users.

These evaluative processes are well-structured versions of standard practice. The Internet has given rise, additionally, to alternative evaluative mechanisms, known as "social filtering." These may find their place in education soon. On sites that include open review, individual users have emerged as "trusted guides" by virtue of their prolific and consistently valuable contributions of reviews to the user community. Open reviews also have given rise to instant polling, in which users contribute simple opinions ("thumbs up/thumbs down") or add more detailed annotations to those of users before them.[56] Closer to the cutting edge, sites now are able to monitor "interaction histories" by adding tracers of use or "footprints" to specific Web resources. This information is displayed as a guide to subsequent users.[57] On some current sites (*www.slashdot.com*), resources that receive the most traffic may, for example, become more "discoverable" in searches, increasing their visibility on the site.

Usability Testing

For professional and institutional developers working in resource-rich environments and under great pressures to succeed, evaluating materials after they are completed may be too late. Critical resources, including time and money, will have been expended. While functionality testing may ensure that the product works in its intended environment, it will fail to reveal flaws in the instructional design and perhaps in the design of the interface. Even review by panels of experts may not uncover the fact that the target audience—say, upper elementary students—finds the visual design dated, the interface too complex, and the rewards for success not motivating. The product may work flawlessly as designed, but it may fail to work with learners.

Iterative usability testing should be woven throughout product design and development, as a means of ensuring that these processes are meeting their overall goals, not only their project milestones. Testing may involve observation of users working with the product, surveys and questionnaires, even review of individual navigation histories on a given Website. Subject-matter experts, designers, and engineers may not be familiar with current practice in this arena, and may feel initially that such measures impede their progress. However, working with trained personnel, they can quickly recognize the clear and significant benefits of integrating usability testing into resource development.

CONCLUSION

Multimedia resources—considered in terms of both products and processes—have great potential to enhance education. New modalities and instruments for development and delivery have radically increased the support that these resources can give students across a wide range of learning activities. Despite the glamour of technology-rich environments, focus must remain on learners and their motivations and challenges, on the knowledge domains to be explored, and on the communities in which learning will take place. We also must keep in mind that developers, teachers, and students all have roles to play in the creation of multimedia, and one of the chief goals of policy must be to support appropriate activities by each of these groups.

Flexibility is a key property of multimedia contentware, and must be marshaled effectively in our development efforts. Despite the complexity of their interaction, the contexts for development and implementation—cognitive, instructional, and technological—can be balanced so as to advance strategic goals and plans within our education systems. Cognitive science, in particular, can guide and give shape to innovation in the development of learning environments, multimedia resources, and teaching and learning practice. Both institutional and private-sector developers can draw on advances in learning science to design innovative and effective contentware. The RIVED project provides a valuable example of collaboration among educators, developers, and policymakers to create an array of proven multimedia resources for regional delivery. RIVED, ESCOT, and others projects engage teachers in sharing their first-hand knowledge of learners, the curriculum, and classroom practice, via processes of review and field-testing. In projects such as the EOE and MERLOT, teachers and university faculty have made invaluable contributions to the growth of online repositories of multimedia resources.

We have seen also that trends in authoring tools and pedagogy support the active engagement of students as designers, as creators, and as publishers. The LabVirt project, ThinkQuest, and iEARN engage students in collaborative problem solving through design-based activities. However, students are strongly motivated by the many new media possibilities for information exchange and communication, such as MP3 files, instant messaging, and peer-to-peer networking. These and other media should be kept in mind, and integrated into ICT planning when the opportunity arises.

Authoring tools support increased ease-of-use and increased power, creating change in development teams and processes at all levels, from the professional to the student. These tools also give rise to new economies, based on reuse, shared code, and more flexible platforms. Institutional and professional developers can create resources that are compatible with the computing platforms and communications infrastructures available to their target populations. Development at all levels—by students, teachers, and professionals—can be promoted through the establishment of libraries or repositories of multimedia resources. Such repositories become focal points for active collaboration, sharing of information, and reuse of material. Appropriate protection of intellectual property and of public access must be balanced, using mechanisms that may include the LGPL or the GPL.

As always, factors outside the development processes and even outside the educational systems affect the creation of effective resources. It is vital for policy makers to influence funding, licensing, and standards for the development of educational multimedia by the private sector. Leading-edge technologies, including tools for adaptive and collaborative learning, will be introduced only with appropriate guidance and effective incentives, yet such tools are vital to realizing the promise that technology holds for personalized instruction and for the integration of higher-order thinking into all aspects of education.

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8

TEACHER PROFESSIONAL DEVELOPMENT IN THE USE OF TECHNOLOGY

Sam Carlson

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INTRODUCTION

Teacher professional development is absolutely essential if technology provided to schools is to be used effectively. Simply put, spending scarce resources on informational technology hardware and software without financing teacher professional development as well is wasteful.

Experience around the world in developing, industrialized, and information-based countries has shown that teacher training in the use and application of technology is the key determining factor for improved student performance (in terms of both knowledge acquisition and skills development enabled by technology). Educational technology is not, and never will be, transformative on its own—it requires teachers who can integrate technology into the curriculum and use it to improve student learning.[1] In other words, computers cannot replace teachers—teachers are the key to whether technology is used appropriately and effectively.

That said, designing and implementing successful teacher professional development programs in the application of technology is neither easy nor inexpensive. There are more cases of inadequate and ineffective training programs than there are success stories. Moreover, success stories are not automatically transferable to other situations, and the total body of experience and knowledge in this field is in its infancy. While some people may know more than others in this area, there are few if any true "experts." This calls for humility, innovation, a willingness to fail, ongoing evaluation, sharing of both positive and negative experiences, and constant revision of teacher professional development programs related to technology.

Even if students could learn independently how to use technology to enhance their learning and skills development, with little or no involvement from their teachers, they are highly unlikely to have those opportunities if teachers do not let them have access to technology. Teachers remain the gatekeepers for students' access to educational opportunities afforded by technology: they cannot and should not be ignored. Moreover, providing technical skills training to teachers in the use of technology is not enough. Teachers also need professional development in the pedagogical application of those skills to improve teaching and learning.

Traditional one-time teacher training workshops have not been effective in helping teachers to feel comfortable using technology or to integrate it successfully into their teaching. Instead, a new paradigm is emerging that replaces training with lifelong professional preparedness and development of teachers.[2] This approach includes at least three dimensions:

- Initial preparation/training (preservice) that provides teachers with a solid foundation of knowledge; competency in teaching, classroom management, and organization skills; mastery of the subject matter they will teach; and proficiency in using a variety of educational resources, including technology.
- Workshops, seminars, and short courses (inservice) that offer structured opportunities for acquisition of new teaching skills and subject matter knowledge, as well as skills development in the use of technology in the classroom, that are government-certified and linked to teachers' professional career development.
- Ongoing pedagogical and technical support for teachers as they address their daily challenges and responsibilities.

While technology increases teachers' training and professional development needs, it also offers part of the solution. Information and communication technologies (ICTs) can improve preservice teacher training by providing access to more and better educational resources, offering multimedia simulations of good teaching practice, catalyzing teacher-to-trainee collaboration, and increasing productivity of noninstructional tasks. ICTs also can enable inservice teacher professional development at a distance, asynchronous learning, and individualized training opportunities. Finally, ICTs can overcome teachers' isolation, breaking down their classroom walls and connecting them to colleagues, mentors, curriculum experts, and the global teacher community.

As has been pointed out elsewhere in this book, technology and teacher professional development in its use is best introduced in the context of broader educational reform, which embraces a shift away from teacher-centered, lecture-based instruction toward student-centered, interactive, constructivist learning. This has consequences for reform of curricula, examinations, provision of educational resources, and teachers' professional development. Indeed, one of the most exciting aspects of information and communication technology is its role as a catalyst for such educational reform.

This chapter begins with an examination of the theoretical principles and methodologies underlying such programs. The specific content of such programs is then discussed, after which the issue of teachers' motivation and incentives to participate in professional development programs related

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to technology is addressed. The importance of training additional school community members is stressed, and recommendations are offered for overcoming the persistent problem of insufficient funding for teacher professional development. Next, the potential of technology as a medium for delivering teacher professional development programs is examined, followed by a discussion of future trends in teacher professional development. Finally, because most of this chapter is directed at educational policy makers designing teacher professional development programs, a series of recommendations is provided specifically for teachers considering professional development programs in the use of technology.

THEORETICAL PRINCIPLES AND METHODOLOGY

Most teachers want to learn to use educational technology effectively, but they lack the conceptual framework, time, computer access, and support necessary to do so.[3] A well-planned, ongoing professional development program, grounded in a theoretical model, linked to curricular objectives, incorporating formative evaluation activities, and sustained by sufficient financial and staff support is essential if teachers are to use technology effectively to improve student learning.[4]

When designing or implementing any teacher professional development program for technology, it is important to situate that program within the context of a theoretical framework for adult learning. For purposes of this chapter, a theoretical framework, developed by Reeves and Reeves[5] is used, based on 10 dimensions of interactive learning. Each of these dimensions is presented as a continuum, with contrasting values at either end. Teacher professional development in the use of technology should be designed and implemented to move teachers (and, eventually, students) toward the right-hand end of this continuum (see Table 8.1).

This framework emphasizes the potential of Web-based instruction to contribute to pedagogical reform, rather than technology's rich multimedia features or its ability to access information resources around the world. Stated more simply, technology can promote effective instruction that is more student-centered, interdisciplinary, more closely related to real-life events and processes, and adaptive to individual learning styles. Such instruction encourages development of higher-order thinking and information-reasoning skills (rather than memorization of facts) among students, and socially constructed (collaborative) learning, all of which are increasingly required in today's knowledge-based global economy. This

TABLE 8.1 • THEORETICAL FRAMEWORK FOR ADULT LEARNING

INTERACTIVE LEARNING DIMENSIONS	END OF CONTINUUM	1	2	3	4	5	6	7	8	9	10 (OBJECTIVE)	END OF CONTINUUM
Pedagogical Philosophy	Instructivist											Constructivist
Learning Theory	Behavioral											Cognitive
Goal Orientation	Sharply Focused											General
Task Orientation	Academic											Authentic
Source of Motivation	Extrinsic											Intrinsic
Teacher Role	Didactic											Facilitative
Meta-Cognitive Support	Unsupported											Integrated
Collaborative Learning Strategies	Unsupported											Integral
Cultural Sensitivity	Insensitive											Respectful
Structural Flexibility	Fixed											Open

potential of technology to improve instruction needs to be integrated (modeled) into the design and delivery of teacher professional development programs in the use of technology. Perhaps most important for the purpose of teachers' professional development, technology implies a shift in the teacher's role from being the sole source of knowledge and instruction to being a facilitator of students' learning, which is acquired from many sources. This is often referred to as a shift from being "the sage on the stage to the guide on the side." Again, teacher professional development for ICTs needs to incorporate and model this shift.

Failure to incorporate these 10 dimensions of interactive learning into teacher professional development programs in the use and integration of technology will cripple the potential of technology to improve teaching and learning. This implies that teacher professional development in the use of technology should embody and model the forms of pedagogy that teachers can use in their classrooms. For example, these training programs should accomplish the following:

- Empower teachers to develop their knowledge and skills actively and experientially, in a variety of learning environments, both individual and collaborative.
- Include a variety of learning strategies, encompassing direct instruction, deduction, discussion, drill and practice, deduction, induction, and sharing.
- Aim at higher-order thinking skills.
- Provide an authentic learning environment so that teachers engage in concrete tasks within realistic scenarios.
- Emphasize ways that technology can facilitate and enhance teachers' professional lives.
- Encourage teachers to be mentors, tutors, and guides of the students' learning process (rather than simple presenters of knowledge and information).
- Develop teachers' skills in learning how to learn (define learning objectives, plan and evaluate learning strategies, monitor progress, and adjust as needed).
- Promote cooperative and collaborative learning.
- Be sensitive to the culture and diversity of teachers as learners, using a multifaceted approach to respond to different learning styles, opportunities, environments, and starting points.
- Enable learning independent of time and place (anytime, anywhere learning).

More concretely, this means that teacher professional development in the use of technology needs to combine lecture/presentation modalities with small-group and plenary discussion, individual and collaborative activities, and opportunities for teachers to reflect on their actual teaching practices and how they might do things differently with technology.

Such an approach also means that learning materials need to be in several formats: print, CD-ROM, e-mail attachments, online (HTML and Java), and even DVD. It also implies a need to develop both synchronous and asynchronous modalities, so that teachers can take advantage of training opportunities when they have the time, which is not necessarily when the trainer is available.

Key to successful teacher professional development programs is a modular structure, corresponding to different levels of teacher experience and expertise using technology. Adapting materials to teachers' comfort level and starting points is essential. In this way, teachers new to technology can be exposed to the full series of professional development modules, while those further along on the learning curve can enter where their knowledge and skills stop, and help their less technology-savvy colleagues along.

The basic principles of adult learning also should be incorporated into the training program. This implies that the program should be highly social and cooperative, with opportunities to share experiences and combine instruction with discussion, reflection, application, and evaluation. In addition to these principles, technology enables an even more collaborative approach and maximizes peer-to-peer sharing of the challenges, frustrations, advantages, and successes of using technology to teach and learn. Such an approach encourages use of illuminating failures in the use of technology in the classroom as well as examples of best practice.

Finally, these principles imply the need to build ongoing community and systems of support from peers, mentors, and experts. Single, "one-shot" training events that leave teachers alone afterward should be avoided.

CONTENT OF PROFESSIONAL DEVELOPMENT PROGRAMS

What should be learned? What skills and attitudes do teachers need to develop? What knowledge do they need to construct to use technology effectively to improve teaching and learning? This topic has been discussed at length over the last 10 years as information technology, and particularly the Internet, has been introduced into schools around the world.

To begin with, designers of a teacher professional development program for use of technology need to determine current teacher competency levels in this area. The International Society for Technology in Education (ISTE) has produced a set of standards for teacher skills and knowledge in the use of technology ("Recommended Foundations in Technology for All Teachers"), a useful guide for determining the content of teacher professional development programs.[6] These standards were developed through a multiyear consultative process with thousands of teachers who were using (or trying to use) technology in their practice, principally in the United States and Canada. Another tool, the "Professional Competency Continuum," can be used to determine the skill levels of individual teachers and their professional development needs.[7] European, Asian, and Latin American educational associations have developed similar sets of standards adapted to their educational contexts.

No attempt is made here to resolve these ongoing discussions and divergent views regarding the content required for teacher professional development in the use of technology. Indeed, differing economic, social, cultural, educational, and technological realities require different approaches. That said, some minimum guidelines and suggestions for the content of teacher professional development in the use of technology are warranted.

Policy makers should assume as a bare minimum requirement at least 24 hours (three full days) of teacher training in the use of technology. This includes basic operating systems (turning computers on and off, opening and closing files, etc.), word processing, and spreadsheets (particularly useful for such noninstructional tasks as grading). Obviously, the more time allocated for this training, particularly hands-on time, the greater the mastery of these basic skills will be. Teachers should finish this basic course with at least the fundamentals necessary for them to practice and develop their skills further back in their schools. Adding another 16 hours of training and Internet access would enable teachers to access information on the Internet, do some basic lesson planning integrating technology, and exchange e-mail messages and files with colleagues and experts. With this base of 40 hours of professional development, provided the methodology of the course incorporates some of the key interactive learning principles described above, teachers should be able to begin using technology in their classrooms.

Experience of the World Links program suggests that at least 80 hours of professional development are required before teachers can really begin to integrate technology into their teaching. Additional content would include linking curricular objectives to technology-based activities, development of lesson plans and evaluation strategies that incorporate technology, construction of educational Websites, and discussion of ethical issues related to technology and education. Ideally, this is provided in various stages, allowing time for teachers to experiment with and apply their new technological skills and knowledge in the classroom before moving on to move advanced applications. This approach also allows teachers to reflect on and share their learning experience (both positive and negative) with their peers, thereby promoting the social construction of knowledge.

World Links has been a pioneer in developing and delivering teacher professional development programs in the use of technology to improve teaching and learning in developing countries. It is by no means the "definitive" program, nor is it the most easily replicated and scaled. However, for purposes of illustration, the complete World Links Teacher Professional Development program includes 200 hours of training, equivalent to five 40-hour weeks. This takes teachers with no prior contact with computers to full competency over a two- to three-year period. As an example, the descriptions of these five training modules are provided in the Annex to this chapter.

In addition to content, professional development for technology should incorporate the fundamental components that research has found to be essential, including:

- Direct connection to student learning. The goal of teacher professional development is improved student achievement.
- Hands-on technology use. This requires development of core technology competencies and skills (referred to above) and actual application of skills in the classroom.
- Curriculum-specific applications. To the fullest extent possible, teachers need to see a direct link between technology and the curriculum for which they are responsible.
- New roles for teachers, as facilitators and guides, not simply as lecturers or instructors.
- Active participation of teachers and collegial learning.
- Professional development as an ongoing process.

MOTIVATION AND INCENTIVES

A key issue that must be addressed is teacher motivation to participate in professional development workshops in the use of technology. While so-called "champion teachers" ask for and seek out professional development opportunities in the use of technology, the vast majority of teachers do not. Teachers generally are reluctant to change their teaching styles and habits; are cautious of time-consuming activities that may take away from other high-priority obligations (economic, familial, or educational); have difficulty seeing the potential payoff beforehand of this kind of training; and may feel so threatened by technology that they want to distance themselves from it rather than embrace it. Put simply, many teachers require additional motivation and incentives to participate actively in professional development activities.

A brief description of some incentives (extrinsic and intrinsic) that have been used successfully in the past follows.

Certification by Ministry of Education (Extrinsic)

Ministries of education should be more active in designing criteria for certifying technology-focused teacher professional development programs. They can begin by seeking examples of best practices/examples of professional development programs (domestic or international), relating training programs to existing teacher knowledge and skill standards, and comparing programs to curricula. Then, departments of inservice training should certify the best teacher training programs and link teachers' progress in salary and grade scales to successful certification. This would send a clear message to teachers and school directors that such training is valued at the highest levels of the ministry, and that it increases teachers' incentive to actively participate.

Recognition and Time Allocation by Supervisors (Extrinsic)

Teachers need to be encouraged by administrators, particularly their school directors, to participate in training activities. Administrators need to ensure that teachers have adequate time to participate, and do not have to sacrifice too much personal time to do so. From an administrative perspective, this should be viewed as an investment and a contribution to the capacity building of the country's teaching force. But, in addition to time allocation, supervisors should recognize publicly teachers who successfully complete professional development courses. This provides immediate personal reward to teachers, raises their status in the eyes of their peers, and encourages others to participate.

Reduced Isolation and Increased Professional Satisfaction (Intrinsic)

Many teachers lead an isolated professional existence, with little input from or collaboration with their peers or supervisors. Alone in front of a class of 25-75 students, they teach according to what they learned (both content and pedagogy) several or more years ago in a preservice teacher training institute. Learning new technological skills, especially if they include Internet and e-mail, allows teachers to break down the walls of their classroom and share lesson plans, evaluation strategies, student assessments, and even just the joys and frustrations of teaching.

For example, more than 80% of teachers in both Africa and Latin America who responded to the survey included in the 1999 evaluation of the World Links professional development program, conducted by SRI International, gave the highest possible ranking to the program's impact on their motivation and satisfaction as teachers. In other words, technology reduced their isolation and made them more excited about teaching. Sharing that experience should serve to motivate other teachers to participate in similar professional development programs.

Enhanced Productivity (Intrinsic)

Technology can speed up and increase the efficiency of a range of noninstructional teacher activities such as student attendance, grading, textbook distribution, and preparation of administrative reports. It also can enhance the productivity of basic instructional tasks, such as preparing lesson plans and class outlines, developing quizzes and examinations, and writing up comments on student papers and reports. More advanced applications include fast identification of educational resources (online), use of CD-ROM materials, and curriculum-linked telecollaborative projects.

In fact, there is a nearly limitless range of opportunities for teachers who develop the necessary skills and knowledge in the effective use of technology in the classroom, and who have access to technology and Internet. They can:

- plan, conduct, and evaluate learning projects with colleagues and students;
- receive and provide support following courses;
- participate in (or lead) topical discussions;
- conduct and attend course activities;
- find resources, experts, and new colleagues; and
- serve as resources for other educators.[8]

Becoming a Trainer (Extrinsic and Intrinsic)

Teachers may be motivated to participate in professional development workshops in the use of technology because they see them as an opportunity to become a trainer/mentor for other teachers. In many cases, becoming a trainer brings additional financial and professional opportunities (travel, participation conferences, publications, etc.). If the training workshops come with some form of official certification for successful completion, motivation is enhanced further.

TRAINING OF OTHER SCHOOL COMMUNITY MEMBERS

Administrators

School directors, finance officers, and other administrative personnel also need professional development in the use of technology for noninstructional purposes. Technology can improve significantly the productivity of activities related to financial management, class scheduling, personnel management, student tracking, administrative reporting, communicating with parents, etc.

However, training of school directors should not be limited to noninstructional uses of technology. It is vital that school directors understand and support teachers' efforts to integrate technology into the classroom. Far too often, school directors minimize the time and effort required for teachers to develop the skills and knowledge required to use technology effectively, and, in many cases, directors actively oppose teachers' efforts to use technology in innovative ways. For this reason, it is strongly recommended that all school directors participate in introductory professional development workshops in the pedagogical application of technology. If at all possible, this should be done in collaboration with teachers (even students!), so school directors understand that technology requires us to be both learners and facilitators of the learning of others.

School directors need to see the potential of technology to be a catalyst for more effective learning. They also need to understand (and empathize with) the process and the time required to tap this potential. If this happens, they will be far more likely to encourage their teachers to participate in training workshops, allow them needed release time, and encourage them to experiment with innovative teaching practices using technology.

Students

Parallel to, and in conjunction with, teacher professional development is the need to provide training for students in the use of technology. It is shared wisdom now that youth acquire technological skills far more quickly than adults, and they are far more likely to share their skills with their peers (either deliberately or simply through interaction). Rather than seeing this as a threat to their authority, teachers should embrace this reality and use it to their advantage.

Technology training for students has a "viral" character to it in that it tends to replicate itself spontaneously and spread among other students, many of whom have extremely strong intrinsic motivation to learn new skills. This motivation is related to youth's natural affinity for new technologies, their desire to improve their academic performance for downstream educational and economic opportunities, and their understanding that these skills are increasingly demanded in their countries' labor markets. Such motivation is not often present among teachers.

Technologically savvy students can help teachers use technology in the classroom in many ways, especially when collaborative, constructivist, and authentic learning strategies are used. At a basic level, students can provide technical support in the classroom to their peers and even to the teacher in the use of software, Internet research, leadership of small groups, and even simple computer maintenance and troubleshooting of common glitches.

At a more advanced level, students often have more time and desire than teachers to develop their technological skills further. Thus, they can "instruct" the teachers themselves, by demonstrating new software applications, building educational Websites, and handling administration of networks/servers/IP (Internet Protocol) addresses, etc. Having students take on these responsibilities can free up time for teachers to focus on pedagogical issues, and empower them to promote a more interactive learning environment.

Parents

Generating parent support for technology in schools is important if technology investments are to be sustained and/or expanded. World Links' experience in more than 20 developing countries suggests that parents are often the primary source of recurrent financing for technology in schools and, actually, the most logical source from an economic perspective. This is because universal access to technology simply is not possible now (even if the hardware and software were free, a huge proportion of schools in developing countries lack the electricity and phone lines needed to use them), and those schools that meet basic technical criteria usually are located in more urban and/or middle-class socioeconomic areas. In other words, technology can exacerbate inequity of educational and economic opportunities within a country. With their children as the direct beneficiaries of technology-enhanced learning, parents are the natural source of financial support to sustain technology at the school level.

Offering training for parents in the use of technology helps them to understand its potential for their children. Consequently, such training makes them more likely to bear a portion of the financial burden and encourage their children to take advantage of these new opportunities. In addition, trained parents can become invaluable "monitors" or aides in school computer labs, either paid or volunteer. This eliminates the need to assign teachers to the computer lab during nonteaching hours, encourages greater school-community integration, and provides opportunities for students and adults to share their skills and knowledge with one another. In many cases, "champion students" (such as those described earlier) can offer training to parents and other community members.

COSTS AND FUNDING

Traditionally, teacher professional development is woefully underfunded, at the preservice and inservice levels. This is *doubly true* with training in the use of technology because education policy makers typically work within fixed technology budgets and are inclined to give priority to hardware and software acquisition over teacher professional development (to spread technology access as broadly as possible, often for political and institutional reasons). In the political economy of education financing, teacher professional development is a low priority. It doesn't excite parents, equipment vendors, or politicians who like ribbon-cutting ceremonies. Indeed, it often is viewed negatively because it is costly, time-consuming, pedagogically and logistically challenging, and often results in difficult-to-measure outcomes.

However, without training, teachers will not use technology; it is that simple. The result of underfunding teacher professional development is that a lot of technology provided to schools is never used—it sits in boxes or closets, gathering dust and becoming obsolete. This is more than a loss of potential learning and skills acquisition; it is also a waste of the resources used to procure technology in the first place.

Actual funding requirements for teacher professional development in the use of technology obviously will depend on the scope (content, duration) and methodology of the program itself, and on the number of teachers who are targeted. Whether teachers have full access to computer training facilities (at least one networked computer for every two teachers) as part of their training also influences costs. To illustrate, the World Links program was operational in approximately 20 developing countries during the 2000-01 school year. More than 16,000 teacher-training-days were provided, through 400 local and international workshops, in five languages. Training costs varied from US$25 to US$400 per teacher per day. Taking into consideration the minimum training content guidelines discussed earlier in this chapter, which would translate into a minimum cost of US$75 per teacher, if the training goals of a ministry of education extend to integrating technology (not just use) into the curriculum, this minimum cost (for 80 hours) would be US$250 per teacher. If the full 200-hour World Links professional development program were implemented according to actual year 2000 cost parameters, US$625 per teacher would be required.

Generally, but not always, the unit cost per teacher declines as the number of teachers trained increases, which suggests that there are important economies of scale to be maximized. This is because the costs of developing the program itself are spread over a wider number of participants, and because, as more teachers are trained, less expensive ways of training new teachers can be used (use of local trainers; mentor programs; school-based activities that do not require travel, accommodation, and per diem expenses; etc.).

Experience in both industrialized and developed countries suggests a guideline of professional development financing equivalent to 40% of hardware/software expenditures. For example, if a school (or a ministry of education) spends $15,000 to establish a computer lab (computers, server, printers, network architecture, software, furniture, etc.), an additional $6,000 (at least) should be budgeted for professional development of teachers, administrators, and students in that school over a two- to three-year period. Assuming a training cost of $25 per day per participant, and an average of 80 hours (or 10 days) of training per participant, that translates into $250 per trainee. A budget of $6,000 would enable 24 teachers, administrators, and students at that school to be trained over several years. This should be enough to promote not only the introduction of technology into the school, but also its integration into the curriculum for improved teaching and learning.

The Costa Rican experience in introducing technology in primary and secondary schools is instructive here. Budget outlays for training and pedagogical support were almost equal to those for computer hardware. Teachers working as computer lab coordinators participated in 120 hours of initial training, with additional hours provided during the school year. Both face-to-face and virtual delivery modes co-exist.[9] The successful use and integration of technology in Costa Rican schools, seen in many evaluation studies, attests to the value of this well-funded approach.

TECHNOLOGY AS A MEANS FOR OFFERING PROFESSIONAL DEVELOPMENT

Once teachers have mastered the basics of ICTs—operating systems, word processing, and e-mail and Internet navigation—they can use the technology to access professional development opportunities. This enables anytime, anywhere learning and overcomes the conventional limitations of face-to-face training workshops (cost, travel, accommodations, and low numbers of participants).

Models for Online Professional Development

Many different technologies have been used to support or provide teacher professional development. Often grouped under the vague heading, "distance learning," they include basic correspondence courses, broadcast television, interactive radio, and video. This section focuses on the potential of new digital technologies (the Internet, digital radio, CD-ROMs, DVDs) for teacher professional development.

To begin, it is important to distinguish among different approaches or models for online professional development. As Bob Tinker of the Concord Consortium states, "Broad claims about the value of online learning need to be qualified by the kind of model being discussed."[10]

Four models are discussed here, based on Tinker's taxonomy:

- the course supplement model,
- the online lecture model,
- the online correspondence model, and
- the online collaborative model.

The *course supplement model* complements a traditional face-to-face teacher training course with online resources that often include readings, suggested activities, chat rooms and discussion forums, and answers to problems and tests. Many developing countries looking to improve the quality of their preservice and/or inservice teacher professional development programs can begin here. However, this approach does not reduce costs (it increases them), nor does it replace face-to-face instructional time (the primary cost) or improve scalability of training.

The *online lecture model* offers opportunities to reduce instructional costs and reach large numbers of teachers. It emphasizes primarily one-way delivery of high-quality content. Considerable resources often are invested in developing online instructional resources, with personal contact provided over the Internet through instructor responses to assignments and exams, moderated discussion groups, online "office hours" for questions and answers, and collaborative project work.

For motivated and disciplined teachers, this model can be an effective way to provide professional development at a reasonable cost, particularly in countries where qualified teachers are in short supply. However, the loss of personal contact implied by this model typically results in extremely high dropout rates (around 50%).

The *online correspondence model* is similar to the online lecture model, but it usually invests fewer resources in content delivery in exchange for increased personal contact with the teacher through graded assignments and examinations. Indeed, quite a few traditional correspondence training programs that used postal systems to exchange the work of participants and instructors have transferred their courses to the Internet. The cost is relatively low, but the lower quality/quantity of instruction (much of the training is actually self-paced reading) limits this model to highly motivated teachers and specialized content.

The *online collaborative model* emphasizes the full potential of technology to enable teacher-teacher collaboration during their training course. Typically, it emphasizes asynchronous collaboration (essential for learning across time zones, less costly, and easy to implement); limited enrollment (no groups larger than 20 teachers, although these may be part of courses with much larger enrollments); and expert facilitation, trust-building activities among participants, explicit schedules, high-quality learning materials of many kinds, continuous assessment, and quality assurance with respect to instructional design, subject matter content, delivery, and impact. This model often requires more time (i.e., more money) to design and deliver than traditional face-to-face courses, but it does offer many advantages (higher impact, anytime/anywhere learning, modeling of what teachers may do in their classrooms with their students, etc.).[11]

For developing countries, the ideal online teacher professional development program may be a hybrid of these models, combining the high-quality content delivery (lecture model) with a system of mentors/facilitators for personal feedback (correspondence model) and frequent participant collaboration on assignments/learning activities (collaborative model).

Advantages of Technology Use

The Costa Rican experience in training teachers to use technology, and using technology to train teachers, is instructive. Over the course of 12 years, more than 15,000 teachers and administrators have been trained, using both face-to-face and distance methodologies. Teachers engage in training online on their own, at their convenience, and they can do so as often and for as long as they want. Ongoing pedagogical support and teacher networking, key ingredients of effective inservice training, are facilitated by the technology. By infusing technology into the teaching and learning process, teachers' career-long professional development has become a continuous and planned process. Technology extends training into and beyond the classroom, no longer bound by fixed schedules or physical spaces for instruction (anytime, anywhere learning).[12] This dramatically increased Costa Rican teachers' motivation for, and participation in, professional development in the use of technology to improve teaching and learning.

This potential can been seen in the evaluation of the World Links Program by SRI International, in which more than 80% of teachers surveyed reported that their attitudes about teaching improved "a lot" or "a great deal" as a result of their involvement in the program. The program offers access to technology and the Internet, teacher professional development, involvement in international telecollaborative projects, and development of online educational content by the teachers themselves.

But perhaps more important than providing additional training opportunities, the use of the Web as the training medium exposes teachers to pedagogical practices analogous to what they may do with their own students using technology. Teachers begin to learn skills and develop new knowledge online, through interaction with instructors, mentors, peers, and subject matter experts, modeling the potential learning experience of their students after the training. More specifically, from a pedagogical perspective, teachers working together online with their instructors, peers, and experts share and collectively construct their skills and knowledge. This replaces the traditional vertical training model of trainer imparting information "down" to a teacher.

Not a Panacea

Using technology to train teachers should not be considered a panacea, however. It is very hard to implement, and the number of successful cases in developing countries is very small. Even in the United States, online teacher professional development programs experience an average dropout rate of more than 30%, in most cases because of a decline in participants' motivation or availability of time.[13]

There are a number of strategies and approaches to maintain participant motivation:

> Don't overload the course. Comprehensive coverage of every topic may not be possible or desirable. Focus on quality not quantity.
> Whenever possible, include materials and assignments that can be used in the classroom.
> Look for ways to involve trainees in course assignments.
> Encourage group work and discussion among teachers.
> Take advantage of the fact that your audience is composed of fellow educators.
> Endeavor to involve teachers in the latest research.
> Expose teachers to new educational products and teaching methods.
> Always keep teachers informed about grades, assignments, etc.
> Use teaching assistants extensively to increase personal contact.
> Clarify course requirements and grading policies.
> Expect diversity among participants in terms of both mastery of subject matter and familiarity with technology.
> Keep online conversations active and lively.
> Grade and return assignments promptly.
> Help teachers to set and adhere to a study schedule.
> Use short, open-ended responses to promote online discussion.
> Force teachers to stay together and keep up with all readings and assignments.[14]

For some middle-income developing countries (e.g., Chile, Malaysia, parts of Brazil, Turkey, etc.) online learning is already in reach because of the spread of technology in the schools and sufficient communication infrastructure. For most developing countries, however, problems of low bandwidth, telecommunications costs, limited computer access, etc., require maximum use of offline training modalities, such as CD-ROMs; use of store-and-forward e-mail for sharing documents and mentor support, video, diskettes; and even printed materials to support other technologies.

This presents a paradox: Before technology can be used for teachers' professional development, teachers need face-to-face professional development in the use of technology. But experience in countries such as Chile has shown that with as little as a half-day of face-to-face training, teachers can develop enough knowledge and skills to participate successfully in technology-based distance learning activities.

In the state of Rio Grande do Sul in Brazil, the state federal university, in partnership with the state department of education, developed a training model that incorporates face-to-face training of teachers in the use of technology with Web-based instruction. In Armenia, the *Three Pomegranates Network* provided almost its entire teacher professional development through the project's Website. Even though none of the teachers had used computers or the Internet with their students previously, they were able to use Web-based tutorials and online training to implement online, collaborative project-based activities with their students.[15]

Economies of Scale

In the corporate world, e-learning has demonstrated over the past five years that it can cut training time by one-third, increase training effectiveness by one-third, and reduce training costs by one-third. The same efficiencies need to be explored in the public sector, even if some of the costs and technology investments are different. (For example, in the private sector, a major cost of face-to-face training is simply the opportunity cost of participants' time, which translates into lost sales and revenue. Shifting to an anytime/anywhere e-learning approach allows private-sector employees to get training during nonworking hours or anytime they can squeeze it in, thereby minimizing these opportunity costs. Public-sector teachers typically have far lower salaries, and their participation in training does not result in revenue loss.)

While experience in this area varies greatly, most observers agree that the key to successful e-learning programs (from both cost and effectiveness perspectives) is attaining sufficient economies of scale. For example, compare the $8,000 cost of a 40-hour face-to-face World Links training workshop for 40 participants with Fundacion Chile's $400,000 cost of providing a 60-hour online training workshop for 15,000 participants. The face-to-face workshop had a 100% completion rate, while only 50% of teachers completed the online workshop. This translates into a unit cost of $200 per teacher for the World Links program, compared with approximately $50 per teacher completing the course for the Fundacion Chile program. Even with a very large dropout rate, the e-learning approach appears to have reached greater numbers of teachers at lower unit costs.

That said, one must take into consideration all of the costs associated with the e-learning approach. In addition to the costs of computers and Internet access, there are considerable costs in designing the online course itself and providing course coordination, participant registration, technical support, and assessment/certification. Over time, these costs can be reduced through standardized templates and greater skill in using the technology and software among all participants, but initial investment costs are likely to be substantial.

FUTURE TRENDS

Future trends in teacher professional development in the use of technology will be shaped by two main factors: increasing demand for teacher training and new technologies/methodologies to enable that training.

Increasing Demand for Teacher Professional Development in the Use of Technology

The demand from ministries of education and teachers themselves for professional development in the use of technology is outpacing the capacity of conventional approaches, such as face-to-face training, to respond. There is a simple issue of scale as ministries of education implement nationwide educational technology programs (in countries as diverse as Chile, Senegal, Turkey, and Sri Lanka), and the sheer numbers of teachers who need to be trained exceeds financial, human, and technical capacity to handle teacher training requirements. In addition, greater complexity and content of the training are required as the Internet and other new technologies are introduced.

At the societal level, what teachers are expected to know and do is increasing every year. Teachers not only have to know their subject matter and basic pedagogy, they also are expected to model higher-order thinking processes, work in interdisciplinary teams, and demonstrate leadership and communication skills. At the same time, they are supposed to deliver better student results on standardized tests, while addressing larger societal problems (HIV/AIDS, conflict resolution, disintegration of families, etc.).[16] Traditional teacher training approaches simply are not equipped to deal with all of these new expectations. By contrast, ICTs can help teachers to meet these expectations, by providing productivity tools, access to information and colleagues, and collaboration opportunities. As teachers experience these external pressures, and realize the potential of technology to help them respond, their demand for training in the use of technology will grow.

Scale and complexity exacerbate the issue of teacher motivation. Ministries of education around the world are struggling for techniques and incentives to get beyond the "champion teachers" and so-called early adopters to reach the average teacher. Paradoxically, there is both excess teacher demand for training (relative to capacity to provide it) and insufficient teacher demand for training (relative to the physical distribution of computer hardware in the schools). New teacher professional development methodologies are required to address this issue of motivation.

In the future, ministries of education will issue new standards for teacher competencies in the use of technology, which will affect both preservice and inservice teacher training levels. These standards are likely to be linked to official certification requirements and processes, so that education ministries can track the proportion of teachers who have the necessary skills and knowledge, and so that teachers have an incentive to participate (certification tied to salary and/or grade enhancement, for example).

As the need and demand for teacher professional development increases, the key challenges will be ensuring content quality, reliable and appropriate training delivery infrastructure, follow-up support, and measurable outcomes—and all at an acceptable cost.

New Technologies and E-Learning

As discussed earlier, e-learning is a way for teachers to learn new knowledge and skills using computer network technologies. The technologies provide not just text, but also sound, video, simulations, and collaboration with other learners who may be scattered around the country or the world. Currently, most e-learning is delivered using the World Wide Web; however, future e-learning could include delivery via mobile handheld devices, cell phones, and digital video devices.

The rapidly declining cost of digital video disc (DVD) production and replay offers exciting opportunities to capture the work of master teachers and trainers and share this with teachers wherever they are. Internet-enabled DVD will be available soon, so that teachers learning with a DVD will be able to access materials and resources located on the DVD itself and on the World Wide Web. A $250 DVD player linked to a computer (and perhaps an Internet connection) would bring full video and audio capabilities to professional development, in combination with community-building tools and other resources. This will open up a whole new range of visual and audio possibilities in a distance training format, which is easily scaled.

As Internet access and bandwidth improve in developing countries, additional Web-based synchronous and asynchronous teacher professional development opportunities will arise. For instance, a reliable 56 Kbps Internet connection would enable online teacher professional development that includes live voice-over-IP, file sharing, control of all participants' computer screens by the instructor-facilitator from anywhere in the world, online assessment, and many other features. The instructor-facilitator would control the microphone, be able to "pass" it to participants when they want to ask a question or make a comment, provide individualized evaluation and support to participants, and do this with teachers located in 25 different countries simultaneously. Holding this up are basic telecommunications infrastructure, the telecommunications costs of extended online connections, and regulatory issues surrounding voice-over-IP.

E-learning is rapidly developing because of four main factors:

> gradually increasing availability of higher-speed computer networks to deliver information and services;
> recognition that teachers need to "work smarter" with constant updating of skills;
> convenient just-in-time education for teachers (often "anytime, anywhere"); and
> cost-effective alternative to traditional classroom-based education and training.

RECOMMENDATIONS TO TEACHERS

This chapter is intended to be as practical as possible. In this spirit a series of recommendations is included directed at teachers seeking to improve their skills and knowledge in the use of technology in their classrooms. Many of these recommendations have been taken from Burniske and Monke's excellent book, *Breaking Down the Digital Walls: Learning to Teach in a Post-Modem World.*[17]

> Be critical. Don't blindly embrace or adopt technology as a panacea. Seek the appropriate place and time for computing and the pedagogical rationale for using it.
> Reflect on your own teaching practices. If you are going down the wrong road, technology will get you there faster. Look for ways that technology can help to catalyze pedagogical reform toward more student-centered, interactive, constructivist learning as opposed to traditional methods of "chalk and talk," teacher-oriented, one-way instruction, which is defined in part by the limited resources at hand.
> Demand technical assistance. Not every teacher should have to become a technical expert at hooking up computers, configuring servers, and loading software.
> Seek training opportunities and demand time from administration to learn how to use technology, especially the Internet. Whether it is formal professional development workshops, self-paced training manuals, or simply hands-on experiential learning, teachers should not have to give up family or personal time outside of normal school hours to learn how to integrate technology effectively into their classrooms.
> Join a community of teachers. This may be one person in the same school, 25 teachers in surrounding schools, or a huge network of teachers online around the world sharing their experiences, frustrations, lesson plans, encouragement, problems, and solutions.
> Consider what existing teaching/curricular activities may need to be dropped to integrate technology (and perhaps telecollaborative projects) into the classroom. Technology should not be an automatic add-on to already full curriculum/teaching loads. For instance, when Singapore developed its Master Plan for Information Technology in Education, the Ministry of Education reduced the amount of curriculum content by up to 30% to allow time for achieving curricular goals using IT.[18]
> Be willing to be a student (or an apprentice) again. Teachers need to recognize that their desire/need to learn new skills and knowledge means learning from others, whether that comes from working with their own students, professional trainers, or other teachers. Patience is required to learn new techniques, to apply them in a limited fashion in the classroom, and to accept comments/suggestions from others.
> Be strong. Having students use computers and the Internet does not mean that the role of the teacher fades away. On the contrary, it requires the teacher to project more forcefully into the students' learning, insisting that students reflect on their learning, evaluate Internet information, develop information-reasoning skills (not just memorizing information), and acquire a deeper understanding of their subject matter.

CONCLUSION

Professional development of teachers in the use and application of educational technology should be designed and implemented as part of a broader educational reform program that, at a minimum, combines technology access with teacher professional development and local content development. No strategy that ignores any of these three elements is likely to succeed beyond superficial applications.

Ideally, teachers' professional development should not be isolated from other elements of instructional and noninstructional educational environments, such as curriculum reform, physical/technological infrastructure, examinations, and research. Simply providing professional development for teachers in the use of computers and the Internet, in a situation with outdated curricula, traditional standardized test systems, and insufficient technology access, is unlikely to produce any systemic improvements in learning. In fact, the high-stakes traditional examinations system frequently operates against teachers trying to incorporate technology and encourage deeper forms of learning, which frequently are not measured by standardized tests.

Teacher professional development in the use of technology to improve teaching and learning needs to be:

- multifaceted,
- modular,
- authentic,
- collaborative,
- "incentivized,"
- iterative and ongoing,
- allocated sufficient time and financial resources,
- cost-effective, and
- evaluated and revised.

While it is neither easy nor inexpensive to design and implement teacher professional development programs in the use of new technologies, it is an absolutely critical element of any initiative to introduce technology into schools to improve teaching and learning. Failure to invest sufficient resources in teacher training will result in failure of school-based technology initiatives, which would result in substantial wasted investment that few, if any, developing countries can afford.

Success in ensuring that teachers acquire the skills and knowledge they need to use technology effectively opens the door to all kinds of new educational opportunities for both teachers and students, and downstream economic opportunities for graduating youth and their countries. It is the key to participation in the global knowledge-based economy. Accordingly, teacher professional development in the use and application of technology must be given the priority and resources it deserves, while maintaining a constructively critical eye on its costs, methodologies, and impact.

ENDNOTES

[1] North Central Regional Educational Laboratory. Available at: *www.ncrel.org.sdrs/areas/issues/methods/technogy/te1000.*

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PHASE I—INTRODUCTION TO THE INTERNET FOR TEACHING AND LEARNING
TABLE OF CONTENTS

Objectives: Introduce fundamental concepts, technologies, and skills necessary for integrating networked technology and the Internet into teaching and learning; initiate discussion of new possibilities; generate basic e-mail projects.

1. Introduction to the World Links Program
2. Expectations & Overview—Clarification of expectations and objectives for Phase I professional development
3. Conceptual Orientation—Definition of key terms: collaboration, community, cooperative learning, project-based learning
4. What Is the Internet?—Structure, e-mail, www, ftp, technical aspects, shareware, etc.
5. Introduction to E-mail—Emphasis on communication and collaboration; receiving, sending, group e-mail, public vs. private, organization, newsgroups, listservs
6. Introduction to the WWW—Navigating the WWW, skills, literacy, evaluation, search engines, html, Web page development, creating content
7. Information Literacy
8. Telecollaborative E-mail Projects
9. Action Plans—Follow-up professional development, professional development plan for schools, coordinators' role, action plans for projects
10. Closing Ceremonies

PHASE II—CURRICULUM & TECHNOLOGY INTEGRATION
TABLE OF CONTENTS

Objectives: Develop skills and understanding of how to create, incorporate, and facilitate innovative classroom practices that integrate networked technology and curricula. Create at least one collaborative publication that reflects the week's activities and encourages future work.

1. World Links Program Update—Progress report from World Links coordinators
2. World Links Schools Update—How are things going with the World Links program in your schools (progress reports written and submitted to coordinator before professional development)?
3. Expectations & Overview—Clarification of expectations and objectives for Phase II professional development
4. Instructional Technology—Examination of new and emerging tools that support integration of technology for instructional purposes, classroom management, and administrative duties
5. Best Practices of Technology Integration—What methodologies or instructional practices work best? Case study methodology and activities designed to address subject-specific concerns, telecollaborative projects, and interdisciplinary studies
6. Online Exchanges and Collaborations—Best practices and case studies to integrate Internet/technology into the curriculum (from participants and instructor): how to find, create, and link resources to the curriculum, including telecollaborative projects
7. Content Creation—Activities designed to help participants use software applications to create content for classroom purposes
8. Websites as Pedagogical and Curricular Tools—Activities designed to investigate the possibilities for educational Websites to serve a dual purpose
9. Closing Ceremonies

PHASE III—TELECOLLABORATIVE PROJECTS
TABLE OF CONTENTS

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

1. World Links Program Update
2. World Links Schools Update—Review experience since Phase I and Phase II professional development: what have you done since your last professional development?
3. Expectations & Overview—Clarification of expectations and objectives for Phase III professional development
4. Key Concepts—Project-based learning, constructivism, collaboration, telecollaborative projects, activity structures, etc.
5. Telecollaborative Project Types—Activity structures and exemplary projects
6. Designing Telecollaborative Projects—Connections to curriculum, brainstorming ideas, steps toward a successful project
7. Project Facilitation & Collaboration—Time management, 'Netiquette, 'Net safety, classroom management
8. Websites & Telecollaborative Projects—Process approach, collaborative process, digital archives, communication tools
9. Publicizing Telecollaborative Projects—Venues for publicizing projects online; creating a successful call for collaboration
10. Action Plans—Next steps in the process to ensure implementation of pilot project
11. Closing Ceremonies

PHASE IV—INNOVATIONS: CONTENT CREATION, DIFFUSION, & EVALUATION
TABLE OF CONTENTS

Objectives: Develop skills and understanding of how to create, evaluate, and diffuse innovative classroom practices that integrate networked technology and curricula while addressing social and ethical concerns. Create at least one collaborative publication or activity to promote dissemination of instructional technology's "best practices."

1. World Links Program Update—Progress report from World Links coordinators
2. World Links Schools Update—Progress reports written and submitted to coordinator before Phase IV
3. Expectations & Overview—Clarification of expectations and objectives for Phase IV professional development
4. Diffusion of Innovations—Collaborative activities designed to brainstorm and implement ways of sharing innovative practices that integrate networked technology and curricula
5. Content Creation—Creation and development of learning units that integrate information and communication technology with existing curricula
6. Evaluation—Exploration of ways to evaluate student performance, Web documents, Websites, telecollaborative projects, etc.
7. Assessment—Exploration of alternative methods for assessment of student learning via ICT
8. Online Ethics and 'Netiquette—Case studies and online activities to discuss intellectual property, decorum, and acceptable use within the classroom and school community
9. Experimenting with Innovations—Activities to explore synchronous communication tools and their potential for teaching and learning
10. Closing Ceremonies

PART III

ICT INTEGRATION INTO LEARNING SYSTEMS

9

INTERACTIVE RADIO INSTRUCTION: AN UPDATE FROM THE FIELD

Andrea Bosch
Rebecca Rhodes
Sera Kariuki

INTRODUCTION

Interactive radio instruction (IRI), a methodology developed to turn a typically one-way technology into a tool for active learning in and outside the classroom, continues to be an attractive educational strategy in developing countries after almost 30 years. The original model for IRI math, created in Nicaragua by a team from Stanford University in the early 1970s, sought to combine the low cost and high reach of the radio medium and a clear understanding of how people learn. Since that time, 20 countries around the world have developed IRI programs for a variety of subjects, audiences, and learning environments, many of which have been sustained for up to 10 years and counting. The methodology has been expanded and adapted to include different levels of math, science, health, English, Spanish and Portuguese, environmental education, early childhood development, and adult basic education for learners of all ages. In each case, the series has been designed specifically by local specialists to be engaging and to meet learning objectives in that country. After three decades, interest in IRI does not seem to be waning. (See the Annex at the end of this chapter for a list of IRI projects and their current status.)

This chapter updates earlier information about interactive radio instruction over the past five years, and introduces two cases where IRI has had an impact in Africa in two ways not captured in the past.[1] In Guinea, IRI has gone to scale on an unprecedented level in West Africa to reach students and teachers on a national level. The Guinean IRI series is integrated with teacher development initiatives and is used in almost all primary schools across the nation, with 880,000 students. In Zambia, a new IRI series is being developed that reaches out to students who otherwise would be without schools, and have become increasingly vulnerable due to poverty and the HIV/AIDs. This example shows how IRI can be used effectively to overcome obstacles of access in Africa and to increase the chances that students can receive an education. These examples show how IRI retains its core elements, yet continues to evolve to meet new educational and social challenges.

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All three authors work for Education Development Center, a U.S.-based nongovernmental organization.

WHAT IS IRI?

IRI is distinct from most other forms of distance education because its primary goal has been improvement of educational quality. Unlike many distance learning efforts that are designed primarily to address access issues, IRI began as a tool to use in the classroom to counteract inadequate teacher training, poor achievement among learners, and few resources. While IRI has demonstrated that it can be used to expand access and increase equity in both formal and nonformal educational settings, it retains a development strategy and methodology that require that active learning, attention to pedagogy, and formative evaluation included in the design.

The IRI methodology is also different in that it requires that learners stop and react to questions and exercises through verbal response to radio characters, group work, and physical and intellectual activities *while the program is on the air*. For both teacher and student, the lesson becomes an immediate hands-on and experiential guide. Short pauses are provided throughout the lessons, after questions and during exercises, to ensure that students have the time to think and respond adequately. Interaction also is encouraged within the learning environment between teacher and learners as they work together to conduct short experiments, perform activities, and solve problems using local resources and imaginative situations and stories.

The pedagogy of IRI is more deliberate than active learning alone. IRI series guide learners through the learning process with activities related to measurable learning objectives. Educational content is organized and distributed across lessons so that learning is built on previous knowledge, and new learners can understand more easily the subject being taught. Activities and problems are modeled first by radio characters so the teacher and learners have an idea of the process they are undertaking and the skills and support that may be required. All of these elements are knit together through story lines, music, characterization, and other attributes available through the audio medium.

IRI programs cater specifically to the audience and the situation where they will be used. Thus, one of the most important aspects of the design is its reliance on audience research, participation, and field-level formative evaluation to ensure that lessons are engaging and relevant and that learners can achieve the educational objectives. The format, activities, and pauses of a program change with each cycle of feedback and observation.

WHAT IS KNOWN ABOUT IRI'S EFFECTIVENESS?

The attraction of the IRI approach can be attributed at least partially to well-evaluated projects that have demonstrated greater learning gains for students using IRI programs than students in control groups not using IRI programs. In the first pilot year in Haiti, third grade students using IRI math improved almost 13% from pre- to posttests, while control students gained only 7%.[2] In a partial academic year in Guinea, second grade students using an integrated French and math series improved approximately 8% more than their counterparts who did not use IRI. Other studies, shown below (Figure 9.1), demonstrate IRI's effectiveness not only for math, but for a variety of subjects and age groups. While these data are impressive at face value, they are more impressive when their impact is analyzed (taken as the effectiveness quotient in cost-effectiveness studies).

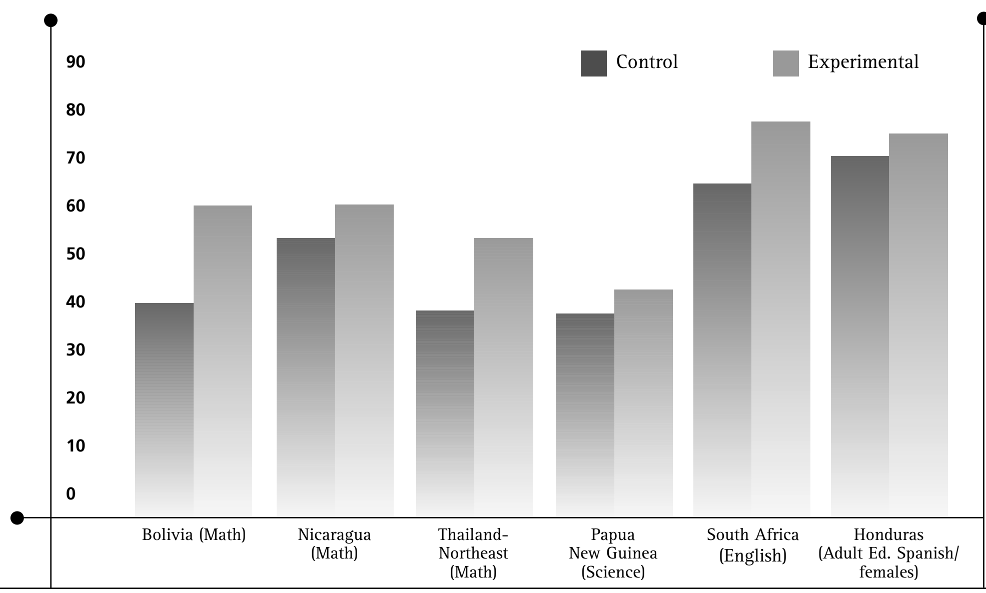
In most cases, students show progressively greater achievement increases over time. In South Africa, for example, students who received fewer than 33 English in Action lessons improved by 6.7%, students who received between 34 and 66 lessons improved by 13%, and students who received more than 66 programs improved by 24%.[3] Similar results were found in Bolivia. In 1991, evaluators found that the average score of second graders using Radio Math jumped from 47.0% to 66.23%. (The mean score of the control group was 35%). Of these, the experimental students who had already completed one year of the radio lessons did much better (51.9% correct), and those students who completed two years of radio programs scored even higher (61.6%).[4]

WHAT ABOUT HARD-TO-REACH OR OUT-OF-SCHOOL POPULATIONS?

The Case of the Dominican Republic

In the Dominican Republic, for example, an IRI project called RADECO was created for children who had no access to school and has been broadcasting for 12 years. Early evaluations compared children who had just five hours of integrated instruction a week using IRI and 30 minutes of follow-up activities with students who were in a regular formal school for more than twice that amount of time. Studies showed that first graders using the RADECO programs responded correctly 51% of the time on posttests, versus 24% of the time for the control group. Second graders using IRI gave 10% more correct answers. Overall, even though these students had enormous obstacles, students in both grades who used IRI for an hour a day had comparable results in reading, writing, and language, compared with the control group, and performed significantly better in math.[5] Based on the early successes of the RADECO project, IRI programs are being developed in other areas where different obstacles are in place, such as failing schools in Haiti, nonformal early childhood development centers in Bolivia and Nepal, and adult learning centers in Honduras.

FIGURE 9.1 • COMPARISONS OF MEAN POSTTEST SCORES



SOURCES: Tilson, T., Jamison, D., Fryer, M., Edgerton, D., Godoy-Kain, P., Imhoof, M., Christensen, P., & Roy, T. (1991). Sustainability in Four Interactive Radio Projects: Bolivia, Honduras, Lesotho and Papua New Guinea. In Technology and Teaching. World Bank. Unpublished; Leigh, S. (1995). *Changing Times in South Africa: Remodeling Interactive Learning.* LearnTech Case Study Series #8. Washington: USAID; Corrales, C. (1995). *Adult Basic Education in Honduras: Managing Multiple Channels.* LearnTech Case Study Series #9. Washington: USAID.

The Case of Zambia

In Zambia, interactive radio instruction now shows that IRI also can help to increase access to education for children who are without schools and teachers and who are increasing vulnerable due to the effects of HIV/AIDs and poverty. IRI is delivering basic education to out-of-school children, especially orphans and other vulnerable children, in community learning centers. IRI is a collaborative effort among communities, churches, nongovernmental organizations (NGOs), the Ministry of Education's Educational Broadcast Services (EBS), the Peace Corps, and the Education Development Center. EBS develops and broadcasts the programs and develops supplementary materials such as mentor's guides, and the Ministry of Education trains mentors in its District Resource Centers and provides supervision/monitoring at participating learning centers. Communities, churches, schools (both government and community), and NGOs provide the learning center venues, mentor(s) to facilitate the radio broadcasts, radio receivers, a blackboard, and some locally made materials. Communities also mobilize out-of-school children to attend the learning centers each day. The Education Development Center (EDC) has trained EBS writers and producers and assisted EBS to develop a training of trainers program for Ministry of Education resource center staff who, in turn, train mentors to run the community-based learning centers.

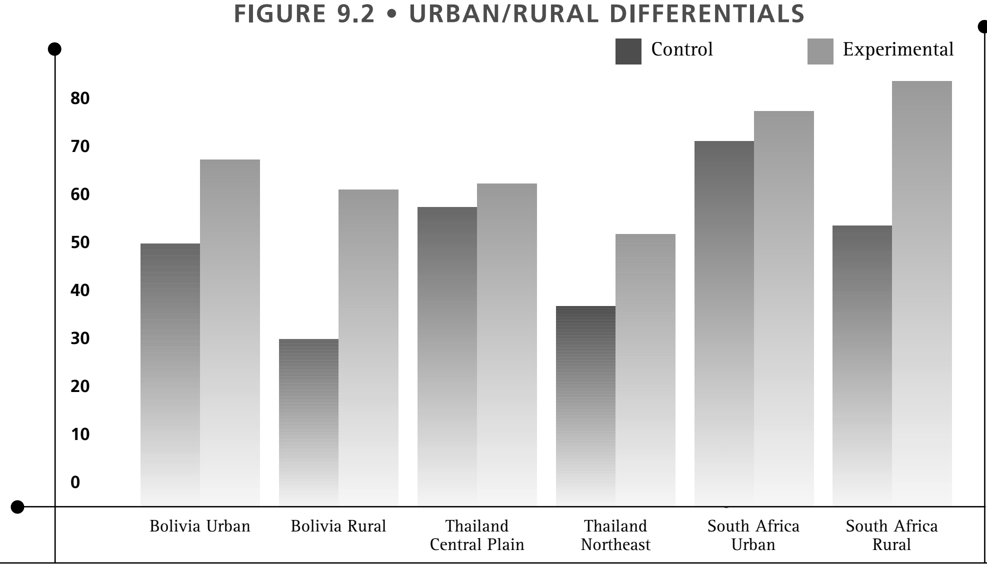
In 2000 and 2001, EBS produced and aired daily 30-minute lessons for grade 1, following the Zambian curriculum for mathematics and English. Grades 2 and 3 are in the process of lesson development. In addition, each IRI program includes skills in English as a second language, basic mathematical skills, and a five-minute segment covering life skill themes (hygiene, nutrition, social values, etc.) in an attempt to strengthen the ability of the community to support its children. The programs are designed to be guided by a facilitator rather than a trained teacher, so the content can be delivered easily and more students can participate. Because the programs promote interactive learning during the broadcast, as do all IRI programs, facilitators are supported in their leadership roles with new content and subject matter. Early evaluations suggest the programs are having positive effects on learning, and more data are forthcoming.

CAN IRI HELP CLOSE EQUITY GAPS?

Evaluations of IRI programs also indicate that they can make a substantial impact on educational equity. In Figure 9.2, evaluations conducted in Bolivia, Thailand, and South Africa show rural students with much higher total gains than their urban counterparts, who have greater access to materials and better-trained teachers. This distribution of evaluation results follows a pattern demonstrated in other countries and indicates that IRI programs are not only increasing in quality, as reflected in achievement gains, but also are having an impact on urban/rural equity gaps.

In a retrospective analysis of the potential of IRI to help close gender equity gaps, a similar trend was discovered.[6] Although girls were achieving about the same as boys in the posttests, because their baseline scores were lower, the total achievement for girls in the experimental groups was greater. This finding was demonstrated in science in upper primary schools in Papua New Guinea, in English in lower primaries in South Africa, and in adult basic education in Honduras, suggesting that the age of the learner and the subject taught did not necessarily matter (Figure 9.3).

FIGURE 9.2 • URBAN/RURAL DIFFERENTIALS



SOURCES: Tilsonet al., op cit; Leigh, 1995.

Another study of learning gains conducted in Honduras shows that the combination of IRI and other interventions may have synergistic effects. That study found that when IRI programs are introduced with new textbooks, the impact on learning gains almost doubles the impact of just providing textbooks (with an effect size of .61), indicating that a well-constructed, multichannel approach—where different educational strategies are aligned deliberately and traditional and nontraditional approaches reinforce each other—may have the greatest impact on learning.[7]

CAN IRI PROGRAMS MOVE FROM PILOT TO NATIONAL PROGRAM?

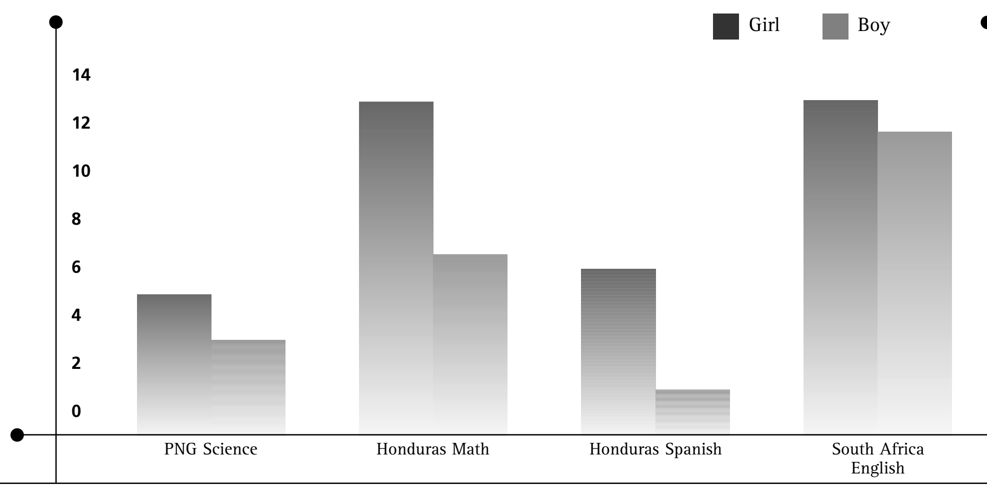
The Case of Guinea

The Republic of Guinea, a former French colony on the West African coast, provides an example of how a multichannel learning approach and IRI can and do improve instruction on a nationwide scale. In Guinea, school enrollment has been at best around 40% (and closer to 30% for girls), and dropout, particularly female dropout, is frequent, and repetition rampant. Even for those who attain grade 6 (about 35% of those who start primary school), more than half fail the state exam that allows them to graduate to the seventh grade. The Guinean curriculum is not strikingly different from or more difficult than the curriculum used by neighboring nations with higher enrollment and retention rates. (Indeed, due to the traditionally centralized nature of instruction in the former French colonies, curricula are strikingly similar across francophone Africa.) This suggests that it is not what is being taught in Guinea, but, rather the organization of the learning process—or the flow of what happens in the classroom—that has to be addressed to provide children with better access to the concepts and topics that make up the Guinean curriculum.

All of the educational models Guinea experienced before the country's independence—the tradition of "apprenticeship," where the apprentice is a blank slate on which the master imprints his knowledge; the Koranic tradition, where pupils spend years memorizing and repeating Koranic verses; and the French tradition, where form and presentation are as paramount as content mastery—have combined to create a postindependence educational culture where teachers "deliver" information to their students through teacher-centered, didactic, repetitive practices that afford children little opportunity to ask questions, draw on their own experiences, or experiment with incorrect answers or hypotheses. In addition, Guinean classrooms are often devoid of any instructional aids. In general, they are undecorated, tin-roofed spaces where teachers, who must instruct between 50 and 80 students, have nothing other than a blackboard and chalk, and the children have only a blank book and a pen.

Such problems are nationwide, so the EDC needed to devise a program that would reach the roughly 22,000 primary teachers in need of support and inservice training. In response, the EDC's Fundamental Quality and Equity Levels (FQEL) project has produced a series of materials, each of which relies primarily on a different "channel" to communicate important concepts and topics to students and teachers. There are 66 IRI programs per grade for every grade from 1 to 6. The children access this learning channel three times a week during their French and math classes. In addition,

FIGURE 9.3 • TOTAL ACHIEVEMENT IN MEAN POSTTESTS BY GENDER



Scores are represented as percentage correct and represent differences in achievement between control and experimental groups.

SOURCES: Hartenberger, L., & Bosch, A. (1996). *Making IRI Even Better for Girls*. ABEL2 Poject. Washington: USAID; Tilson, T., Jamison, D., Fryer, M., Godoy-Kain, P., & Imhoof, M. (1991). The Cost-Effectiveness of Interactive Radio Instruction for Improving Primary School Instruction in Honduras, Bolivia and Lesotho. Paper presented at CIES Annual Conference, Pittsburgh, PA; Project LearnTech, (1991); Leigh, op cit.

there are materials that rely primarily on "print" to channel information toward the student: student workbooks for children in grades 2-6, and short-story readers for children in grades 1-2. Finally, there is a primarily visual channel: color posters, of which every primary school classroom has a set.

IRI was the glue of this nationwide system of teacher support. The radio programs quickly developed such a large following that teachers and students did not want to miss a single program. The reach of radio allowed EDC to introduce strategies, ideas, and resources into every classroom in Guinea in a much more efficient manner than organizing the equivalent amount of face-to-face training. Print materials also were distributed nationwide and were linked to the radio programs in such a way as to be supportive of and complementary to the IRI material.

At the very least, the addition of IRI programs and print materials to the teachers' spoken explanations of French vocabulary and basic math provide the children with a second auditory learning "channel" (the IRI programs), a more stimulating visual "channel" than their own notebooks (the color posters), and a number of kinesthetic "channels" supplied by the activities recommended in the IRI programs, on the backs of the posters, and in the teacher's editions of the workbooks and readers. All of the different materials are specific to the Guinean context and use objects/examples from the students' surroundings, thereby drawing on the learning "channel" to which students are exposed the most: the one that links them to their homes, families, and communities.

Teacher development is also an important component of the FQEL project. Both face-to-face training and materials focus on widening the channel of teacher-student communication to permit two-way communication (teacher-student and student-teacher). Once teachers are able to accept student input along the teacher-student communication channel, they are better able, for example, to perceive the abilities of their female students and better able to call on those abilities in organizing student-student communication. In addition, the combination of multichannel materials introduced under FQEL is designed explicitly to facilitate a more integrated, student-centered flow of instruction in the classroom.

In this sense, the materials are designed as much for the teacher as for the student. They provide support to the Guinean teachers as they try new practices and new configurations in the classroom. For example, the IRI programs prompt teachers to pair students for certain activities, thus facilitating cooperative learning; they prompt teachers to call on girls as well as boys; and they pose questions directly to students that require higher-order thinking skills such as problem solving and analysis. By doing these things, they support teachers in expanding their repertoire of instructional practices. The print materials and posters are designed to do this as well, because they provide structured activities the teachers can try, modify, or build on as they gain confidence and become more comfortable with the new practices. Although the materials in themselves help to create new learning opportunities, when the flow of information along the teacher-student channel is improved in these ways, they function with maximal efficacy to improve Guinean children's learning environment.

WHAT ABOUT THE ECONOMICS OF IRI PROJECTS?

Alongside the data on learning gains is a growing body of literature analyzing the economics of IRI. A brief description of how IRI projects are designed and implemented will help to explain the implications of these studies. IRI projects are front-loaded—that is, they have higher initial fixed costs associated with creating management and training systems and producing audio and print programs than the far lower recurrent costs associated with permanent staff, dissemination, training, and maintenance. While IRI projects have capacity-building components, they are also product-oriented and are evaluated continuously during the early design and production stages to ensure that their products are relevant and effective. Because most of the radio programs have gone through this extensive formative evaluation and have built-in strategies of training, active learning, and quality control, high-level use can be maintained relatively easily over time, and the dilution of quality associated with some other strategies, such as pyramid training schemes, can be avoided. Teacher training and other recurrent costs stay relatively consistent over time after the development stage, and then vary, depending on how much training is integrated into the program, the subject being taught, and the special circumstances of the country. Other recurrent costs include airtime, distribution of simple supplementary print materials (such as one-page worksheets inserted into local newspapers or distributed at the beginning of the year), batteries and radios, and maintaining a management system or unit focused on IRI.

IRI is also different from many other educational strategies because of the wide reach of the radio broadcasts. As a result, increasing the number of learners increases the cost very little. In contrast, most other interventions with high variable costs require a proportional number of new school facilities, textbooks, or teachers as additional learners are added. In an IRI project, these extra factors do not influence the cost of the program dramatically, and, because the primary products—radio programs—are broadcast, the cost per learner decreases proportionally with any increase in users.

Governments using IRI projects have experimented with various cost-sharing and income-generation schemes to pay for recurrent costs. These strategies have been specific to the special circumstances in each country, but three interesting examples include Lesotho, where a tax pays for a portion of the costs; Honduras, which is currently experimenting with private-public-NGO strategies of cost sharing on the municipal level; and the Bolivian early childhood development series, which is experimenting with decentralized methods of sustaining IRI programs through local municipalities. In addition, most IRI projects are sustained at least partially through partnerships between ministries of education and ministries of communication and broadcasting.

What Do Cost Data Show?

Most cost analyses of IRI programs have incorporated these factors into their design and project per student costs over time using the underlying principle that the cost of development is offset when more learners use the programs.[8] In a study of Honduras math programs conducted in 1990, for example, it was discovered that the annual per student cost of using IRI mathematics was US$2.94 in the first year when development costs were included (based on 200,000 students and including a discount rate of 7.5%), but the incremental cost to continue the program fell to US$1.01 per student per year thereafter, which would be distributed across learners and government, and would be reduced dramatically if airtime, the highest-cost item, were provided free of charge or if the number of learners were increased.

While early economics studies may have overemphasized the scale some projects might reach in a short period of time, later studies showed that, with the economies of scale achievable with radio, the cost per student can be quite low. According to a 1999 World Bank/USAID study, for IRI to increase quality in primary schools, costs are likely to be in the range of US$3 to US$8 per pupil reached, depending on the size of the program.[9] The Adkins study calculated that once the lessons have been developed and the system is in place, the annual recurrent costs were approximately US$2.32 (large-scale program) and US$2.97 (small-scale program). Adkins also cites studies showing that IRI has been a cost-effective method of teaching language and math in primary schools in a number of countries, and that it is more cost-effective than some textbook or teacher training strategies.

Is IRI Cost-Effective Compared to Other Interventions?

A number of cost-effectiveness studies also have found IRI to be a highly competitive educational strategy, compared to other interventions. As early as 1988, Lockheed and Hanushek[10] published a study comparing cost-effectiveness data on three IRI projects, two textbook projects, and four teacher training projects. Cost-effectiveness was measured as a ratio of incremental effectiveness (units of effect size) to incremental cost (dollars per student per year) and referred to as efficiency. The study showed that providing textbooks results in an attractive efficiency ratio of about .2 effect units per one dollar per year (with the exception of one case in the Philippines, where the gain was 1.5 per dollar). All other interventions were considered less cost-effective than textbooks, with the exception of IRI, which proved to be more cost-effective, with efficiency ratios in the .3 to 1.3 range.

Finally, in recent cost analyses conducted in South Africa, evidence suggests that IRI is still proving to be cheaper and more effective than other programs. A 1995 study showed that when the cost of South Africa's English in Action was compared to other English-language programs, the cost per student of English in Action ranged from one-third to one-half of other options.[11] Like other projects, South Africa's English in Action is now broadcast across country, indicating that the recurrent costs associated with sustaining the programs are considered justifiable.

CONCLUSION

IRI applications differ depending on the degree of activity required of the learners, subject matter, age and background of the learners, learning environment, and background of the teacher or facilitator. One might even say that the differences are greater than the similarities. But, despite these differences and the adjustments that IRI has undergone over time to become more culturally intriguing or educationally up-to-date, studies consistently demonstrate high learning gains, decreased equity gaps, and cost-effectiveness across projects. Today, IRI is showing that it can be taken to scale in complex environments or used to reach generally hard-to-reach populations to address the types of educational crises the world is facing in the new millennium.

It is difficult to pin the successes of the IRI methodology on any one characteristic. More likely, a number of key factors converge to provide the conditions needed for active and supported learning. The consistency of these factors seems to be able to fill a needed gap and provide an impartial educational catalyst for teachers and learners across traditional boundaries, such as gender, distance, and access to quality schools. We have seen additional examples of how IRI can be taken to scale and used to reach new audiences in Africa, arguably during the most difficult time in its history. These examples and the continued exploration of ways to make IRI a useful tool to improve educational quality, access, and equity hold our attention after three decades.

ANNEX: IRI PROJECTS AND THEIR CURRENT STATUS

COUNTRY	YEAR	SUBJECT	AUDIENCE	KEY POINTS
Nicaragua	1974	Math	Grades 1-4	> Original model developed > Adapted in other countries
Kenya	1980	English	Levels 1-3	> Original model developed > Adapted in other countries
Thailand	1980	Math	Grades 1-2	> Main audience changed (formal schools to nonformal hill tribe schools) > Distribution methods adapted (radio broadcast to cassette)
Dominican Republic	1981	Integrated programs for nonformal; math for formal	128,000+	> Original model developed (integrated programming) > Small nonformal population reached annually (app. 8,000 per year), but has been sustained for 20 years
Papua New Guinea	1986	Science	Grades 4-6	> Original model developed (science) > Strategy compatible with educational needs > Payment for airtime (recurrent costs) > Program decentralized and coverage reduced after 11 years
Honduras	1987	Math	Grades 1-3	> Original model developed (mental math) > Attempted cost sharing > Program discontinued and transformed into adult basic education (see below)
Bolivia	1987	Math	Grades 1-5	> Strategy compatible with educational needs > More than a millions students served > Needs troubleshooting to change with policy shifts
Lesotho	1987	English	Grades 1-3	> Strategy compatible with educational needs > Innovative levies pay for recurrent costs
Guatemala	1990	Spanish, math	(3 grades in 220 schools)	> Attempted to recreate entire series rather than take advantage of work already done (more expensive) > Strategy not found to be cost-effective
Costa Rica	1991	Environmental education	Grades 4-5	> New model developed (environmental education) > Transition from pilot to national program did not occur; potentially connected to changes in policy and administration at key moments
Bolivia	1992	Health	Grades 3-4	> Original model developed (health) > Child-to-child method implemented > Strategy compatible with educational needs
El Salvador	1992	Math	Grades 1-2	> Strategy compatible with educational needs > Agreements between government and private press and radio stations to sustain airtime

ANNEX: IRI PROJECTS AND THEIR CURRENT STATUS

COUNTRY	YEAR	SUBJECT	AUDIENCE	KEY POINTS
Honduras	1992	Adult basic education	Grades 1-6	> Original model developed (adult basic education) > Strategy compatible with educational needs > Agreements among government, regional radio stations, and organizations
South Africa	1992	English as a second language	Levels 1-3	> Model successfully recrafted from Kenya Language Arts to make it compatible with South Africa's needs
Indonesia	1992	Teacher training/ split shift	Teachers	> Strategy compatible with educational needs > Project received only minimal external support—quality unknown
Pakistan	1992	English	Grades 3, 4, 5	> Pilot
Indonesia	1993	Civics, math	Middle school	> Strategy compatible with educational needs > Project received only minimal external support—quality unknown
Portuguese-speaking African countries	1992	Math, Portuguese	Grades 1, 2, 3 ,4	> Still in pilot stage > Intended to reach Cape Verde, São Tomé, Principe, Guinea Bissau, and Mozambique
Bolivia	1994	Early childhood care and development	Early childhood development centers, preschools	> Original model developed > Uses both radio and cassette > Decentralized dissemination matches education reform > Broadcast in 3 local languages
Bangladesh	1995	English	Unknown	> Methodology planned to be integrated into current work in Bangladesh
Nepal	1996	Early childhood development	Early childhood development centers	> Model adapted from Bolivia > Institutionalized within Radio Nepal > Broadcast nationally as of 1998 > UNICEF study (in 2000) showed 50% of formal and informal caregivers listen across Nepal
Haiti	1996	Reading, civics, math	Grades 2, 3, 4	> Pilot > New model being developed for reading > Math adapted from Nicaragua
Ecuador	1996	Conflict resolution/ critical thinking skills	Early childhood development centers, preschools	> New model developed (conflict prevention/ critical thinking skills) > Pilot incomplete
Venezuela	1991	Math	Grades 1, 2, 3	> Between 1991and 1999, program reached more than 3 million children nationwide
Guinea	1997	Integrated: English, math, life skills	Grades 1-6	> New emphasis on teacher development > First West African program to go to scale nationally with 880,000 students

ANNEX: IRI PROJECTS AND THEIR CURRENT STATUS

COUNTRY	YEAR	SUBJECT	AUDIENCE	KEY POINTS
Costa Rica	1997	English	Grades 1-6	> Piloted with 14,000 students and continues to be broadcast
Zambia	1999	English; math, integrated	Grades 1-7	> Primary audience is AIDS orphans in communities > Pilot
Nepal	1999	Teacher training for English and math	Grade 3, 5	> Dual audience program for teacher training and instruction in math and English language > Pilot
Ethiopia	1999	English	Grade 1	> Pilot effort to reach all 10,000 schools in country
Honduras	1999	Integrated English, math, civics, environment	Grade 7-9	> Pilot > First program to target secondary school
Nigeria	2001	Math, literacy	Grades 2-4	> Pilot > Includes Koranic schools
Ethiopia: Somali refugees	2001	Integrated programs		> Pilot

ENDNOTES

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10

TELEVISION FOR SECONDARY EDUCATION: EXPERIENCE OF MEXICO AND BRAZIL

Laurence Wolff
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INTRODUCTION

Television has been used for educational purposes for many years and throughout the world. The oldest and most established form of educational television is the programming transmitted by major public broadcasting organizations, in the form of open-access programs serving specific groups, such as preschoolers, enrichment programs for school-age children, and adults who wish to learn new skills or gain new knowledge. The United Kingdom's Open University, mainly based on television, and *Sesame Street*, tailor-made versions of which are now broadcast with in many countries (see chapter 11), are two of the best-known and most successful uses of television for educational purposes.

On the other hand, television for direct instruction in primary and secondary education has had a much more problematic history. In the 1970s, it was thought that television might help to "leapfrog" over problems of low-quality education in developing countries by providing high-quality, centralized instruction with receivers located in classrooms, especially at the secondary level. With support from international agencies, secondary instructional programs based on TV were developed in Côte d'Ivoire and El Salvador. The results of in-school television in those two cases were disappointing. Per student costs were too high, teachers resisted centralized institutions, and the programs ended as soon as external financing was discontinued. On the other hand, one program—*Telesecundaria*—started in 1968 by the Mexican government without external financing, has had continued success and recently has grown rapidly. *Telesecundaria*, directed at rural children in isolated communities, illustrates some of the strengths of educational television. The case study provided here seeks to identify why *Telesecundaria* has been so successful while other secondary television programs have had limited impact or have failed.

Beginning in the 1960s, Brazil also experimented with educational television, beginning with in-school broadcasting in the states of Maranhão and Ceará. While these broadcasts have not had a significant impact, in the late 1970s, Roberto Marinho Foundation (a private foundation), supported by Brazil's biggest commercial network (Rede Globo), began *Telecurso*, directed at working young adults who were seeking primary or secondary school equivalency certificates. While Brazil's *Telecurso* has not been as well documented as *Telesecundaria*, a number of characteristics appear to be contributing to its success. These are described in the second case study.

MEXICO'S *TELESECUNDARIA*

Telesecundaria was created more than three decades ago to respond to the needs of rural Mexican communities where a general secondary school (grades 7-9) was not feasible, because there were too few students and it was difficult to attract teachers. The main characteristics of *Telesecundaria* have always been:

- using television to carry most of the teaching load, and
- using one teacher to cover all subjects, rather than the subject matter specialists used in general secondary schools.

This combination permits effective installation and implementation of these schools in sparsely settled rural areas that usually are inhabited by fewer than 2,500 people and have low primary completion and secondary enrollment rates; the complete curriculum can be covered with just three classrooms and three teachers.

Telesecundaria has experienced substantial growth since its inception in 1968. After a reform in 1993 and the introduction of satellite transmission, growth increased further, from approximately 512,700 students in 1993 to 817,200 by the end of the 1997-98 school year and an estimated 890,400 by the end of the 1998-99 school year. Current enrollment is estimated at 1,050,000 students in 14,000 schools. In 1998, enrollment was equivalent to 17.6% of the country's total enrollment in grades 7-9. Traditional general schools accounted for 53.6% of the enrollment, technical schools for 28.5%, and "workers' schools" for the remaining 0.3%. On average, the *Telesecundaria* schools have three teachers—one for every grade—and 22 students per grade. Students attend school 200 days a year, 30 hours a week. Table 10.1 summarizes the differences between the two systems as of 1997-98.

How the Program Works

Educational television has been a mainstay of the program throughout its years of operation. Yet, the mode of use of television has evolved and is already in its third generation. At the earlier stages, a regular teacher ("talking head")

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delivered lectures through a television set installed in classrooms. Books and workbooks were provided to follow the television program with exercises, revisions, applications, and formative evaluations. The second generation improved on this process and created programs with greater variety and more sophisticated production techniques. The third and current generation, which began in 1995, deploys a satellite to beam the program throughout the country and uses a wider range of delivery styles. *Telesecundaria* is now an integrated and comprehensive program providing a complete package of distance and in-person support to students and teachers. It puts teachers and students on the screen; brings context and practical uses of the concepts taught; uses images and available clips extensively to illustrate and help students; and enables schools to deliver the same secondary school curriculum offered in traditional schools.

The programs are aired from 8 a.m. to 2 p.m. and repeated from 2 p.m. to 8 p.m. to a second shift of students. At eight o'clock, the teachers in all of the *Telesecundaria* schools in Mexico turn on the TV. The students then watch 15 minutes of television. At the end of the TV session, the set is turned off, and the book, workbook, and teacher take over, following detailed instructions on what to do in the remaining 45 minutes. At first, the teacher asks whether students need a better understanding of the concepts just seen. Then, they might read aloud, apply what was taught in practical exercises, and participate in a brief evaluation of what has been learned. To finish, there is a review of the materials taught. At 9 a.m., another subject starts, following the same routine.

In contrast with traditional schools, where students use a separate text for each subject, *Telesecundaria* students use two: a book of basic concepts that provides explanations of the televised lessons and covers all core subjects, and a student learning guide used to engage students in group activities to apply lesson contents to practical situations. Teachers follow a guide that contains instructional strategies and learning objectives. The guide also helps teachers to overcome some of the limitations they may encounter because of unavailability of teaching materials or learning tools and provides strategies for adapting the lesson to local contexts and individual student needs.

Telesecundaria teachers and supervisors also receive inservice training through televised programs that are broadcast during the afternoons or on Saturdays. In addition, *Telesecundaria* is implementing a training program designed to update teachers on teaching techniques and materials. This program is estimated to have benefited thousands of teachers.

Cost-Effectiveness of *Telesecundaria*

Effectiveness

There are two ways to measure the effectiveness of *Telesecundaria*: by analyzing flow rates and through achievement testing. According to an Inter-American Development Bank (IDB) study, flow rates of *Telesecundaria* are slightly better than those of general secondary schools and significantly better than technical schools. At first sight, this is a counterintuitive finding. After all, this is a school catering to the poor, predominantly located in rural areas, where one would expect the worst performance in a

TABLE 10.1 • *TELESECUNDARIA* AND GENERAL MIDDLE SCHOOLS, 1997-98

	TELESECUNDARIA SCHOOLS	GENERAL MIDDLE SCHOOLS
TOTAL NUMBER OF SCHOOLS	**13,054**	**8,410**
Total number of students enrolled	817,200	2,640,400
Total number of teachers	38,698	166,940
Student/teacher ratio	21	16
Average number of teachers per school	2.9	19.9
Average number of classrooms per school	3.33	8.9
Average number of students per school	63	314
Student/class ratio	22	35
Number of school days	200	200
Total number of existing *Telesecundaria* program modules	6,500	N/A

SOURCES: Secretaría de Educació Pública (SEP), Informe de Labores 1997-98; Subsecretaría de Educación Básica, Unidad de *Telesecundaria*.

school's ability to prevent its students from dropping out. The explanation offered by *Telesecundaria* officials is that the strong involvement of local communities, use of single teachers who are much closer to students (instead of one teacher per discipline), and the quality of the delivery all encourage retention.

A recent study[1] found that achievement on standardized tests in *Telesecundaria* schools was lower than in regular schools. Differences were relatively small, but they were statistically significant. In the absence of control by socioeconomic origin of children—so far—the study could not answer the most important question about the "value-added" of *Telesecundaria* compared to that of conventional schools after controlling for socioeconomic status. On the other hand, an earlier, unpublished Secretaría de Educación Pública (SEP) study has shown that *Telesecundaria* students start significantly behind other students but catch up completely in math and cut the language deficit in half.[2]

Qualitative studies have suggested some advantages of *Telesecundaria*. For example, there are a number of *Telesecundaria* schools in urban areas that share with their rural counterparts the use of one teacher for all subjects; this teacher stays with the class through all subjects and uses both the video and written materials typical of the program intensively. The schools usually function in lower-middle-class neighborhoods of working-class parents with modest incomes and jobs in the formal sector. It has been reported that these parents prefer *Telesecundaria* schools because they have textbooks available, and they must keep pace with the broadcasts, which forces teachers to stay on course during the school year, without losing time, missing many classes, or becoming distracted in particular subjects. Teachers seem to perceive the one-teacher-for-all-subjects practice as an advantage instead of a handicap, because children may work better with one teacher who gets to know them better and is able to integrate knowledge for them.

Costs

Estimated unit recurrent costs in 1996 were US$456 for general lower secondary schools and US$535 for technical schools. (These figures do not include depreciation for school construction.) The recurrent costs of *Telesecundaria* were estimated at US$471 per student. The fact that *Telesecundaria* is no more than 16% more expensive per student is surprising, since the student/class ratio in *Telesecundaria* is 23:1 rather than the average of 35:1 to 40:1 in urban secondary schools, and since the costs of television product material and transmission hardware are considerable.

The student-teacher ratio in a general lower secondary school is 16:1. This relatively low ratio is a result of the fact that there are 12 different disciplines in the Mexican lower secondary school curricula, each of which is taught by a different teacher. Clearly, unless the schools are very large, it is practically impossible to avoid having fewer teaching periods than is the norm. The result is that, while students have about 35 periods of class per week, the average teacher more than likely has 20-25 teaching periods, much lower than the expected 35. On the other hand, *Telesecundaria* schools operate with a single teacher (a "home teacher") who deals with all disciplines of the corresponding three grades instead of with one teacher for each discipline. This means that the number of students in a class is about equal to the student-teacher ratio. In a few cases of very small communities, the same teacher deals simultaneously with more than one grade. Although the average number of students attending *Telesecundaria* schools is 63, some *Telesecundaria* schools are able to operate with just a few dozen students in total.

Most of the *Telesecundaria* buildings (85%) consist of three rooms, restrooms, a science lab, a small library, a playground, and a small parcel of land used for farming. The average per student cost of building three *Telesecundaria* classrooms is US$627. In comparison, the average per student cost of constructing the nine classrooms in a general secondary school is estimated at US$336; however, these figures do not include libraries, science laboratories, or workshops. Physical facilities costs for technical secondary schools are significantly higher than for *Telesecundaria* and general secondary schools.

The *Telesecundaria* Unit (*Unidad Telesecundaria*) includes teachers and communication and pedagogical experts and is in charge of the instructional model, curriculum content, teacher training, and text production. The Educational Unit *(Unidad de Televisión Educativa)* produces the TV programs, and the *Instituto Latinoamericano de la Comunicación Educativa* (ILCE) is responsible for their programming and for broadcasting them. On average, it takes approximately 20 days to produce a 15-minute module, which costs between US$30,000 and US$50,000 (1998-99 estimates). A program usually is kept in stock until significant changes in the subject content or pedagogy are made; they usually last for five to 10 years. Prorated over eight years, the annual cost of all programs per student is estimated at US$27 (not including the unit costs of providing televisions, antennas, and other equipment to schools). Overall, *Telesecundaria*'s annualized investment cost per student for the 1998-99 school year is estimated at US$113.

Each *Telesecundaria* book covers 50 days of schooling, so four books of each type are provided to each student to cover the 200 classes offered during the year. The students receive the books at no charge, but are expected to return them in good condition. There is a fee of US$0.35 per book if a student does not return it or returns it in bad condition. The unit cost per book is US$1.30, compared with $8 in general secondary schools. Table 10.2 summarizes these cost estimates.

Cost-Effectiveness

Cost-effectiveness usually is measured by comparing two different treatments of the same or similar populations. In the case of *Telesecundaria*, there are two different populations, urban and rural children, so we need to examine cost-effectiveness on a hypothetical basis. While *Telesecundaria* schools are more expensive than urban secondary schools, a more appropriate comparison would be with the cost of setting up a general secondary school in a rural area. In principle, the cost would be prohibitive, since a school with 60 students would require 12 teachers, for a 5:1 student-teacher ratio, as well as a full laboratory and administrative personnel. This would mean running costs nearly four times those of *Telesecundaria*. Even after subtracting the unit costs of television programs, the cost still would be three times as great. In principle, *Telesecundaria* in urban areas would cost 16% more than regular schools. Urban *Telesecundaria* would be a good investment if there could be comparable increases in test scores and/or flow rates. An alternative in urban areas would be to increase the *Telesecundaria* student-teacher ratio to, say, 25:1, thereby reducing the cost difference significantly. A final alternative would be to use the *Telesecundaria* approach only for math and science, where conventional teaching would be weakest, and where, in principle, achievement levels could be raised.

Why Is *Telesecundaria* a Success?

Telesecundaria goes against the grain of Latin American school tradition. It constitutes one of the very few programs in which the poor receive a better-conceived and better-managed program than do the urban middle- and upper-socioeconomic classes. *Telesecundaria* takes away more freedom from the teacher than is acceptable to many teachers, on the grounds of both pedagogical doctrine and ingrained habits of conventional schools. It replaces teachers' lectures, and it structures the remaining classroom time. The accompanying textbook, which is closely linked with each individual class, ensures that each minute of class time is used in a prescribed manner. The moment the teacher turns off the TV set (which is exactly the time other grades turn on theirs), he or she is supposed to follow a preordained routine. Administrators say that, with this routine, *Telesecundaria* students read a minimum of 14 pages each day, supposedly far more than regular students.

Super-teachers can do better with their own imagination and personal style. They can deploy their own bag of tricks and help students to rediscover the physical world and invent novel and creative ways to teach. But very few teachers have the skills, preparation, available time, or initiative to conduct such a class. The overwhelming majority—and an even larger proportion of the teachers who end up in rural

TABLE 10.2 • COMPARATIVE ANNUAL COSTS PER STUDENT IN US$

ANNUALIZED INVESTMENT COSTS	*TELESECUNDARIA* 1996-97*	*TELESECUNDARIA* 1998-99 (EST.)**	GENERAL SCHOOLS 1996-97***	TECHNICAL SCHOOLS 1996-7
Television-related	57.8	50.1	N/A	N/A
Start-up & other facilities	65.9	63.1	20.9	N/A
RECURRENT COSTS	430.9	413.4	456.2	534.5
TOTAL COSTS	554.6	526.6	477.1	N/A

SOURCES: *Telesecundaria* 1996-97 figures from Calderoni, J. (1998). *Telesecundaria*: Using TV to Bring Education to Rural Mexico. *Education and Technology Notes Series*, 3 (2), p. 9; *Telesecundaria* 1998-99 figures and general and technical schools figures based on Secretaria de Educación Pública (SEP) (1998). *Informe de Labores*, 1997-98. Mexico: SEP.

* Costs are estimated in 1997 US$.

**Based on Calderoni, with enrollment estimates for 1998-99 provided by SEP as follows: enrollment increases from 767,700 in 1996-97 to 890,400 in 1998-99 and average school size increases from 60 to 63.

***Annualized investment cost assumes an average class size of 35.

schools—have neither the talent nor the dedication to be super-teachers.

The circumstances that make this delivery model possible have much to do with its structure. The first secret is these schools did not have to be transformed from conventional ones to those that use *Telesecundaria*. Schools are hard to change, but *Telesecundaria* schools were created that way, not adapted. Second, teachers are recruited differently from those who teach at general schools, While 60% of *Telesecundaria* teachers are fully qualified to teach in urban schools, 40% are not trained as teachers but are university graduates who are recruited. Those wishing to become *Telesecundaria* teachers need to be explicitly interested in the process, have a community orientation, and be willing to live in rural areas.[3] In principle, this would lead to more committed professionals (although teacher turnover in *Telesecundaria* is still very high). Finally, being rural and isolated from the conventional habits of general schools makes it easier to use methods that impose high levels of control.

Current Problems and Issues

Telesecundaria is not without its management problems. For example, although *Telesecundaria* is not designed for one-teacher schools—where one teacher teaches several grades simultaneously—as many as 25% of schools in the program are one-teacher schools, thus calling into question the adaptation of the program to a key feature of many rural schools.[4] In 1997-98, 17% of schools had either malfunctioning reception equipment or no equipment at all. However, little difference in learning seems to have been found between these schools and the rest, suggesting that TV broadcasts are relatively less important than printed materials, which were distributed efficiently to all of the schools. Teacher absenteeism has been found to be an important determinant of student learning in *Telesecundaria* schools. Teachers who live in the community were less likely to skip class and more likely to spend long hours with children. Apparently, rapid growth, fueled by *Telesecundaria*'s advantage as a low-cost alternative well suited to rural environments, may be overwhelming pedagogic and technical support capabilities.[5]

In 2000, ILCE launched an extensive maintenance and repair effort seeking to update and set up all of the antennas and reception equipment in all the schools that participate in the program. Repair and maintenance teams in each of the 30 states were trained to perform this work on a continuing basis. ILCE has concluded that about half the states have done a very good job in this regard, but infrastructure is performing at less than full capacity in the other half of the jurisdictions, because state governments have failed to live up to their responsibilities.

Finally, *Telesecundaria* suffers from rigidity because of scheduling. An Internet-based system would allow teachers and students to view programs at different times and to repeat them. Mexico is upgrading its satellite capabilities and expects to be able to provide data transmission to schools very soon, but full Internet connectivity is still technically difficult, expensive, and requires high maintenance.

BRAZIL'S *TELECURSO 2000*

History of *Telecurso*

With its large area and low school attendance, Brazil has been experimenting with radio and television education for more than three decades. Two states in the Northeast (Ceará and Maranhão) created secondary schools through television in the 1970s. Then, a bit later, another player—the private Globo Television Network—stepped onto the stage and completely changed the relationship between secondary schools and television. The world's fourth-largest network, Globo had ample experience in production, particularly excelling in soap operas that found huge markets on every continent. Twenty years ago, the Roberto Marinho Foundation (FRM), a grant-making and educational foundation financed by Globo, created the first *Telecurso*, adding a number of important innovations beyond what had been offered in the Northeast. The first of these was very expensive production values, and, second, it used actors instead of teachers. This program was a major success, in terms of number of listeners and sale of accompanying textbooks, and was aired for more than 15 years. It was never formally evaluated, however.

In contrast to Mexico's *Telesecundaria*, *Telecurso* targeted young adults who left primary or secondary schools before graduation. Brazil always had open examinations for primary (eight years) and secondary (11 years) certificates (*exame supletivo*) for young adults who are beyond a certain age. Since these were open examinations, students could prepare on their own or enroll in preparatory courses. *Telecurso* took the place of these preparatory courses, allowing students to follow the curricula by watching television. A number of institutions received supervision from FRM to create classrooms where, under the supervision of a teacher (improvised or certified), students could watch the programs/classes and use the complementary written materials.

In the early 1990s, with the rapid transformation and globalization of the Brazilian economy, industrialists began having problems with the low schooling levels of their workers. In many cases, they sponsored employees taking preparatory courses leading to the government examinations. However, the quality of these courses was mediocre at best. The Federation of Industries of the State of São Paulo then struck a deal with FRM to prepare a new *Telecurso* for its workers. For this joint venture, the industrialists contributed US$30 million to produce a new program, and Globo offered to broadcast it free of charge. Globo also donated the equivalent of US$60 million worth of commercial TV time to promote the new program, called *Telecurso 2000*.

Content and Approach

Telecurso 2000 is a condensed version of a basic curriculum for secondary education, to be provided through a combination of direct television, videotaped classroom sessions, and books. Thus, both television sets and videocassette equipment are used. In addition, an optional curriculum is offered that focuses on teaching basic mechanical skills (the vocational course on mechanics).

Initial discussions on development of a curriculum for the three courses to be offered by *Telecurso 2000* (Level One, Level Two, and the Vocational Course on Mechanics) were led by education specialists who wished to define basic skills in the context of a postindustrial society. With that beginning, the following guiding principles for the educational program of *Telecurso 2000* were developed:

- *Job-oriented education.* The purpose is to educate individuals for a job: to educate workers to enable them to relate in a meaningful way to life in society, bearing in mind the fundamental role of education in ensuring worker productivity.
- *Development of basic skills.* In a society marked by scientific and technological progress, it is not enough simply to learn to read, write, count, and solve simple arithmetic and geometry problems. People also must learn how to organize their thoughts, solve problems involving numbers, interpret what they read and

TABLE 10.3 • COMPOSITION AND RESOURCES OF *TELECURSO 2000*

COURSE	DISCIPLINE	TV SESSIONS		RESOURCE		HOURS OF STUDY REQUIRED
		N	HOURS	VIDEO	BOOKS	
Level 1	Math	80	20.0	10	4	1 hour 45 minutes per class session
	Portuguese	90	22.5	12	4	
	Brazilian History	40	10.0	5	2	
	Geography	50	12.5	7	2	
	Science	70	17.5	9	3	
	English	30	7.5	4	1	
TOTAL	**6**	**360**	**90.0**	**47**	**16**	**630 HOURS**
Level 2	Math	70	17.5	9	3	1 hour 45 minutes per class session
	Portuguese	80	20.0	10	3	
	Chemistry	50	12.5	7	2	
	Physics	50	12.5	7	2	
	English	40	10.0	5	2	
	Biology	50	12.5	2		
	Brazilian History	80	20.0	10	4	
	Gen. Geography	40	10.0	5	2	
TOTAL	**8**	**460**	**15.0**	**60**	**20**	**735 HOURS**
Technical Course in Mechanics	17 modules including a variety of subjects	360	90.0	53	19	1 hour 45 minutes per class session = 630 hours

apply it in different situations, read and express themselves in another language, understand instruction manuals, develop basic know-how in economics and quality control to be able to produce more and better products and eliminate waste, and hold discussions by making use of cognitive and social skills.

- *Citizenship education.* The nature of the new relationship among science, technology, and society makes it necessary for workers in all categories and at all levels to broaden the scope of their learning, so they can play an active role in the political and cultural life of their countries. Production-oriented skills must go hand-in-hand with civic responsibility.
- *Contextualization.* The most advanced teaching theories stress the importance of applying what is learned in class to situations that arise in daily life. In other words, life provides the material for the teaching of specific skills.

These four principles—job-oriented education, development of basic skills, citizenship education, and contextualization—underlie all the disciplines taught through *Telecurso 2000*. Teams of professors associated with the country's major universities, all of whom were required to have ample experience in curriculum development for basic education, were selected to develop the program content for each discipline. This requirement was particularly important given the highly specialized nature of adult education and the need to adjust the language used accordingly. Textbooks had to be easy to read without having content more suitable for children or adolescents.

Table 10.3 shows the content of the curricula for the three courses offered by *Telecurso 2000*, as well as the number of TV classrooms and books used in each discipline.

The new program employs only professional (soap opera) actors, thus making the production even more expensive than the first *Telecurso*. There are other differences as well. Since it is aimed at young adults, it does not put classrooms, teachers, or students on the screen. All scenes take place in factories, streets, homes, offices, newspaper stands, and travel agencies. Real-life problems precede presentation of theories and explanations. *Telecurso 2000* also borrows heavily from the pace of commercial TV, moving very fast and including plenty of humor, very much like regular TV programs Brazilians usually watch. Although the program occasionally may sacrifice depth, it seldom sacrifices rhythm.

The forms of delivery also evolved. The programs are broadcast nationwide between six and seven in the morning, a most inconvenient time. Then they are rebroadcast through cable and satellite at more convenient hours. Public television stations also broadcast them during the day. In many cases, these programs are recorded in the school or by the viewer and later played at a more convenient time. In contrast to *Telesecundaria*, such "videotape education" is common, occurring not necessarily by design, but by the users' choice. A telephone survey indicated that few watch the programs on TV to prepare for the examination, confirming the hypothesis that those who want to take the examinations work from tapes in classrooms with teacher support.

Users of *Telecurso 2000*

It is difficult to identify all who use *Telecurso*. Suffice it to say that 5.2 million accompanying texts were sold or distributed between 1995 and 1999. *Telesalas* (classrooms with television sets) have been established in enterprises, and a support system for those working with students has been established. At present, more than 200,000 students attend classes in factories, schools, churches, offices, prisons, ships, and buses.

An unknown—but probably large—number of people watch television and study on their own. But even more surprising, another large and uncounted crowd watches the programs regularly or occasionally, apparently because they are interesting and entertaining. A recent telephone poll indicated that 5% of the respondents—closely representative of the Brazilian population—had watched *Telecurso 2000* during the previous week (this is close to 7 million people). The interviews revealed that most of the audience has had some higher education, and most respondents say they watch the programs because they like education programs.

An additional development is the spontaneous and increased use of the programs in regular schools, something that had started already with the old *Telecurso*. The data are unreliable, but it seems that in 1999, more than 200,000 students attended classes where *Telecurso* was the predominant mode of delivery. A number of states are now developing explicit programs to incorporate portions of *Telecurso* into regular secondary schools, especially in rural areas, that are similar to *Telesecundaria*.

The Economics of *Telecurso*: Big Is Beautiful

Like all forms of education using technology, television requires extensive initial investment. There can be significant savings in recurrent costs, because using less expensive teachers can still result in success. However, the upfront fixed costs are quite high.

To have reasonable costs per student, many students are needed to share the fixed costs. Assuming a cost of US$30 million for preparing *Telecurso 2000*, if the program were to stop today, figures for book sales indicate that several million students participated in *Telecurso* somewhat seriously. If 3 million used the program, this would amount to US$10 per student. This is a very modest price per student for a set of 1,200 15-minute lectures. Costs per book are approximately US$4 (the primary school program uses a single book, and the secondary program uses more). Hence, the social cost per student working on his or her own is US$14.

Classroom modalities change this cost equation completely. Since the program requires one teacher per classroom, the costs begin to approach those of conventional education. Estimates per student for classes offered in factories and in well-respected philanthropic institutions are around US$400. This is no more than the average cost of public education but less than the cost in the more affluent states where most of these classes take place. In other words, once we put a teacher in each classroom, the costs of *Telecurso* are approximately equivalent to those of regular schools, without the support of technology and good books. At the same time, at current scales of operation, the imputed costs of the US$30 million initial investment almost disappear inside the much larger recurring cost of paying teachers or instructors. There is also a tendency to hire regular teachers for the *telesalas*, so, in terms of cost, the *Telecurso* is similar to a regular school, because the television component has negligible weight. But there are unexplored ways of reducing costs, even with a teacher in the classroom. For example, the number of classroom hours for night schools, attended by 60% of all secondary school students, could be reduced by, say, half, requiring students to watch the program on their own for half the time and in teleclassrooms for the rest of the time, where teachers or monitors can help with problems.

How Effective Is *Telecurso*?

Telecurso 2000 is an ambitious initiative, mobilizing hundreds of people at the production, distribution, and instructor-training levels. Does it pay? Are the results commensurate with the costs?

Contrary to the experience of *Telesecundaria*, reliable research studies on effectiveness are not yet available. Costs are easy to compute, and the delivery and its organization are clear enough, but good measurements of outputs are lacking. And, when they are available, they lack comparability with other groups (regular students attending four hours per day of day or night school or students preparing for *supletivo* by other means). Research is underway to answer these fundamental questions. In any event, *Telecurso* has proved its value through already providing opportunities that previously were unavailable to young adults, by opening a new perspective on pedagogy and educational materials. As in the case of *Telescundaria*, being outside the formal secondary system permits *Telecurso* to be highly innovative.

CONCLUSION

These two case studies lead to some very powerful conclusions. In mid-size and large countries, television at the secondary level works: it can be used to reach underprivileged groups, either rural children or young adults who have left schools. It is likely that the learning described above is equal to or greater than at conventional schools. Costs are lower than the equivalent requirements (e.g., setting up full schools in rural areas or fully operational, four-hour-long "night schools" in urban areas). The very rigidity of the television format may be to its advantage, especially in the Mexican case, since it requires students and teachers to be punctual and to keep up with the pace of the program. While the future suggests that television will be replaced at least partially by the Internet, TV is available now, and does not have to wait for the more sophisticated environment of fully two-way Internet and data connections.

It must be pointed out that any centrally prepared program, be it television or Internet, requires a large, up-front investment. Only mid-size and large countries can achieve the economies of scale needed to make the program feasible. On the other hand, Mexico has made its programs available free of charge to several Central American countries, which are using *Telesecundaria* in their own schools, thus reducing the fixed costs per student enormously. There is anecdotal evidence that these programs are effective in spite of cultural differences among countries. It must be noted, however, that any country considering setting up a new distance education system will have to consider the role and costs of the Internet and its relationship to television. Finally, setting up an alternative distance secondary education system requires convincing and/or bypassing the traditional education establishment.

ENDNOTES

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SESAME STREET RUNS ALONG THE NILE

Michelle Ward-Brent

- Improving Children's Readiness to Learn
- Promoting Girls' Education
- *Alam Simsim*
- Unprecedented Reach
- Early Childhood Development
- Outreach

Development experts note that investments in education of females have the highest return of all educational investments. However, in most parts of the developing world, significant disparities continue to exist in the educational standing of girls and boys. This is particularly true in rural Upper Egypt. Eliminating such gender disparities is the focus of United States Agency for International Development (USAID)/Cairo's Education and Training program, which supports a number of educational programs to improve the access, quality, and efficiency of basic education. Among these is a highly successful local co-production of *Sesame Street*, called *Alam Simsim*, which is watched by more than 4 million Egyptian children and their families every day.

IMPROVING CHILDREN'S READINESS TO LEARN

Why *Sesame Street* in Egypt? *Sesame Street* has long been associated with documented improvements in children's literacy and numeracy skills and with helping to prepare young children for school. Research conducted in association with the project found that some children in rural communities of Upper Egypt had acquired fewer literacy and numeracy skills than children in comparable countries and even children in more developed parts of Egypt. These skills are fundamental to early childhood development and successful participation in school. Nationwide, only 12% to 14% of Egyptian children have access to preschool education, and primary school dropout rates are high. Learners in the poorest communities, on average, have only three years of education.

However, nearly all Egyptian households have access to television and electronic media, which has a 96% penetration rate. By improving children's readiness to learn, and by increasing the skills and knowledge levels of their parents, *Alam Simsim* has been designed to address some of the underlying factors that contribute to Upper Egypt's low primary school enrollment, high primary school dropout and failure rates, and low literacy levels among adult women.

PROMOTING GIRLS' EDUCATION

Egypt needs to increase literacy skills and girls' participation in school to advance development and improve equity. USAID/Cairo has responded to this need by placing a high priority on programs to reduce gender disparities in education, expand access, and improve the quality and efficiency of formal and nonformal education. The goal is to ensure that Egyptian learners will enter the 21st century with the skills and problem-solving abilities required for a modern economy. The program places particular emphasis on increasing girls' enrollment, retention, and achievement rates in primary school in communities in three poor governorates in Upper Egypt (Minya, Beni Suef, and Fayoum).

Egypt's female adult literacy rate, although growing at 1% per year, is only 41%. This is low even by the standards of poor countries. In 1999, the *Human Development Report* of the United Nations Development Program (UNDP) ranked Egypt 120 out of 174 countries on its human development index, and attributed the low ranking primarily to Egypt's low literacy rate. The report also noted that Egypt's ranking fell nine places from the previous year. Low literacy, the lack of universal enrollment, and the poor quality of basic education in Egypt are seriously constraining the country's social and economic development and adversely affecting the health and well-being of millions of people.

Despite these challenges, considerable progress is being made in increasing girls' participation in school, especially in the targeted areas of Upper Egypt. The 2000 Egypt Demographic and Health Survey reported that girls' primary school enrollment in Upper Egypt rose from 54.5% in 1995 to 74.0% in 2000. USAID's programs have contributed to this improvement.

Working in collaboration with the Government of Egypt and other local and international partners, USAID/Cairo funds programs that support school construction, teacher training, English–language instruction for teachers, literacy and job skills development, community advocacy, girls' scholarships, nonformal life-skills training, and preschool education. These programs have improved the quality of teaching and increased community and parent involvement in school management, which, in turn, has contributed to higher retention and achievement rates. Many of these programs are implemented through nongovernmental organizations (NGOs) working with local communities. Many of the constraints to girls' educational achievement in poor areas are beyond the capacity of government to solve; they must be addressed at the local level. USAID's programs have recognized this, promoting new relationships among government, NGOs, communities, and families. *Alam Simsim* is one such model of successful collaboration that involves the government, business, NGOs, and local communities.

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ALAM SIMSIM

Despite a rich history in film production, Egypt had few educational media resources for children and none that approached the magnitude, innovation, and educational efficacy of *Alam Simsim*. The series models positive images for girls and boys, promotes girls' education and good health and environmental practices, and celebrates Egypt's rich culture and traditions. It has been designed to encourage girls' early and continued educational participation. One of *Alam Simsim's* leading characters, Khokha, is a "four-year-old" female Muppet with a passion for learning. Curious and creative, she loves to ask questions and find solutions. The portrayal of girls as active, equal participants in all elements of the series has been a pioneering advance in a culture that has traditionally promoted limiting gender stereotypes.

Two seasons of 65 half-hour programs each have been produced, and the program is broadcast twice a day, five days per week. The first season premiered in August 2000 to domestic and international acclaim. The second season launched with a special "back-to-school" event that was hosted by First Lady Suzanne Mubarak. The third season is underway.

Over the past three years, Sesame Workshop (the United States-based producers of *Sesame Street*) has provided technical assistance and training to the local production company, Alkarma Productions. The training focused on scriptwriting, puppeteering, directing, production, editing, and research. Throughout the development and production phases, leading Egyptian educators, linguists, health specialists, and others worked in close cooperation with program writers and directors to ensure that the program's curriculum is educationally effective, culturally sensitive, and reflective of Egyptian priorities.

Alam Simsim's lessons are illustrated through humor, music, fantasy, and daily life situations. Short story segments on the "Street" are combined with animation and minidocumentaries to create an engaging program format that can be enjoyed by the whole family. Among those calling *Alam Simsim* home are friends and neighborhood Muppets Khokha, Filfil, and Nimnim (created by The Jim Henson Company). Khokha, as noted above, is a four-year-old girl. Filfil is an ageless Muppet who has all the answers, even though he may not know what the questions are. Enthusiastic and easygoing, Filfil genuinely wants to help his friends in need, and Nimnim is a young Muppet who is wise for his age. Gentle and patient, he finds his surroundings fresh and amazing, especially when it comes to nature. Surprise celebrity guests also appear in the series, along with a regular adult and child human cast.

UNPRECEDENTED REACH

After only eight months on the air, *Alam Simsim* has become a highly popular family series, reaching the majority of children throughout the country. A November 2001 omnibus household survey conducted by the Middle East Media Research Bureau reported that the series is now watched by more than 90% of children under age eight (more than 4 million children) in urban areas and 86% of children in rural areas. Such extensive reach is unprecedented in Egypt, or anywhere else in the world. Surveys have also reported that 54% of mothers regularly view the series. The proportion of low-income families who view the series increased significantly.

The success of the series validates USAID/Cairo's belief that distance education for preschoolers can make an enormous contribution in a country where less than one-eighth of children receive formal preschool education, but where TV penetration is nearly universal. The series is strongly supported by First Lady Suzanne Mubarak, who recently called it an example of "intelligent children's programming that can instill certain ideas and values that are indispensable in today's world."

Over the 30 years since *Sesame Street* was first broadcast, extensive research has been conducted on the series' effectiveness in improving literacy and numeracy skills, especially among the disadvantaged. To date, 20 international co-productions have been built on the *Sesame Street* model, each one a unique series that reflects local culture and tradition and a curriculum that emphasizes local priorities. These productions tap the tremendous power of media to bring the four corners of the world into homes that lack exposure and education. Simple and entertaining lessons on literacy, numeracy, health, education, and the environment have the power to change attitudes and practices and to build basic skills and knowledge among children and their parents. In Turkey, research indicated that the country's *Sesame Street*-based series produced learning gains equal to an entire year of schooling. *The Economist* recently lauded the South African co-production of *Sesame Street*, which focuses on issues specific to a post-apartheid South Africa, for its innovative use of radio, television, and outreach.

Research in Egypt is documenting both the problems that the series addresses and the progress being made. The *Alam Simsim* team's research in Beni Suef and Minya found that boys aged four to six years old can count significantly higher than girls and are more skilled in letter recognition. But children who had watched the series (in comparison to those who had not), showed tendencies toward a change in views on gender (such as whether women can become pilots) and an increase in knowledge of hygienic practices (washing hands, brushing teeth, getting enough sleep, etc.). Research also documented that gender bias begins to form at an early age.

EARLY CHILDHOOD DEVELOPMENT

Why invest in early childhood development? The high returns on such investment have been documented throughout the world. Research has shown that the first five years of a child's life are critical to cognitive, physical, and emotional development, and that half of a person's intelligence potential is developed by age four. The Consultative Group on Early Childhood Care and Development notes that early childhood interventions can have a lasting effect on intellectual capacity, personality, and social behavior. Such programs have been shown to increase school enrollment rates, improve the learners' performance in school, reduce the costs of education, and positively affect a range of related long-term social and economic indicators.

The 1994 Carnegie Task Force on Meeting the Needs of Young Children reported on scientific research, specifically noting the following findings: 1) brain development before age one is more rapid and extensive than was realized, and, although cell formation is virtually complete before birth, brain maturation continues after birth; 2) brain development is much more vulnerable to environmental influence than was understood; 3) inadequate nutrition before birth and in the first years of life can seriously interfere with brain development and lead to such neurological and behavioral disorders as learning disabilities and mental retardation; 4) the influence of early environment on brain development is long lasting: infants exposed to good nutrition, toys, and playmates have better brain function at age 12 than those raised in a less stimulating environment; and 5) environment affects not only the number of brain cells and connections among them but also the way these connections are "wired."

OUTREACH

Educational outreach efforts to support the series' educational messages, extend their impact, and sustain the program are now being developed. A series of public service announcements (PSAs) incorporating the series' characters has been developed to promote family literacy and girls' education. A series of PSAs on health and safety is in production (for example, promoting Egypt's new seatbelt law), and a complementary parent education program for rural families is now under development. The latter program will provide outreach and training support to illiterate or semi-literate parents to improve their ability to prepare their children for school; increase their awareness of the importance of all children attending school and becoming literate and numerate; improve their understanding of developmental phases and their role as their children's first teacher; promote good health practices; and educate them on how to stimulate a child's cognitive development.

USAID/Cairo has provided funding for three seasons of *Alam Simsim* through a grant to Sesame Workshop. The program was developed in collaboration with the Egyptian Ministry of Education and has been supported by the Ministry of Information. As noted, First Lady Suzanne Mubarak is a patron of the series. In addition, Americana, the leading food company in the Middle East, is an official sponsor.

Sesame Workshop is a nonprofit educational organization committed to maximizing the power of media as an educational force in the lives of children. Its properties include television, Internet, CD-ROMs, magazines, books, film, community outreach, and product licensing. Its *Sesame Street* programming and 20 indigenous co-productions have been enjoyed in 140 countries. The Workshop can be accessed online at *www.ctw.org* or *www.sesamestreet.com*.

12

COMMUNITY TELECENTERS:[1] ENABLING LIFELONG LEARNING

Mary Fontaine

INTRODUCTION

An expanded vision of education that has rocked the world is that of "cradle to grave," or lifelong, learning, an ongoing process that the new century has made increasingly necessary. While devising the ways and means to promote, facilitate, and sustain the process, educators and computerphiles have crossed paths.

In informal education—the world of learning that goes on informally all around us—information and communication technology (ICT) is causing quite a stir, sometimes in the most unlikely of places. In developing countries on every continent, public ICT access centers are springing up and bringing information from around the world to communities that, for the most part, have had little experience with it. The phenomenon is particularly interesting in poor neighborhoods and remote and rural areas, where formal schooling suffers from access, equity, and quality problems and where, heretofore, informal opportunities for learning have been more or less limited to local wisdom. Though the experience varies from place to place, these centers are emerging as a new learning system for people of all ages and from all walks of life. Known by a variety of names, but generically as telecenters, they represent a potential means to enable lifelong learning in the best and broadest sense of the notion.

Yet, unequal access to ICT—also known as the *digital divide*—is an increasingly important concern in international development and education communities. While computers are spreading at a faster rate than any other technology in history, the gap between those with access and those without is growing as well. We all know the startling statistics: Less than 5% of computers connected to the Internet are in low-income countries, where fewer than four telephones per hundred people is the norm. Nearly half the world's population has never even made a telephone call. And a computer alone, much less a telephone line that enables Internet connectivity, is an unattainable goal for most people in developing countries.

Can ICT increase opportunities for disadvantaged individuals, groups, and regions? Will it provide people with the potential for ongoing personal and professional growth? Or will it contribute to a growing information and knowledge gap between countries—and within them? The answer depends upon access.

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PUBLIC ACCESS

The most literal definition of *access* is to make Internet, computing, and telecommunications tools available in a given community. Once the technical issues are solved, those who already understand the advantages of ICT—a relatively small segment of the population—will use it. In this model, entry and start-up costs are relatively low. The risk, however, is that the digital divide within countries will widen.

Adding orientation and demonstration programs to the process combines access with *awareness*. This approach takes time, money, and planning, but it reaches beyond the technical elite to other early adopters who, given the opportunity, will take the time to learn and take advantage of the potential educational benefits of ICT.

The most comprehensive approach to a full-bodied access program includes *diffusion*, which involves a preplanned, systematic program of activities designed to spread the message broadly. (The message includes "what is ICT" and "how ICT can help you.") Diffusion is time-consuming and resource-intensive, but it is how disadvantaged groups—those lacking access—are reached. Effective diffusion programs focus on local needs and priorities, both in the message conveyed and the method used. What works in one environment may not work in another.

To exploit the potential benefits of ICT for widespread lifelong learning, therefore, ICT access involves more than making equipment available, though that, too, is important. The full complement of access concerns includes:

- reliable hardware;
- appropriate software;
- awareness of ICT functions and benefits;
- effective training in use;
- equitable/affordable opportunities for use;
- sufficient literacy/language skills—or access to mediators;
- ability to synthesize, organize, and apply information; and
- ability to produce and disseminate information as well as receive it.

Public ICT access centers are diverse, varying in the clientele they serve and the services they provide. Some for-profit, private-sector cyber cafés cater to those able to pay well for online time, providing young people with a place to play computer games, for example, or talk in chat rooms. At the other end of the spectrum is the small computer kiosk, also a commercial endeavor but typically offering offline services only, for example, at outdoor country markets.

All models are useful. But so far, the version designed specifically to achieve education and development goals—including affordable access and training for students, teachers, nongovernmental organizations (NGOs), and other social development agents—is the most likely to ensure access for targeted, low-income populations.

Sponsored, subsidized telecenters—initially supported by local or national governments, bilateral or multilateral donor agencies, private foundations, or local entrepreneurs—are a case in point. This type of telecenter typically offers a host of technology products and services, ranging from a telephone, photocopier, and fax machine to computers equipped with a variety of software and peripherals, such as a printer and scanner.

A place for public access to ICT, these telecenters often offer technical assistance and training in use at rates affordable for low-income people. They build on the concept of public access but emphasize the learning functions of the communication technologies that are made available, thereby increasing access to lifelong learning opportunities. To ensure relevance to community priorities, needs assessments are conducted to identify needed products and services, and telecenter staff are trained to help visitors become familiar with the technologies, resources, and services offered at the centers. To facilitate long-term sustainability, fee and management structures are established based on ability to pay, and community involvement, as well as collaboration with the private sector, are actively promoted.

TAXONOMY OF A TELECENTER

The community telecenters model described above is characterized by an emerging taxonomy that includes:

> the *adoption model*, where an NGO serves as the host organization, managing the center and integrating it, to one degree or another, into the organization's core business;
> the *municipal model*, where a government agency opens a center, often disseminating information, decentralizing services, and encouraging civic participation as well as providing public ICT access; and
> the *private-sector/commercial model*, in which entrepreneurs launch for-profit centers with "social good" services offered as well.

An Adoption in Benin

When the Songhai Center established telecenters at its three agricultural training sites in Benin, it called the program "CyberSonghai." A strong, vital NGO with a reputation for world-class work, the Songhai Center is no stranger to challenge. Songhai's mission, overall, is to end hunger in Africa.

CyberSonghai provided the dedicated director and his staff formidable challenges:

> limited infrastructure;
> a largely illiterate population;
> revenue prospects limited initially to fees for photocopiers, business card laminating, and Christmas card production;

BOX 12.1 • HOW TO REACH THE PEOPLE

In Savalou, Benin, the "town crier" announced the opening of a new telecenter providing ICT tools for public use. The telecenter also spread the word through radio interviews, strategically placed posters, brochures, newspaper ads, and open houses for groups from different sectors and segments of society.

In Asunción, Paraguay, the openings of new public telecenters were gala affairs, accompanied by music, dancing, feasts, and the local priest, who blessed the centers.

In Kumasi, Ghana, the Queen mother of Mampong Kronko, Nana Aboagyewaa Kente, cut the tape to the new telecenter facility.

Effective outreach, using traditional methods to market new ideas, is the first step in promoting public awareness of ICT benefits.

To reach disadvantaged communities, advertising access to computers may not be the most compelling draw. Initially, what appeals may be much more basic—the photocopier, fax machine, even the telephone. Over time, other functions become popular, too: laminating business cards, designing logos, desktop publishing to produce letterhead stationery—or even greeting cards.

- staff turnover as trained technicians were lured away by the private sector in the capital city—or in Europe or the United States; and
- a target group of farmers initially unfamiliar with—and little interested in—computers.

Nevertheless, with a commitment to "turning on the lights in Africa," and with funding from USAID/Cotonou, CyberSonghai agreed to strive to achieve substantial results:

- Establish three telecenters providing Internet access and multimedia production equipment to Songhai staff, student farmers, and the general public.
- Market and provide outreach to community members and other NGOs.
- Design and deliver training courses on ICT applications for community clients.
- Design and produce multimedia products for development partners.
- Develop a business plan leading to financial sustainability.

With project funding ending in October 2001, the CyberSonghai telecenters are expected to succeed because the Songhai Center has brought the necessary elements for success to its public ICT access task:

- a firm institutional foundation;
- credibility in the community;
- effective outreach ability;
- a competent, dynamic, and visionary leader (and ICT champion) able to articulate the benefits of ICT for development;
- a willingness to change, grow, and take risks;
- upper management support and involvement in the activity;
- upper management modeling of ICT use for staff and clients;
- openness to the new patterns of communication and work flow that accompany computerization;
- interest in expansion; and
- a willingness to provide institutional support, including equipment and funds, to help ensure the activity's success.

Three Adoptions in Ghana

In Ghana, three NGOs in different parts of the country each established and assumed responsibility for operating a telecenter. Their stories illustrate lessons for public access efforts, including the importance of reaching out creatively to people and groups unfamiliar with ICT, achieving a balance between social service and commercial interests, and providing ICT training programs to build a firm client base.

Before opening their doors, Ghana's telecenters wisely undertook a comprehensive outreach program to familiarize future clients with the possibilities, potential, and relevance of ICT. For example, special days (or weeks) were set aside for women, youth, entrepreneurs, medical practitioners, local officials, and other groups to visit the telecenters. Invitations were distributed widely, and when the groups arrived, they were presented with an orientation program designed specifically for them. Local celebrities, tribal leaders, and dignitaries from a variety of fields addressed the groups and cut the ribbons, and local radio and television stations covered the events. Each group left with a specially developed "takeaway," such as a floppy diskette containing information relevant to its work, which helped to make tangible the virtual world to which they were introduced. These events were followed by the launch of a seminar program that invited people back to explore topics of special interest, such as "The Computer as a Tool for Medicine."

One of the NGOs operating a telecenter in Ghana faced a dilemma between its desire to serve its constituents—the poor—and its need to generate revenue from clients able to pay. In part, it was a moral issue for the telecenter. While its contractual obligation included achieving financial sustainability, the clients it was dedicated to serving did not have sufficient funds to pay the fees necessary for the telecenter to cover its costs. By the end of the project, the NGO managed to achieve a balance in three ways: first, by developing a sliding fee scale whereby higher-income groups subsidized lower-income groups; second, by building a popular training program for individuals and groups that generated substantial revenue; and, third, by bringing in large blocks of income through outside contracts. For example, through a British Council-sponsored program, the telecenter was paid to provide computer training to groups of secondary school students. In this way, the telecenter could bring in sufficient revenue without having to rely exclusively on individual fees from low-income users to support its operations.

One of the greatest strengths of the LearnLink-launched telecenters in Ghana is their focus on training. From a modest beginning, the telecenters became a significant skill-building force nationwide, supplementing and extending learning opportunities beyond those available in both public and private educational institutes, and providing more practical, hands-on training than some technical universities. In just two years, the training program not only provided more than 10,000 individuals—students, teachers, business people, even staff from the national telecom—with useful ICT skills, but it also contributed to the financial sustainability of the telecenters, which have relied on client fees to operate since external funding ended. Moreover, when the centers first launched, clients required assistance for even the most basic functions. Due to effective marketing of the training program, 77% of telecenter users registered for training classes. As clients developed their own skills, staff were freed to attend to other functions.

A Municipal Model in Asunción

The vision was good: The Municipality of Asunción would provide less-advantaged communities in the city with the benefits of ICT for civic development purposes. People no longer would have to travel downtown and stand in long lines to register to vote, obtain licenses, or access databases of government information. Instead, they could do it all at neighborhood-based municipal centers. The telecenters would help devolve official functions to the neighborhood level, the public would be better informed and more engaged in democratic processes, and citizens in poor communities would be provided with access to improved communication facilities and opportunities for civic education and lifelong learning. According to Sergio Aranda, LearnLink resident advisor, "it became clear that...this project needed to be looked at in terms of social demand. It needed to be tied into the daily lives of the residents."

Considering every person and group in town a potential partner, the local director of the municipal telecenter activity forged alliances with the potential to contribute greatly to its long-term sustainability:

- In return for displaying marketing materials in the telecenters, the local Internet service provider gave them free Internet connectivity.
- In exchange for free e-mails, Peace Corps volunteers provided free administrative assistance.
- For use of the IT equipment, Catholic University instructors trained telecenter staff in facilitation skills.
- College students designed Web pages for the municipality in exchange for discounted online time at the telecenters.
- Police and prison officials, who used the telecenters to learn computer skills, provided security.
- The mayor, an enthusiastic supporter, participated in teleconferences with local residents, attended telecenter launch celebrations, and found scarce municipal funds to help cover maintenance costs.

Informal contributions were elicited, too, with enthusiasm. Just for the chance to have a telecenter in its neighborhood, a local association of bricklayers, masons, and carpenters built the center, literally and voluntarily, from the ground up.

A Commercial Model: PC3s in Bulgaria

Nearly half of all Bulgarians live in small towns not yet reached by the economic progress underway in urban areas. The farther a community is from one of Bulgaria's five largest cities, the greater is the gap in economic development.

This also holds true for access to ICT. While multiple Internet service providers (ISPs) compete with one another in urban centers, few operate in small towns and rural areas. Where Internet access is available, the average prices for service are almost twice as high as in the cities.

In Bulgaria's cities, ICT is helping to drive development by:

- stimulating economic competitiveness;
- catalyzing spin-off businesses;
- creating a platform for e-commerce;
- contributing to higher levels of employment;
- increasing education and training opportunities;
- improving communication; and
- facilitating the provision of government and social services for city dwellers.

Lacking infrastructure and access to ICT, small towns and rural areas are in danger of falling even further behind than they already are. To meet IT access needs in these areas, a Public Computer and Communication Center (PC3) program is underway to create viable telecenter businesses that combine for-profit and public good services within a sound business plan.

Essential elements of the business plan include:

- launching PC3s with local entrepreneurs;
- distributing prepaid computer access cards, redeemable for PC3 services, to groups throughout Bulgaria to stimulate use and reduce risk for operators;
- developing local language resources on social and economic development for clients;
- providing hardware, technical assistance, training, and Internet connectivity subsidies to operators;
- promoting spin-off businesses, such as the sale of peripherals, desktop publishing, and equipment repair; and
- providing local businesses with e-commerce assistance.

FACING FISCAL SUSTAINABILITY

Telecenters providing affordable IT access, training for disadvantaged communities, and access to resources and information for social development face fiscal sustainability issues.

Global telecenter experience indicates useful approaches for achieving sustainability. As demonstrated in the examples above, these include:

- creative marketing to diverse groups to increase client use of ICT;
- sliding fee scales to enable access by low-income groups;
- subsidizing ICT use, at least initially, to create demand;
- offering training programs to create client capacity;
- launching creative alliances with public, private, and voluntary sector partners for inputs; and
- working with the private sector to launch ancillary, spin-off businesses and engage in e-commerce.

THE GENDER DIVIDE

On the surface, there is no traditional, preconceived resistance to women using computers. Yet, research indicates that many factors mitigate against equitable access to ICT for women, and experience suggests that, even where access is available, the more sophisticated the technical task, the more men tend to dominate. In training courses, for example, women tend to enroll in word processing classes while men are more likely to take an introductory course in using the Internet.

Experience also indicates that gender equity in the use of ICT will be achieved more easily with specific interventions, beginning with outreach and social marketing, that demonstrate how higher-order ICT processes can benefit women.

Beyond that, larger issues related to "income, time, literacy, education, language, and culture affect access to facilities, training, and employment in the IT area." Despite frequent claims to the contrary, information technology is not gender neutral.[2]

ACCESS WORKS

A telecenter volunteer in Ghana writes: "My life has completely changed from an unknown to a known world." Ms. Awuah, a volunteer at a telecenter in Kumasi, echoes the sentiments of many of the staff and patrons of the three telecenters established in Ghana through the LearnLink project.

Though marketing still is needed to reach disadvantaged groups, there is growing demand for ICT access, training, and use among all sectors of society. Experience indicates that, among low-income people, disadvantaged populations, ethnic minorities, and rural and remote communities, there is growing awareness that ICT provides new opportunities—and new hope for breaking the cycle of poverty.

In Ghana, for example, overall use at the three telecenters exceeded 10,000 over the duration of the pilot project, and 2,500 of these users were women. In Asunción, more than 3,000 people used the eight telecenters operating in 1999, and a year later, 360 children were visiting one telecenter each week after school to explore the science and geography CD-ROMs there. In Benin, hundreds of people each week are using Internet services at the telecenters in Porto Novo, Savalou, and Parakou, including students and teachers from secondary schools and colleges, NGO staff members, business people, co-op members and village groups, farmers, and individuals from all walks of life.

ENDNOTES

[1] This review of community telecenters is based on five years of experience with the LearnLink project, a "Global Communications and Learning Systems" program. LearnLink is an Indefinite Quantities Contract (No. HNE-I-00-96-00018-00) of the U.S. Agency for International Development (USAID). It is funded by the Human Capacity Development Center in the USAID Global Bureau and other USAID Bureaus, offices, and missions. LearnLink is implemented by the Academy for Educational Development.

[2] Hafkin, N., & Taggart, N. (June 2001). *Gender, Information Technology, and Developing Countries*. The LearnLink Project. Washington: Academy for Educational Development.

13

OPEN UNIVERSITIES: A REVOLUTION IN LIFELONG LEARNING

Robert Savukinas
Gregg Jackson
Xiao Caiwei

Learning can no longer be viewed as a ritual that one engages in during only the early part of one's life.

—UNESCO[1]

ANYTIME, ANYWHERE

During the second half of the 20th century, "open universities" have revolutionized lifelong learning in many countries. These institutions were inspired by democratization, growing demands for tertiary education, technological developments well suited to mass education, and the human resource needs of modernizing societies.[2]

At most open universities, a substantial portion of the students are seeking regular university degrees, and another significant portion are engaged in lifelong learning, advancing their knowledge and skills for occupational, family, and personal purposes. Open universities generally are distinguished from traditional universities in at least three ways:

> They are *open* to a broad segment of the population; usually serving those from social groups that previously had not access to higher education and sometimes admitting students regardless of their prior educational credentials.
> They are *open* in the courses they offer, usually including traditional college courses, career-development courses, and personal growth courses.
> They are *open* to different times and places of study; sometimes the time and place is determined entirely by the student.[3]

Open universities have based their instruction on self-study printed materials, often called "correspondence materials" because they are sent through the mail system. They include texts, study guides, and workbooks. These printed materials often are supplemented with small laboratory kits for science courses, periodic face-to-face instruction in geographically dispersed study centers, and some course delivery and instructor-student communication through telecommunications technologies—radio, telephone, television, and video.[4] The Internet and the World Wide Web are being adopted by some for instructional and promotional purposes, but access by these means is still impossible for most citizens in developing countries.

Open universities have been a great success, by several indicators, in most countries where they have been established. More than a dozen have total enrollments in excess of 100,000 students, and their costs are generally one-half to one-third those of the traditional universities in the same country. In addition, several have evidence of high-quality instruction.[5]

EXAMPLES OF OPEN UNIVERSITIES

The following are examples of the lifelong education programs provided by open universities. The information is taken from Sir John Daniel's *Mega Universities & Knowledge Media* and Keith Harry's *Higher Education through Open and Distance Learning*, unless otherwise indicated.[6]

China TV University

China TV University is the largest university in the world, with a total enrollment of 850,000 in 1994. The system includes a central unit that develops and produces course materials, 44 provincial units that also develop and produce such materials, 1,550 Education Centers at the county or company level, and 30,000 tutorial groups. The Education Centers have pressured the system to provide more job training, courses of local interest, and continuing education. Although China TV University serves mostly urban residents, there are plans to broadcast some of its programs more widely, and 20 million farmers reportedly already have received "intermediate education of a practical interest" through an associated unit. (For more information about China TV University, see *http://www.crtvu.edu.cn.*)

Indira Gandhi National Open University

India has the second-largest higher education system in the world. By 1980, 20 Indian universities offered correspondence courses, but most were considered to be of low quality. Indira Gandhi University was established to provide high-quality distance education and coordinate standards for tertiary distance education throughout India. From the beginning, it was planned that only one-third of the students would be in degree programs, and the rest would be in shorter programs directly related to employment. The programs of study include computer education, nursing, agriculture, food and nutrition, creative writing, and child care. The university has been able to secure only 90 minutes of nationally broadcast television each week and no radio coverage, so instruction is mostly by printed materials and required periodic attendance in 229 study centers located primarily in urban areas. Despite those

This chapter is adapted from an article by **Robert Savukinas**, a doctoral student in the Higher Education Administration program at The George Washington University (GWU), and **Gregg Jackson, Ph.D**, Professor and Coordinator of the Education Policy Program at GWU. The section on China's UTA is an adaptation of another article by **Xiao Caiwei**, Director, International Department, China National Committee on Aging. Both articles appeared in *TechKnowLogia*, September/October 2000 *(www.TechKnowLogia.org)*. Used by permission.

constraints, and competition from seven other state open universities, Indira Gandhi University had 162,540 registered students 1998. In the late 1990s, the University began establishing high-capacity telecommunications links with 16 regional centers and, later, some of the study centers. Satellite communications systems are also in use now. (For more information about Indira Gandhi University, see *http://www.ignou.org/index.htm.*)

Sukhothai Thammanthirat Open University

Sukhothai Thammanthirat Open University (Thailand) is committed to lifelong education, expansion of educational opportunities for secondary school graduates, and personnel development. It provides academic degree programs, short training programs, and individual courses. About 300,000 students are enrolled in the nondegree programs, and three-fourths of the students are from rural areas. The university combines printed materials with 1,100 30-minute television broadcasts annually and 150 20-minute radio programs each week. It also makes extensive use of physical facilities scattered throughout the country. It operates 87 Regional and Provincial Study Centers for the orientation of new students, tutorials, and examinations. It has Special Study Centers in government agencies, such as hospitals, regional agricultural offices, and government offices that have laboratory and other facilities needed for the study. It also has eighty Corners located in provincial libraries that provide library and education media support for students. Telephone communication between students and instructors is common. The University hopes to expand its services with cable television and satellite television broadcasts accompanied by two-way audio links. (For more information about Sukhothai Thammanthirat Open University, see *www.stou.ac.th/eng.*)

Universidad Nacional Abierta

Universidad Nacional Abierta (Venezuela), Venezuela's answer to the rising social demand for higher education and the scarcity of study opportunities for adults, focuses on providing high-quality education and serving working individuals. It also attempts to spur innovation in individualized and self-directed learning. The programs are organized into five sections: Introductory Courses, General Studies, Professional Studies, Postgraduate Studies, and Continuing Education. The goal of the continuing education section is to elevate the level of knowledge of the general population in specific disciplines of science, technology, and culture. Instruction is by printed correspondence materials, audiovisual media, and face-to-face instruction at 21 regional study centers. (For more information about Universidad Nacional Abierta, see *www.una.edu.ve.*)

University of South Africa

The University of South Africa has been open to all races since before and throughout the apartheid era. In 1995, it had 130,000 students, 47% of whom are black and 40% are white. More than 80% are employed, and the average age is 31. Almost a third of the students are schoolteachers. Applicants who have not completed high school are admitted conditionally and are restricted in the number of courses that they can take during the first year. There are more than 2,000 course modules; most are developed by individual instructors, but some courses are being developed by teams. Instruction is primarily by texts and printed study guides, sometimes supplemented by audiocassettes and some radio broadcasts. Instructors and students communicate by mail and telephone. The limited numbers of face-to-face tutorials, staffed by part-timers, are being expanded. The University of South Africa's most famous graduate is Nelson Mandela, who studied while jailed. (For more information about University of South Africa, see *www.unisa.ac.za.*)

CHINA'S UNIVERSITY OF THE THIRD AGE

With the increase of the elderly population and the compulsory retirement system in the last two decades, China has been facing a big challenge in meeting the needs of the elderly in learning. Various forms of education and learning programs have been developed for seniors all over the country, and the University of the Third Age (UTA) has been the most successful program in promoting lifelong learning in that country. However, existing UTAs can hardly meet the increasing demand, so the use of new technology, such as remote teaching and the Internet, has been explored to make learning accessible to more elderly.

The Development of UTAs in China

The first UTA in China was established in Shangdong Province in 1983. Since then, the UTA concept has been accepted widely, and UTAs have spread throughout China. Statistics show that the number of UTAs in China had reached 16,676 by the end of 1999, and more than 1.38 million seniors were studying at them.

The programs for lifelong learning, especially the development of UTAs, have been supported and encouraged by the Chinese government. The Law of the People's Republic of China on Protection of the Legal Rights and Interests of the Elderly, passed by the Chinese National People's Congress in 1996, stipulates that the elderly have the right to continuing education, and the State will develop education of the elderly and encourage the establishment and operation of various kinds of UTAs. In 1994, 10 of the ministries of the Chinese central government jointly worked out the National Seven Year Development Plan of the Work on Aging, which mobilizes and requires local governments to devise a development plan to educate the elderly.

To promote the development of UTAs in China, the China Association of Universities for the Aged (CAUA), a network organization, was established in 1988. It now has 207 member UTAs. CAUA publishes a magazine on lifelong learning, which provides guidance to Chinese UTAs, and it has set up a research group on the development of textbooks for UTAs.

Most of the UTAs are established, financed, and operated by government, but some are set up by the private sector. For instance, of the 207 members of CAUA, 26 were established by the private sector. Some of the privately operated UTAs also receive financial assistance from the government. Normally, a UTA is different and separate from an ordinary university: it has its own classrooms, and the courses offered are designed with the interests and demands of the senior students in mind. Popular courses include calligraphy, painting, literature, cooking, gardening, health care, music, dancing, and computers. In rural areas, the courses primarily teach the technology needed in agriculture.

The Use of New Technology

In 1998, a TV UTA was opened in Zhe Jiang Province with the joint efforts of the Committee on Aging, the Personnel Department, the Trade Union, the Financial Department, the Labor Department, and the Administrative Department on Radio and TV of Zhe Jiang Province. Zhe Jiang TV UTA has more than 10 courses, including medicine, health care, calligraphy, painting, literature, history, psychology, and science and technology. In addition, courses may be added or adjusted according to the interests and demands of the elderly. The TV UTA program is offered from 8:30 to 9:20 A.M. every Friday; there are two classes of 25 minutes each. The same TV UTA program is rebroadcast every Saturday. The examination is conducted in the form of a written test or by discussion among the students. Students receive diplomas after they have completed eight courses. Zhe Jiang TV UTA has branches in 22 cities and counties in the province where the elderly can register.

With the development of the Internet, Shanghai TV UTA opened an online UTA in 1999 in cooperation with the Shanghai TV Station. Although it is the only online UTA in China, and most elderly people do not have access to the Internet, it represents the new development trend. This new technology is expected to make lifelong learning more easily accessible to the elderly. (For more on Shanghai online UTA, see *www.ol.com.cn* or *www.shtvu.edu.cn*.)

THE FUTURE: PROMISE AND PITFALLS

As a result of population growth and modernization, the need for accessible lifelong formal education is swelling worldwide. Open universities have several advantages in meeting these needs.

- They have a broader reach through their respective countries than any other institution of higher education.
- Many of their degree courses can serve double duty as lifelong learning for adults who have not earned a university degree, and as a way to broaden or update expertise for those who have such a degree.
- By the very fact that they are universities, they convey status to the students, including those who are not engaged in degree programs. It has been noted that adult formal education is often undertaken partly to gain self-esteem and impress others.[7]
- Open universities' costs are generally modest for the level and quality of training provided.

What will the future bring? The following are three scenarios by which spreading computer and telecommunications technologies may affect open universities and their lifelong learners. None of them is assured, but all are possible.

- *Scenario 1:* Open universities' growing use of telecommunications networks to deliver course content and communicate with students improves the quality and timeliness of the instruction. The instruction will be more graphic, engaging, up-to-date, and interactive, and open universities will thrive. Popular sentiment will require continuing print materials for those without access to telephone systems, but those materials will suffer from neglect, and the digital divide will widen temporarily. Then, probably before 2010, satellite wireless Web and US$200 solar-powered downlink/uplink computers will bring access to the remotest villages of developing countries. Each will have at least one shared station. Open universities will use the graphics and audio capabilities of the Web to create courses for those without literacy skills.
- *Scenario 2:* Open universities will put some of their courses, particularly those aimed at professionals, on the World Wide Web. Citizens in one country occasionally will enroll in a course from another country. Initially, differing languages will limit their options, but within a decade, automatic translators probably will overcome that barrier. This will be a boon for individual learners, enhance knowledge transfer between countries, and foster international understanding. It will also be an opportunity for enterprising open universities to expand their services and earn foreign revenues, as the UK Open University is attempting to do with its entry into

European and U.S. markets. Conversely, it might mean the death of some open universities that fail to compete successfully for students.

> *Scenario 3:* Artificial intelligence will be used to create computerized adaptive tutors that optimize instruction for each individual learner, taking into account his or her interests, learning styles, prior knowledge, and progress through the course content. These tutors could enhance the progress of nontraditional learners and those with learning disabilities, while simultaneously reducing the costs of instruction.

Open universities probably will go down in the history books as one of the most important educational innovations of the 20th century. They have provided unprecedented access to a broad range of degree programs and lifelong learning opportunities; they have instilled hope and made it a reality; they have helped to preserve national cultures and introduced progress; and they have become popular national resources.

In all likelihood, rapidly spreading ICTs will expand open universities' capabilities further to provide lifelong learning opportunities,[8] except for those institutions that may be undermined by the technology.

ENDNOTES

1 UNESCO (December 20, 1999). Learning without Frontiers. Available at: *www.unesco.org/education/lwf.*

2 Harry, K. (1999). *Higher Education through Open and Distance Learning.* London: Routledge.

3 Jenkins, J. (1993). Distance Education for Small Countries. In K.M. (ed.). *Policy, Planning and Management of Education in Small States.* Paris: UNESCO. Available at: *www.worldbank.org.*

4 Daniel, J.S. (1999). *Mega-Universities & Knowledge Media.* London: Kogan Page Limited.

5 Ibid.

6 Harry, op cit.; Daniel, op cit.

7 Tough, A. (1979). *The Adult's Learning Projects.* Toronto: Ontario Institute for Studies in Education.

8 Lockwood, F. (ed.) (1995). *Open and Distance Learning Today.* London: Routledge.

14

VIRTUAL UNIVERSITIES: CHALLENGING THE CONVENTIONS OF EDUCATION

Ryan Watkins
Michael Corry

INTRODUCTION

In recent decades, educational institutions have benefited from the application of the conventional models of instruction and institutional structure that were derived from nearly a century of industrial growth. And while these models were quite useful in the rather stable educational environment that dominated most of the 20th century, the marketplace for education is changing rapidly with the development of information technologies, demand for knowledge workers, and expanding globalization of all sectors (private and public). Leaders of educational institutions increasingly are being held accountable for supporting the growth and long-term success of dynamic learners (i.e., students and employees). Learners today bring rapidly changing requirements to the *learning environment*, and the role of universities in our society is changing equally quickly. Meeting these demands will require not only a new perspective on education, but a new set of tools for institutional leaders as well.

Virtual universities provide a unique function for today's educational leaders around the world. These cutting-edge universities commonly offer glimpses into the possible future of higher education, while at the same time paving the way (in terms of both policy and implementation) for other universities and colleges. The struggles of today's virtual universities will provide the foundation for institutional (and government) leaders in the future as they weigh the financial and academic options of distance education.

Like Jurich[1], who uses distance education to indicate institutions that have as their primary activity provision of education at a distance, regardless of size and technology preference employed, we will apply the equivalent definition to the virtual university. This definition of the v*irtual university* incorporates a variety of institutions that may be classified as mega-universities[2], open universities, and dual-mode universities[3], and whose primary programs are at a distance, as well as those that may be referred to commonly as virtual universities.

In this chapter we survey the modes of instructional delivery and administrative structures of several virtual universities.[4] We identify primary characteristics of the distance education programs offered by these unique institutions and those characteristics that may be practical in providing useful educational results through nonconventional educational programs. This review is not intended to provide a complete picture of the current and possible structural models for distance education, however. Rather, by briefly examining essential characteristics from a sample of today's virtual universities, we intend to synthesize for institutional leaders an appraisal of options available when considering information and communication technology (ICT)-supported instruction.[5] By doing so, this chapter can be used by a variety of decision makers who otherwise may only be familiar with a small number of delivery and administrative options for providing nonconventional educational opportunities.

USEFUL DISTANCE EDUCATION AND THE VIRTUAL UNIVERSITY

Distance education has evolved over time from correspondence courses, to educational radio, to educational television, one and two-way teleconferencing, and videoconferencing, to computer assisted/Web-based interactive learning opportunities.[6] Yet, with all the technological changes that have evolved in distance education, there have been few changes in the rationale for virtual universities. The virtual university is intended to offer useful learning opportunities to people at times and locations that are convenient to them.[7] And in recent decades these institutions have been very successful at finding alternative media for providing learners at times and locations that are more convenient than those offered by conventional educational opportunities. Unfortunately, the value and usefulness of these delivery opportunities have come into play rarely in the unfolding of this evolution. A great deal has been written about the technologies that allow organizations to offer educational opportunities at a time and place convenient to the learner. Yet, the usefulness of those opportunities (i.e., the value-added for learners and their constituent partners, including employers and communities) has been questioned or improved only rarely.[8]

How Is "Usefulness" Defined?

Useful distance education provides a measurable value-added toward achieving the results defined by the ideal vision (i.e., the kind of world we want to create for our children) of a society, the mission objective of an organization, and the objectives of an individual.[9] Virtual university programs that can align and link achievement of results at all three of these levels will be successful. Through linking the success of the learner in the classroom with meeting graduation requirements that lead to future employment, and linking both with continuing positive contributions to the shared community, virtual university programs can align themselves with accomplishment of results that add value for the learner, the institution, and the community.

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Usefulness, when defined by results at these three levels, becomes the focus of organizational strategic planning and needs assessment activities.[10] Accompanying each level of measurable value-added is a level of planning and results (see Table 14.1), and the alignment of these three levels of results is essential for continuing success.

Usefulness a Key to Success

Kaufman and Watkins[11] suggest that offering "useful learning opportunities" is the key to the future success of educational institutions, particularly virtual institutions.[12] Many educational institutions around the world will offer distance education in the future. Some will use the Internet, others will use satellites, and still others will use technologies we can only dream of today. But those that will make a valuable contribution to learners and society will be those that focus on offering "useful learning opportunities." After all, does it really add any value to an organization (or a learner) to provide educational opportunities at a convenient (to them) time and location if the opportunity provides little or no value in terms of assisting them, their organizations, and/or our communities in achieving defined and useful goals?

Providing "useful" opportunities, we contend, has always been the intention of the virtual university. From the beginning of correspondence courses during the first half of the 19th century to the modern virtual university, providing students with useful knowledge, skills, attitudes, and abilities is the purpose of successful educational programs. The manner in which they have met the goal or objective[13] has changed many times over the years, but the goal itself has not changed.

Many institutions are offering high-tech distance education, yet few have focused comparable resources on the basic elements of sound instructional and performance system design (e.g., needs assessment, strategic planning, needs analysis, performance requirements analysis, performance objectives, systematic instructional development, formative evaluation based on performance, continuous improvement). These oversights in instructional design have brought most distance education programs to a point where technology expenditures are exploding, university presidents and boards of trustees are pressing for more effective and efficient institutions, interest from learners in available opportunities is rising, and little progress has been made to validate the value-added of many virtual university initiatives. It is no wonder that so many institutions do little in the way of long-term evaluations; measurable results and useful contributions are not likely to come from placing mediocre education programs on the Internet. Learning, after all, is influenced more by the content and instructional strategies in a medium than by the type of medium itself.[14]

We do not wish to suggest that useful results can (or should) be achieved mainly without the use of new technologies. On the contrary, it is the new technologies that likely will allow organizations and individuals to achieve the required results efficiently and effectively. But applying the technologies without a focus, an intended design and development, and continuous improvement toward the achievement of defined results will not lead to the success that organizations are seeking for the future.

TABLE 14.1 • THE LEVELS OF MEASURABLE VALUE-ADDED

LEVEL OF PLANNING	PRIMARY CLIENT AND BENEFICIARY*	DEFINING STATEMENT	RESULTS	EXAMPLES
Mega	Society	Ideal vision	Outcomes	Learners are self-sufficient, self-reliant, and contributing members of the community.
Macro	Organization	Mission objective	Outputs	Graduates master the required skills and knowledge for future employment security.
Micro	Individual/ small group	Individual's objectives	Products	Learners master the required skills and knowledge to prepare them for continuing their education.

SOURCES: Kaufman, R., & Watkins, R. (2000). Assuring the Future of Distance Learning. *The Quarterly Review of Distance Education*, 1 (1): 59-67; Kaufman, R., Watkins, R., & Guerra, I. (2001). The Future of Distance Education: Defining and Sustaining Useful Results. *Educational Technology*, 41 (3): 19-26.
* It is understood that the listed primary client always incorporates the clients at the lower levels.

SURVEY OF VIRTUAL UNIVERSITIES

In this section, we examine the essential characteristics of an array of institutions as a basis for comparison with the institutional models being applied internationally. Each of the selected virtual universities has distinctive and exemplary characteristics that offer educational leaders insights into the development of effective and efficient models for distance education.

Peru's Higher Technological Institute (TECSUP)

Peru's Higher Technological Institute (TECSUP) is a dual-mode institution that uses both conventional campuses, in Lima and Arequipa, and a virtual campus that was introduced in 1999. As of 2000, more than 1,600 learners were enrolled in a variety of distance education courses, primarily technical training. According to Wolff and Garcia, learners can access the TECSUP virtual campus through TECSUP conventional campus locations, their workplace, home, or public Internet kiosks. Courses are generally seven weeks and include online content, self-evaluations, and discussions with the instructor and others students.[15] (For more information, visit *http://www.tecsup.edu.pe*.)

The African Virtual University (AVU)

The African Virtual University (AVU) is a single-mode institution that operates without a conventional campus, but uses the facilities of conventional universities in 22 sub-Saharan African universities in 15 countries to provide learners with facilities to access technology delivery systems.[16] Started in 1997, the AVU supports learners across the continent through videotaped instruction and/or live broadcast (via satellite or fiber optic connections), with learners participating in the discussion by way of e-mail, telephone, or fax. Additional reference materials such as books, journals, and course notes are also available for learners. Courses currently offered by the AVU focus primarily on training and certificate programs, with more than 23,000 learners having completed at least one semester-long course. Though current fees per course are still out of reach of many Africans, they generally are much less than those of competitive programs offered by other international universities. (For more information, visit *http://www.avu.org*.)

The University of the Highlands and Islands (UHI)

Serving a dispersed and rural population in Scotland, the University of the Highlands and Islands (UHI) provides a diverse collage of thematic multidisciplinary learning opportunities for both degree-seeking and nondegree-seeking learners. Like many single-mode institutions, UHI uses 50 local learning centers to provide regional support to learners. Using instructional readings, local classroom instruction, informal tutors, videoconferencing, self-paced computerized instruction, and other media, UHI offers courses that, like most professional development training, focus more on "building individual competencies than the transfer of knowledge."[17] UHI courses are developed in consultation with employers and are tailored specifically to the needs of the Highlands and Islands. They cover a range of subjects focusing on the region's principal industries and businesses, including fisheries, land management, forestry, marine ecology, and tourism. (For more information, visit *http://www.uhi.ac.uk*.)

The Virtual University of the Technological Institute of Monterrey (ITESM)

The Virtual University of the Technological Institute of Monterrey (ITESM), Mexico, is the primary provider of distance education in Mexico and many other areas of Latin America. ITESM is a dual-mode institution that offers mainly master's degree-level programs through its virtual campus.[18] Using primarily satellite technology, ITESM provides courses to more than 1,300 reception sites throughout Mexico and Latin America. In addition, ITESM offers a franchised[19] master' program in educational technology with the University of British Columbia. (For more information, visit *http://www.itesm.mx*.)

The University of Phoenix (UP)

One of the few private for-profit universities to offer distance education internationally, the University of Phoenix (UP) operates a variety of small campus facilities throughout the United States and an online virtual campus. For the majority of learners, the online campus provides a variety of resources to support their classroom sessions.[20] In addition, the UP offers courses that are conducted completely through the virtual campus. In addition, the UP offers nonfranchised international programs to learners around the world through online courses.[21] Currently enrolling more than 80,000 working adult students, the UP completion rate averages approximately 60% across all programs. (For more information, visit *http://www.phoenix.edu*.)

The Open University of Hong Kong (OUHK)

Previously known as the Open Learning Institute of Hong Kong, the Open University of Hong Kong (OUHK) offers a variety of degree and certificate programs in the arts and social sciences, business and administration, education and language, and science and technology.[22] Currently the university offers more than 100 postgraduate, degree, and sub-degree programs to more than 25,000 enrolled learners. The OUHK uses a flexible credit system under which learners earn credits for each course, which accumulate toward a degree. Similar to other open universities—specifically, the

United Kingdom Open University—the OUHK provides course-related materials to distance learners through a variety of instructional media, including text, videotape, and some broadcast television. Additionally, learners are required to attend tutoring sessions at local study centers periodically during each course. (For more information, visit *http://www.ouhk.edu.hk*.)

Nova Southeastern University (NSU)

Like the University of Phoenix, Nova Southeastern University (NSU) offers international programs to learners around the world. NSU is private, not-for-profit university that has students at its conventional campus and learners taking courses offered at a distance. NSU currently enrolls more than 18,000 learners. Many programs at NSU provide dual-mode educational opportunities to students who meet both in person and online. Providing online programs all the way to the doctorate level, NSU's virtual campus supports online learners with an extensive virtual library. (For more information, visit *http://www.nova.edu*.)

The Center for Open Distance Education for Civil Society (CODECS)

The Center for Open Distance Education for Civil Society (CODECS) now offers educational opportunities to learners throughout Romania.[23] In cooperation with the United Kingdom Open University (UKOU), CODECS operates 12 regional centers that offer tutorial support for learners using UKOU instructional materials (including videotapes, instructional texts, course software, etc.). Certificates, diplomas, and degrees attained through CODECS-offered courses are recognized internationally through the UKOU. The CODECS model for institutional structure is a primary example of franchised international distance education. (For more information, visit *http://www.open.ac.uk/collaborate/romania.htm*.)

SYNTHESIS

As is evident from the above survey, the options available for delivery of distance education are expansive. While relatively few institutions provide educational opportunities solely at a distance (like Peru's Higher Technological Institute), most have chosen a dual-mode structure that provides learners with at least some interaction with instructors or tutors. Some institutions, like the University of Phoenix, own or lease their facilities for local learners, while others sign cooperative agreements with local institutions, each ideally designed and built around providing useful skills and knowledge to learners, thereby creating a diverse array of institutional structures.

Similarly, the variety of delivery media used by virtual universities is equally as extensive as their institutional structures. From text-based courses in the mail to satellite transmissions, delivery of distance education can be structured to meet the requirements of the learner while maintaining a financially feasible model for the institution. Choosing the right delivery system is a decision that should not be made outside of the educational context, however. Depending on the needs of the learners and the desired results of the institution and community, selection of the delivery media may even vary across programs within a single institution (like those at Nova Southeastern University).

Additionally, the offerings of virtual universities are growing dramatically. While traditionally focused on professional programs (e.g., teacher education, business, agriculture, etc.), they are venturing now into offering academic programs in the arts and humanities. This diversification of programs corresponds to an increase in the number of degree programs offered at a distance. For example, the Virtual University of the Technological Institute of Monterrey (ITESM) now offers 29, primarily master's-level, degree programs through its virtual campus.

CONCLUSION

There are many educational technologies and institutional structures that can assist in developing successful distance education initiatives. Through dual-mode, as well as single-mode, institutions, learners around the world have more options than ever for achieving laudable objectives through education. Access to these opportunities is, however, only one of the essential components of an educational system focused on the long-term success of learners. The quality and utility of content cannot be an afterthought in the distribution of educational opportunities. Useful educational results are the product of integrated strategic planning, pragmatic needs assessment, instructional design, media development, and systematic continuous improvement.[24]

Individuals and institutions are often eager to consider the many options related to delivery of instructional content. However, before making those decisions, several questions that are essential to the long-term success of any distance education initiative should be considered: Is planning focused on processes or results? Is it focused on value-added for the individual, the organization, and society at large? Is planning driven by media and content delivery, or by the program's usefulness to the learners and their community? Are needs defined as gaps between the current situation and required resources or desired results? Are needs (ideally, gaps in results) formally or informally identified and prioritized? Are the courses/programs linked to internal administration or external usefulness? Does a formal, clear, and common goal link courses/programs with other learning opportunities?[25]

ENDNOTES

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[4] The survey of virtual universities for this chapter was drawn primarily from a series of international case studies published in *TechKnowLogia* (*www.TechKnowLogia.org*). Additional references and resources are identified throughout the chapter.

[5] It should be noted that the authors use the terms ICT-supported instruction, distance education, and the virtual university throughout this chapter. These terms, each having a variety of academic and operation definitions, are used by the authors to describe educational events and institutions whose primary mission is to provide opportunities to students at a place and time convenient to them.

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[7] Kaufman, R., & Watkins, R. (2000). Assuring the Future of Distance Learning. *The Quarterly Review of Distance Education,* 1 (1): 59-67.

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[9] Kaufman, R. (1998). *Strategic Thinking: A Guide to Identifying and Solving Problems* (Revised). Arlington, VA & Washington: American Society for Training & Development and the International Society for Performance Improvement; Kaufman, R. (2000). *Mega Planning.* Thousand Oaks, CA: Sage Publications; Kaufman, R., Watkins, R., & Leigh, D. (2001). *Useful Educational Results: Defining, Prioritizing and Achieving.* Lancaster, PA: Proactive Publishing.

[10] This is also a major focus for the dramatic educational change recommendations by Harless, 1998.

[11] Kaufman & Watkins, op cit.

[12] See also Kaufman, Watkins, & Guerra, op cit.

[13] We define "goal" as a purpose statement measurable on a nominal or ordinal scale and "objective" as a purpose statement measurable on an interval or ratio scale. (Kaufman, 1972, 2000). The more rigorous we can be in our statement of purpose, the greater the likelihood of designing subsystems and methods that will add value.

[14] Clark, R.E., & Salomon, G. (1986). Media in Teaching. In Wittrock, M. (ed.). *Handbook of Research on Teaching,* 3rd edition. New York: Macmillan.

[15] Wolff, L., & Garcia, N. (January/February 2001). Higher Education and Enterprise Training in Latin America: The Case of the Virtual Campus of Peru's Higher Technological Institute. Available at: *www.TechKnowLogia.org.*

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[18] Wolff, L. (200)). Mexico: The Virtual University of the Technological Institute of Monterrey. *TechKnowLogia,* 2 (1): 32-33. Available at: *www.TechKnowLogia.org*.

[19] A franchise is a granted right to use someone else's materials and services in a specific territory.

[20] Jackson, G. (2000). A New Model for Tertiary Education in Developing Countries? *TechKnowLogia,* 2 (1): 34-37. Available at: *www.TechKnowLogia.org*.

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[23] Ionescu, A. (2000). CODECS Brings the Open University to Romania. *TechKnowLogia,* 2 (1): 68-69. Available at: *www.TechKnowLogia.org.*

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15

TEACHER TRAINING WITH TECHNOLOGY: NOTES FROM THE FIELD

Mary Fontaine

- Guatemala
- Morocco
- Namibia
- Uganda
- Brazil

This chapter[1] summarizes computer-mediated professional development activities in five countries. These activities illustrate the kinds of applications of information and communication technologies (ICTs) that can enhance pre- and inservice teacher training and provide valuable and ongoing professional development opportunities for educators.

GUATEMALA

Home to 22 indigenous Mayan cultures, Guatemala is multiethnic, multicultural, and multilingual, with nearly 40% of children starting school without a productive knowledge of Spanish. Yet, only 12% of schools are bilingual. This linguistic and cultural mismatch is particularly pronounced in certain provinces, or "departments," as they are known in Guatemala, like Quiché, where 95% of the population is Mayan.

Typically, teachers working in areas with large indigenous populations possess limited local language skills—many speak the language but can neither read nor write it—and are essentially ill-prepared to teach Mayan children in their own tongue. Opportunities for training are also inadequate, particularly in bilingual education and intercultural understanding.

To help bridge the gap between home and school, Guatemala's teacher training institutions need to strengthen instruction in Mayan language literacy and cultural concepts, first and second language learning and bilingual pedagogy, multigrade teaching methods, and cultural sensitivity. Focusing on the Department of Quiché, an area severely affected by decades of armed conflict, an innovative teacher training program was designed to meet these needs. The program includes the following components:

> Culturally appropriate Mayan language instructional support materials. Drawing on local wisdom and community groups, program staff have developed and digitized a set of K'iche' and Ixil Mayan language materials for teacher training and student learning. The result is culturally appropriate and linguistically relevant teacher guides, instructional units, workbooks, and manuals for classroom use. An illustrated bilingual audio dictionary on CD-ROM, produced by teachers and students, enables both to expand vocabulary and cultural concepts. Visual images—art, really—resonate with rich local tradition, and an audio track ensures proper pronunciation.

> Teachers' professional skills and proficiency in oral and written Mayan languages. The program has purchased equipment and installed multimedia computer labs in four teacher training schools *(escuelas normales)* in the region. In the labs, training materials for bilingual teacher preparation are produced, including an interactive, multimedia CD-ROM to train teachers in oral and written K'iche' and Ixil.

> Early childhood activities to enhance learning. After researching and collecting K'iche' and Ixil language materials, the program is producing radio programs that will be aired on local stations to provide preschool children with early learning opportunities.

> Institutional capacity in computer applications for teacher training institutes. The program is training trainers to use the computer labs, and is training Departmental Directorate of Education staff to increase their effectiveness in using software, e-mail, and the Internet.

> Community outreach and capacity building. Program plans include opening the computer labs to indigenous communities, thereby helping to develop a more aware and educated rural society.

Beyond teacher training, the program in Guatemala also is using ICTs to help preserve Mayan culture while linking indigenous schools and communities with the outside world.

MOROCCO

With the Ministry of National Education, the Computer-Assisted Teacher Training (CATT) project trains student teachers—and their professors—in using ICTs for education. Seven *Centres de Formation des Instituteurs* (CFIs) (teacher training institutes) throughout the country—in Sidi Kacem, Ouarzazate, Errachidia, Al-Hoceima, Tiznit, Tardudant, and Essaouira—now have multimedia laboratories and offer a specially designed Arabic-language training program for future primary teachers. Through the program, participants learn at an individualized pace and in stages, moving from basic computer training to skill development in communication and networking to research and instructional design. Each step is geared to particular tasks that student teachers will have to perform in their classrooms—Excel spreadsheets are used to record student grades, for example—thereby rendering the training immediately relevant.

The overall purpose of the program is to:

> improve educational quality by incorporating technology into teacher training;

> promote ICT use in education more broadly for distance learning and networking purposes;

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- develop communications networks to facilitate the work of the teacher trainees, teacher trainers, and inspectors, as well as collaboration and information sharing among peers across provinces;
- build local education technology capacity by training "Master Information Teachers" who will sustain local development of learning technologies; and
- contribute to national policy discussions on the use of learning technologies in education.

> As student teachers and professors become proficient, they are applying their new skills on the spot. Professors are transferring their handwritten notes to the word processor—in one case, perhaps the most detailed analysis of the geology of southeast Morocco ever prepared—and preparing to launch a Website. They also are open to sharing the wealth with their neighbors. Labor unions, local government officials, inservice teachers, and members of surrounding communities want access, and several CFIs are considering ways to open their doors to the public in the evening and on weekends. Said, a student teacher, took so naturally to the technology that he devoted months of his free time to cataloging via computer every book in the college library. ("We have 6,000 books," the Director said. "We never knew that before.") And Latifa, a 20-year-old student teacher in Ouarzazate, spends evenings and weekends sharing what she has learned about Word, Excel, and PowerPoint with her professors, an age and gender reversal uncommon in small towns in Morocco.

Leveraging the potential of available, low-cost electronic networking technologies, the CATT project hopes to create dynamic learning environments that will enable—and encourage—Ministry teachers, trainers, and staff to engage in substantive collaboration that will result in better teaching and learning in Moroccan primary schools. The CATT project also supports the Ministry's initiative to introduce the use of computers throughout the education system by 2008. By using technology in their own training, it is expected that teachers will be better able to prepare their students to use computers in the classroom.

Since October 1999, when the CATT project began, 50 trainers, 500 student teachers, and 70 CFI professors have completed the entire training program, and 1,500 instructors and student teachers have participated in a portion of it. Recently, the Ministry of National Education approved the curriculum produced for the project for training in all institutions of learning nationwide.

NAMIBIA

Since its independence in 1990, Namibia has expressed a commitment to removing the last vestiges of apartheid's social and economic policies. However, high student failure rates, unemployment, population growth rates, and the menacing incidence of HIV/AIDS remain major development challenges.

Namibia's Ministry of Basic Education and Culture (MBEC), its National Institute for Educational Development (NIED), and donors are working to improve the education sector overall. Within this arena, teacher training ranks high on the list. Currently, teacher education and qualifications are uneven across regions, and existing teacher training methods are inadequate for dealing with these disparities. The great distances between schools, training centers, and colleges of education add to the difficulties teachers face in gaining any training, inadequate though it may be.

The CATT project, part of a greater plan to improve teacher training nationwide, includes the following components:

- developing computer-assisted training courses for teachers and other educators;
- constructing a communications network linking educators to NIED through the Internet and other technologies;
- designing prototype curriculum-based training materials for primary school students;
- training and helping to integrate "Master Information Teachers" into the administrative structure of the MBEC and NIED as champions of teaching/learning technologies; and
- introducing teaching/learning technology concepts into the national policy dialogue.

In addition, the project is helping NIED to create a Website that facilitates communication, research, and training among officials, teachers, principals, inspectors, and researchers—a virtual community of educators. Now available at *http://www.edsnet.na*, the Educational Development & Support Network enables educators throughout Namibia to join forces for their own professional development and the improvement of education nationwide.

UGANDA

Uganda is emerging as a leader in African education reform. One of the country's most progressive moves is its adoption and application of ICTs for national development, with its growing computer capability harnessed to serve education. Through the CONNECT-ED (Connectivity for Educator Development) project, for example, Uganda is integrating ICTs into professional development programs for primary school teachers, with a focus on computer-assisted teacher-training.

Through newly created multimedia teacher training laboratories in eight Primary Teacher Training Colleges (PTCs), located in both rural and urban areas, teachers will have access to the training curriculum through computer-mediated learning environments and digital library resources. The program also is working with Ugandan governmental agencies and the Institute of Education Kyambogo (ITEK) to set up multimedia training laboratories at its facility in Kampala. The program is enhancing the curriculum with ICTs by developing, testing, and distributing online multimedia training modules for teachers and tutors. These teachers, in turn, will train current and future teachers at the participating PTCs.

Through March 2003, PTCs in Shimoni, Gulu, Bushenyi, Mukujju, Ndegeya, and Kibuli, plus two more rural communities will start to benefit from access to the multimedia laboratories, interactive instruction, and digital library. With new Internet service providers (ISPs) and Internet points of presence moving into these areas, ITEK and the PTCs will all go online. Then the new material will be accessible from ITEK's Website at *http://www.itek.ac.ug*. To ensure effective use, a new feature of the program is the Professional Development Training Course for computer literacy, which will enable user groups of PTC administrators, tutors, pre- and inservice teachers, and school staff and students to learn basic computer applications, multimedia production methods, and Internet skills. Even PTC principals have expressed interest in receiving training.

In building the network, teachers at PTCs also will learn how to construct their own Websites. Later, interactive media such as discussion boards can be installed for facilitating communication among educators.

The computer laboratories in this teacher training network reach most of the country, serving as access points for developing teaching curriculum electronically, teacher training, and, eventually, selected community use. By providing the equipment, training users, and facilitating production of educational products, project staff members expect teachers to find innovative ways to use ICT for teaching and learning well beyond the scope of the activity.

BRAZIL

LTNet—the U.S.-Brazil Learning Technologies Network *(http://www.LTNet.org)*—is an Internet-based learning environment and clearinghouse on the ever-expanding role of ICTs in education, as well as a means of enabling interactive collaboration among educators in the United States and Brazil. Bilingual in English and Portuguese, LTNet provides Brazilian and U.S. educators with access to information about computer-assisted learning and efforts to integrate the use of technology in teaching and learning. LTNet also presents information on Brazil's ProInfo program, a bold effort to integrate computers into schools throughout the country. The Website includes:

- A virtual library containing reviewed articles, many of which have been abstracted, as well as a means by which users can submit new articles.
- A *SchoolLinks* program that promotes professional collaborations among U.S. and Brazilian educators.
- Announcements about events, developments, and news of interest to those involved in educational technology.
- A place for users to post information about their own projects, events, activities, and experiences, and an online discussion forum and listserv.
- A Help Desk that responds within 24 hours to questions about information and resources related to learning technologies.
- Free subscriptions for Brazilian schools to an online course in English-language instruction, launched in collaboration with GlobalEnglish.com, a U.S. Internet company that offers free online English-language instruction for Brazilians.

In addition to the Website, LTNet facilitates a variety of activities to support learning and professional networking among teachers. For example, in partnership with ProInfo in Brazil, LTNet's SchoolLinks program is enabling educators across Brazil to meet and work together. Through LTNet's Virtual Exchange Environment (VEE), a group of Fulbright English-language teachers from the United States and Brazil are able to communicate with each other by e-mail, threaded discussions, and live chat sessions to plan activities, share documents, collaborate on projects, and develop individual and group Web pages. Two other VEEs are enabling groups of educators and students in Rio de Janeiro and Manaus in Brazil to develop collaborative programs with counterparts in Oakton, Virginia, and Oxon Hill, Maryland, in the United States.

ENDNOTE

[1] This chapter is an updated article that appeared in *TechKnowLogia*, September/October 2001 *(www.TechKnowLogia.org)*. Used by permission. The activities described were launched by LearnLink in collaboration with USAID Missions and education leaders. LearnLink is a five-year Indefinite Quantities Contract (HNE-1-00-96-00018-00) of the U.S. Agency for International Development (USAID). It is funded by the Human Capacity Development Center in the USAID Global Bureau, the Africa Bureau, and other USAID Bureaus, offices, and missions. It is operated by the Academy for Educational Development.

16

HONDURAS: LOADING TECHNOLOGIES IN ISOLATED COMMUNITIES—LESSONS TO LEARN

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SOLAR VILLAGES LIGHTING A PATH

San Ramón, a village of about 840 people located in the hills above Choluteca (Honduras), is positive proof of the power of new technologies to leapfrog over traditional barriers to development. San Ramón, with support from UNESCO and Consejo Hondureño de Ciencia y Tecnologia (COHCIT) and others, has become the world's first solar-powered community hooked up to the Internet. Above and beyond the potential of the Internet and other less sophisticated technologies (e.g., radio and television) to expand horizons beyond San Ramón and Choluteca, the results are interesting for a number of reasons.

First, the fact that solar energy has been the power source of choice says volumes about the status of San Ramón vis-à-vis public policy. To say that San Ramón is an isolated community may be an understatement. Access to it is difficult: although it is located a mere 24 kilometers from a main thoroughfare, the journey up to San Ramón requires a good 45 minutes in a 4x4 all-terrain vehicle—and a strong stomach. There is no road to speak of. Rather, a path of stones, ravines, and otherwise tough conditions leads slowly upward. It has been this lack of accessibility, coupled with a relatively low number of inhabitants that has made the government less than anxious to extend the distribution network from Choluteca to San Ramón—at least in the short to medium term. Per unit costs and accessibility considerations meant that if power were to come to the village, it would have to do so by means other than the "traditional" methods at the disposal of the state and public policy. Among these, solar energy figured prominently.

Second, San Ramón, like many remote villages throughout the country, suffers from low levels of education, productivity, and, in general, quality of life. In fact, it was rated zero (on a scale of one to 10), according to its *cacique*, or leader, Don Jeronimo. Given its remoteness, the village could neither maintain teachers for its school (primary level only) nor benefit in a timely manner from a number of other public services—e.g., vaccinations. Aspirations were low as well. Indeed, as one villager joked, "The moon seemed closer than Tegucigalpa [the capital]. The moon we could see. Tegucigalpa, no."

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With the support of UNESCO and COHCIT, San Ramón started exploring the potential of alternative energy sources as a way to trek out of its darkness and isolation. In February 1999, and in the wake of Hurricane Mitch, solar panels were installed strategically throughout the village. This process culminated on July 8, 1999, when the President of Honduras, Carlos Roberto Flores, inaugurated San Ramón as the first solar energy village of Latin America. Since then, the results and experiences of San Ramón have caught the attention of many, within Honduras and beyond.

The energy generated through the solar panels powers a variety of community services:

- five streetlights;
- six classrooms, each of which has its own electrical outlets for a TV/VCR, a computer, and other pieces of equipment;
- a community center, also with outlets for fans, computers, TVs, etc.;
- an innovative classroom equipped with 11 computers, a TV, video and tape recorder, digital cameras, scanners, printers, etc.;
- a health clinic, including a heating and cooling system for water and medicine and vaccine storage; and
- lighting in the village's church.

As of October 2000, San Ramón has gone global, wired to the Internet through each of the 11 computers in its innovative classroom. These changes, literally, have given power to the people. On a scale of one to 10, villagers claim the quality of life has improved from a zero to an eight.

Governed by a local development council comprised of representatives from throughout the village, San Ramón has had resources allocated, decisions made, and activities prioritized. The use of new technologies to improve the quality of education has received considerable attention, both from village elders and across Honduran society.

The success of San Ramón has prompted COHCIT and other agencies and donors to identify other villages where similar interventions could bring similar benefits. To date, two additional villages, San Francisco and La Hicaca, have been endowed with solar panels and a package of lights, hardware, and software similar to San Ramón's. San Francisco is a municipality, not a village per se. Located approximately 25 kilometers from the city of Edandique in the Department of Lempira, one of the country's poorest, it has a population of more than 900 inhabitants, and based on this size, operates both a primary and a secondary school. La Hicaca is about a third of the size of San Francisco. It is located outside the

Pico Bonito National Park, an area renowned for its Emerald hummingbirds (an endangered species).[1] San Francisco's educational facility remains limited to a primary school.

TECHNOLOGY OVERLOAD?

Technology has considerable potential for improving the quality of education. The options are many and run the gamut from using distance education modalities to increase access to students and provide training for teachers, to using materials (e.g., CD-ROMs, videos) to supplement official curricula. Using relatively advanced technologies compared to the general technological and educational environment may be considered by some as a technology "overload." For these villages, the bottom line may well come down to a dire choice: an overload of technology or the status quo of poverty, isolation, and ignorance.

Lower-End Technologies; Higher-End Impact on Learning

By creating a necessary condition—electricity—the solar villages are in a position to empower themselves. Of immediate access are programs of distance education. Radio and television may fall relatively low on the scale of technological sophistication and costs, but they have a proven track record in improving the access and quality of education. And, in areas where there is little or no supply of education at the seventh to ninth grade level, delivery via radio or television—or tape or video—is preferable to no delivery at all.

Of those distance education programs currently in use, two figure prominently. Both are formal programs of the Ministry of Education, and both receive support from external donors, particularly USAID. *EDUCATODOS* is an interactive radio program (also available on cassette tape) targeted to youth 13 years of age and older and adults without access to schools, the majority of whom live in rural areas (see chapter 9). Implementation parallels the country's decentralization process. Each of the country's 18 departments has a paid coordinator. Under their coordination and direction, about 178 "promoters" (paid and trained) travel to communities and organize groups to disseminate the program and its benefits and to arrange for creation of an *EDUCATODOS* center. There are more than 2,800 centers (in homes, maquilas, schools, nongovernmental organizations [NGOs], and the three solar villages) throughout the country and an estimated 370,810 learners. Voluntary facilitators (numbering 4,000+ throughout the country) staff each center to orient and direct learning activities.

It should be noted that *EDUCATODOS* recently finished work on curricula for grades 7-9 (grades 1-6 curricula were completed in 2000). These curricula are aligned with the competencies and skills outlined in national curricula for use in "regular" schools. *EDUCATODOS* curricula differ, however, in that they integrate the basic skills and competencies (math, communications, social science, science, and technology) into five crosscutting themes: population, environment, health, national identity, and citizenship and democracy. The Ministry of Education is debating the possibility of adopting the *EDUCATODOS* curricula as the official curricula for grades 7-9. In the absence of the resources to deliver face-to-face education at the basic grade 1-9 level, *EDUCATODOS* appears to provide a sound alternative. (In about 110 Basic Education Centers,[2] *EDUCATODOS* remains the only alternative for instruction in grades 7-9.)

Telebasica is a distance education program delivered via television. Modeled after Mexico's *Telesecundaria* (see chapter 10), the program operates along the same general guidelines as *EDUCATODOS*, albeit with differences in staff and infrastructure. Whereas *EDUCATODOS* works with voluntary facilitators in centers "created" or "established" within existing structures (e.g., houses, schools, maquilas), Telebasica uses teachers and operates within the Basic Education Centers, the majority of which are in semiurban areas, and covers grades 7-9. In Centers lacking teaching staff with proper credentials, Telebasica has allowed education to be delivered at a level unlikely to be achieved with uncertified teachers. Thus, it shares many of the same advantages of *EDUCATODOS* in terms of expanding access and ensuring quality. Although planned as an alternative in each of the three solar villages, none has access yet to the program.

Higher-End Technologies

There are many reasons for installing computers and access to the Internet in schools. Through interactive modules and access to the "information superhighway," such technologies are likely to be able to help leapfrog beyond obstacles and limitations left untackled by radio and television. Teachers can be trained in situ, thus increasing the number of days of teaching and reducing expenditures in travel and lodging. For students, technology displays a real potential to increase efficiency and quality, reducing dropout and repetition, increasing completion rates, and compensating for the inputs (e.g., books, materials, labs) teachers and schools may lack. Such technologies also give new meaning and substance to "lifelong learning," opening new possibilities for learning to populations outside the formal education system, and to motor small and micro enterprises.

Yet, there are few reasons for introducing these technologies in schools if the link to learning is not explicit. If technology—particularly more sophisticated and high end—truly is to be used as a tool to improve the quality of education, then a strategy, or at least a broadly agreed-upon pedagogic model, must be in place first.

THE LEARNING CURVE

Sequencing Matters

It is fundamental to start not with the technology but with educational objectives and problems instead, and then seek the most cost-effective integrated teaching/learning system, including a variety of technologies that need not be the most advanced, to meet the objectives and solve the problems. To be successful inside the school, technology-based reforms require strong support from the top, acceptance and understanding by teachers, integration into the overall system of instruction, and phased introduction. Absent a clear idea of which learning goals are most amenable to technology and which technologies are most appropriate or relevant to these goals and the teaching-learning context within which they are pursued, there is a real danger that technology will only make a bad situation worse. Technology does not make teachers into good educators or students into good learners. It can add value to the teaching-learning process, however, if there is a consensus on what constitutes good teaching and what methods help students learn best.

Start with Education, Not Technology

This perhaps has been the clearest lesson coming from the solar villages: No technical department or unit responsible for coordinating and introducing the use of technology in education has existed within either the Ministry of Education or COHCIT. The result has been that almost all initiatives, including the early phases of the solar villages and other projects supported by international cooperation, have started with technology, not education. Thus, in the absence of any strategy or other type of guideline, the potential of technology to improve education has yet to be maximized.

The use of an educational software called Microworlds (Micromundos) is particularly telling in this regard. Microworlds was implemented as part of a larger package of technologies that included CD-ROMs of, for example, the Honduran constitution and other symbols of nationalism and Microsoft Office. Microworlds was not chosen on its educational merits per se; its alignment with national curricula is loose at best. Yet, in the absence of a strategy or model for introducing technology into the teaching-learning process, Microworlds was adopted and implemented without much discussion. Indeed, the fact that it arrived as a donation from an international agency all but put the program beyond the scrutiny of policy experts or other interested parties within the Ministry of Education or elsewhere. That said, there has been value in Microworlds: it has familiarized children with computers and helped to overcome the novelty of computers in classrooms.

Yet, the program has failed to meet some expectations. For one, the merits of its underlying highly structured approach remain debated; in instances where the quality of teaching staff is inadequate and student performance is lacking, a more preferable option may be to reduce the degree of freedom in the learning process by leading students, as well as teachers, through more structured activities. And, whereas there is much to be said for the idea that the first step in introducing technology into the classroom is to familiarize all users with hardware and peripherals—a task Microworlds fulfills well—it seems that such familiarization needs be contextualized, linked, and made relevant to other tasks. This seems to be particularly true for teachers, few of whom appeared to understand the value and connection of Microworlds vis-à-vis the rest of the curricula (although they did receive some training on the use of Microworlds). Moreover, Microworlds was not user-friendly, and the students in San Ramón and San Francisco grew bored with it.

The "Honduranization" Process

Recognizing the limitations of Microworlds, Carlos Velásquez of COHCIT analyzed other options. After an intensive search and discover process, the software program Clic, developed in Spain, was adapted to national curricula for grades 4-8 and piloted in San Ramón. Although there is still no framework or strategy in place to guide the introduction of technology into the teaching-learning process (it is under preparation), such efforts seem to be a big step forward toward applying the official curricula developed by the Ministry of Education.

In short, an innovative process of "Honduranization" has taken place. Curricula were obtained from the Ministry of Education and code books from *Xarxa Telemática Educativa de Catalunya*, which created Clic, and from the administrators of the Website where it is posted. From here, codes were adapted to align the software with the specifics of the Honduran curricula. The result has been a menu of activities running the gamut of competencies specified in the national curricula—from English, to Spanish, to math and science—purposely structured to complement lessons and other learning activities.

Clic has been installed in all three of the solar villages, and all teachers have been trained. But there has been an interesting twist: the version currently operating in each of the solar villages is a product of review and redesign by teachers in San Ramón, all of whom participated in efforts to make the software more compatible with classroom and student needs and more relevant to the conditions under which they teach. These revised programs will complement curricula through grade 6. A series of activities specifically targeted to adult education, also available in the public domain, will be installed as well. Again, each of these activities has been aligned with official curricula for formal and nonformal education, including adult education. Bottom line: teach with computers, not from computers.

Plans are underway to extend activities to the secondary level. In the Department of Lempira (one of the poorest in the country, with education levels below the national average), the groundwork has been laid to complement curricula in the technical institutes in much the same way as fortified, Honduranized versions of Clic have been used to complement curricula in primary schools. Curricula in these institutes are—as their name suggests—technical in nature, running the gamut of subjects from agronomy and ecology, to forest and soil management, to cartography. More "traditional" subjects, such as history, also are taught. Although there are six institutes in and around San Francisco that could benefit from a Clic-based dose of quality enhancement, each faces severe equipment and resource limitations. In the short term, then, implementation is likely to be limited to only one institute: the Jacobo Orellana Institute in San Francisco, which, given its proximity to the primary school, has access to the equipment installed through the efforts of COHCIT.

No Need to Reinvent the Wheel

This "Honduranization" of existing software merits closer examination. The costs are comparatively low, and the benefits are likely to be significant. Students show interest in the program, and teachers maintain they are impressed by the extent to which such activities sink in and facilitate the learning process. Yet, if this or any similar effort were to be taken to scale, other actors—particularly the Ministry of Education and the National Pedagogic University—would have to be involved. Use of Clic remains limited to the three solar villages established through the technical assistance of COHCIT and international donors, and engineered by a single person who had an idea, reprogrammed software in the public domain, adapted it to national curricula, and trained teachers accordingly—no small feat. But the time has come to develop a low-cost, realistic option with broad participation from ministries and communities that shows considerable promise for improving the quality of education, even in the most remote and isolated of schools.

WHAT ELSE TECHNOLOGY DOES FOR EDUCATION

In the solar villages, solar energy and other technologies have served to leverage more from the state. San Ramón and La Hicaca have inaugurated the third cycle of "basic education,"[3] thus expanding the supply of education from six to nine years; preprimary cycles also have been added. Future plans include creating the diversified cycle (grades 10-12). Technology also gives new meaning and substance to "lifelong learning," opening new possibilities for learning to populations outside the formal education system, and may energize small and micro enterprises.

Although no hard data are available, there is sufficient justification for what may appear to be a "technology overload" in villages such as San Ramón, San Francisco, and La Hicaca. Technology—including TVs, VCRs, and computers—increase the "attractiveness" of school. This may be subjective, but it is no minor consideration. In a country plagued by low education attainment, where repetition and dropout run rampant, any "incentive" that keeps children in school and channels their energies toward learning-related activities is likely to go a long way in reducing overall costs. Witness the volume of resources governments throughout the world lose due to repetition. (By one estimate, the total resources the Inter-American Development Bank has invested in education over the last four decades pales in comparison with the amount lost each year throughout Latin America and the Caribbean due to repetition.) Seen in this light, investments made in machines, software, and training are likely to be recovered in a relatively short time.

In much the same vein, and especially in communities as isolated and remote as Honduras's solar villages, technology increases the chances that teachers actually will show up for class and remain in the service of the village for years to come. Again, this is no small consideration. Students across Honduras often receive less than 100 hours a year of class time (compared to 1,200 hours a year in industrialized countries), given high rates of absenteeism among teachers and other factors, including strikes; time on task tends to be even less in rural areas where supervision is lacking and multigrade schools are the norm. Thus, a formidable challenge is making better use of time actually spent in the classroom.

WHAT TECHNOLOGY CANNOT DO

Technology offers neither a magic wand for improving the quality of education nor a means for shortcutting the educational process. Technology can help inform, but it cannot "knowledge." Knowledge results from using a series of intellectual and analytical tools to interpret information and make it relevant to a given situation. Considerable care needs to be taken in introducing technology into the educational process by recognizing the difference between information and knowledge. If technology is used and programmed as an add-on that requires extra time and effort from teachers, and not as an integrated component of the learning process itself, neither attitudes nor learning are likely to change. On the contrary, such technology may trivialize education.

If the solar villages are to take full advantage of access to technology, the state, despite all obstacles (including infrastructure), will have to have a larger presence in the community (this process has begun already). Sustainability will have to be explored in details, as will issues related to cost recovery. To wit, local development councils in each of the villages already have mandated user fees for all activities not strictly related to the community. For example, villagers wish to use the Internet to communicate with relatives beyond village limits, and Hondurans must pay to do so. Coordination issues also will take on added importance. COHCIT will have to expand its supervision and, if access and coverage of public policies such as education and health is to be increased, collaboration between the local levels and respective Secretariats at the state, regional, and municipal levels will have to be deepened. The foundation for such collaboration has been laid and, if the experience to date is any indication of what the future holds, expectations should be kept high. It is in this regard that the solar villages' experience may have the most lasting effects: serving as a catalyst for mobilizing communities around and in the name of the common good.

ENDNOTES

[1] Two additional solar villages are currently under preparation: Las Trojas (with a population of just over 190) and La Montaña (population of 240), both of which are in the Department of Francisco Morazán (in which Tegucigalpa is also located) and have a primary school in operation. Las Trojas serves as a gateway to the La Tigre National Park; La Montaña is located 30 minutes outside of Tegucigalpa. These villages already have access to telecommunications.

[2] Initiated in 1999, the Basic Education Centers offer an innovative approach to expanding access in rural areas. These centers offer grades 1-9 under the same roof. By doing so, they allow students in rural areas to have access to the full cycle of "basic" education, likely to be made obligatory in the near future (see endnote 3).

[3] Only six years of education are obligatory in Honduras. A law currently before the Congress would extend the obligatory cycle through ninth grade, converting primary education into "basic education." This same law also would create one year of obligatory preprimary education.

17

ICT FOR ADULT SKILL TRAINING: THE VICTORY OF SPONTANEOUS ACTION

Claudio de Moura Castro

Many complain about the moribund nature of most traditional programs of adult skill training. Are they indeed dead, or are we looking for them at the wrong place? This chapter[1] proposes that adult skill training is well, exploits the technologies of the day, and was reinvented on the go by people who had never heard the term or read the books proposing it. In fact, it is happening everywhere, except where it was supposed to happen, namely, the adult education centers of the governments.

Due to the scarcity of research and data, most evidence in this chapter comes from the United States and Latin American countries, with which the author is more familiar. But one would expect the situation in other countries not to be much different.

WHERE IS ADULT SKILL TRAINING TAKING PLACE?

Extension Courses

In the United States, the catalogs for extension courses are several times thicker than those describing regular course offerings. In some cases, these courses are considered to be cash cows to cross-subsidize other levels of education. Each year, many American community colleges enroll the equivalent of 20% of the population of the towns where they are located. Adult education is a booming business.

In Latin America, there is much going on. In fact, leading business schools have taken this route. IESA (*Instituto de Estudios Superiores par la Administracion*), a business school in Venezuela, has 300 postgraduate students, no undergraduates, and 6,000 extension students enrolled in its short management courses. Business schools in Peru and Costa Rica have taken the same route.

Training and Retraining for Jobs

There is a progressive shift in training programs, from youth to mature adults and from preemployment to inservice training. In the United States, preemployment training has been erratic and often inadequate. To compensate for this casual and heterogeneous system, the United States has a vast array of training programs geared to adults and young adults. High schools and community colleges offer many evening courses to local residents. Many of them are in the traditional trades, such as auto mechanics, welding, electricity, woodwork, and construction. In addition, office technology has become a popular area, with courses in computing, accounting, opening business, secretarial skills, and so on. Equivalent offerings come from municipalities and other government agencies. Many people taking these courses are immigrants.

Most Latin American countries have structured training systems run outside the regular education system and funded from a levy on the payroll. At least three-fourths of the funds, if not more, are allocated to activities that could be considered adult education, since the clients are adults who take the courses while they are employed. In Brazil, around 3 million people take courses in one of these institutions every year. One of the new agencies—in charge of training for the trucking industry—has rented time on a satellite and beams eight hours of courses a day to transportation company employees. Transmission is received in classrooms in transportation companies and now reaches more than 300,000 employees.

In the recent past, many ministries of labor have created training programs geared to young unemployed adults. In Chile, the *Projecto Joven*, funded by an Inter-American Development Bank (IDB) loan, pioneered a new model of contracting courses with private or public institutions, conditioning the contracts on the existence of jobs or internships at the end of the course. There is a similar program operating in Argentina, and others are to follow. Brazil has a similar program, sponsored by the Ministry of Labor, which trains more than 300,000 workers each year.

The training budgets of the American armed forces have been estimated at US$30 billion, and a large share of pilots, mechanics, and electronic technicians in the United States have received their training from the armed forces. In Brazil, most airplane mechanics received their training in the Air Force.

Countries like the United States have a thriving proprietary market for training. Hundreds of courses are offered in each major city in office technology, secretarial skills, and computers, and there is a multitude of short courses geared to the service sector. Exactly the same happens in Latin America, where in any city's downtown area, the signs for courses are as abundant as those for pharmacies or bars. In addition to the areas mentioned above, English-language training is popular. These are the typical second-floor schools in the downtown areas, with signs outside advertising their courses. As one could expect, their quality is varied, ranging from serious, to fly-by-night operations, often closed down by the police. Be that as it may, they

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offer services that people are willing to purchase year after year. It is unreasonable that consumers would take such courses if they were completely ineffective.

Correspondence schools are major players in the proprietary training business. Some are local branches of American schools, but the majority of them are local. They offer radio and TV repair, drafting, sewing, embroidery, electricity, and, more recently, computers. Like their second-floor counterparts, they get little respect, in the United States or Latin America; yet, they perform a social function, particularly for those who live far away from face-to-face programs. More than 3 million people have taken a course from the second-largest Brazilian correspondence school. Research conducted by this author indicates that they are very cost-effective for those students who graduate.[2]

One would expect the Internet to become a major force in such training, stand-alone or in conjunction with printed materials or personal encounters. This is already happening in the United States, and countries such as Brazil, Mexico, Chile, and Costa Rica should follow the same path.

Employer's Training

There is at least as much learning taking place at the work site as in regular schools, and many firms are using information technology to deliver their training. From IBM's two satellites beaming training around the world to its staff, to videotape in less formidable enterprises, the new media seem to be taking over industry. Videos and CD-ROMs are becoming more common as a means of delivering training in enterprises. Available evidence is scant, but trade fairs suggest vigorous production of training materials using the new media.

Probably the most spectacular development along these lines is the so-called corporate University (see chapter 18). Motorola University is well known, as is "Hamburger University," created by McDonald's, and the graduate school of public policy created by the Rand Corporation. But several other large organizations have similar institutions, whose number is approaching a thousand. The oil company of Venezuela (*Petróleos de Venezuela*) two years ago created a corporate university, *Centro Internacional de Educacion y Desarrollo* (CIED), along the lines of Motorola. Initial reports suggest that it is a well-run operation, with nine campuses and attracting professionals from other companies in the same industry.

Self-Learning and "Edutainment"

A lot of learning takes place throughout the life of citizens who received some education; consider that a very significant number of the books published in the United States are in the "do-it-yourself" or "how-to" category. In addition, every little town, and every corner of big towns, has its own library, with all the usual magazines, reference books, how-to books, and classics as well as helpful librarians. One could well imagine that everything else pales next to the self-learning underway in mature societies.

But there is a lot more going on that is not strictly self-learning. Television and computers have created a new category of activities, sometimes called "edutainment" to connote the combination of education and entertainment. With the popularization of cable TV and satellites, the number of channels allows for greater specialization and lower costs. Some channels specialize in this mixture of culture, education, and entertainment. The Discovery Channel and The Learning Channel are typical examples of this new model. In general, these channels aim at a general audience that wants more intellectually sophisticated entertainment, such as archeology, history, geography, science, and technology. Documentaries about the petroleum industry or the theory of evolution also fall between education and pure entertainment.

In a more practical vein, cable channels have produced a large number of programs on cooking, woodworking, and household repairs. These have become genres on their own, with different characters and styles of presentation competing for the preference of Saturday TV viewers.

The new satellite channels are paving the way for dedicated education channels operated by commercial networks. This is a new chapter in edutainment TV: Venezuela, Brazil, and other countries are just beginning to operate commercial TV channels entirely dedicated to education.

The other noteworthy trend is in computers and the Internet. CD-ROMs and the Internet are true learning tools, and many people use them. Even in Latin America, the number of Internet connections is growing at unimaginable speeds. The practical uses of the Internet are not ignored by a large proportion of subscribers, even though chat rooms and e-mail remain the most widespread Internet activity.

WHY I LOVE (GOOD) TRAINING VIDEOS

Recently, videos and instructional CDs have become valuable tools for professionals who need their employees to be trained in specialized fields and practices. They are also excellent resources for those who wish to hone their own job skills or update their knowledge. Several companies specialize in providing educational materials for these purposes, ranging from the professions to generalized self-improvement (Box 17.1).

BOX 17.1 • INTERACTIVE MEDIA TRAINING[3]

Interactive software is out there, and it's not just for children. One of the most useful applications for multimedia (videos and CD-ROMs) is skill enhancement and training. Below is a sample of such products:

TECHNICAL TRAINING

Automation Studio *(www.ttaweb.com)* is a technical and interactive CD package that trains individuals in circuit design and automation technology. The software package is designed so users are able to outline, simulate, and animate their own circuits while using various methods of electrical controls, including hydraulics and pneumatics. Appropriate for engineers, teachers, and students alike, *Automation Studio* is available in English, Spanish, French, Italian, Japanese, and Portuguese.

Aircraft Systems Review *(www.nolly.com/asrv.html)* can be used to train pilots on unfamiliar aircraft and enables those in the aviation field to refresh their knowledge. The videos incorporate one-on-one instruction with visual explanations and procedures, viewed from a pilot's perspective. These videos are also "generic" in the sense that they can be used universally despite an individual trainee's airline affiliation.

TPC Training Systems *(www.tpctraining.com)* offer an extensive video and interactive CD library. They specialize in machine and mechanical training and have provided training to more than 3 million employees. The training videos cover such topics such reading blueprints, schematics, and symbols; electronics and digital electronics education; and engine mechanics, hydraulics, and even heavy machinery use. The training CDs cover process instrumentation, mechanics maintenance, and air conditioning/refrigeration systems.

MEDICAL TRAINING

TUTOR Series *(www.labmed.washington.edu/tutorproducts)* is a set of interactive CDs produced by the University of Washington. They cover several different aspects of evaluating medical data and train individuals in interpreting multiple results. *ElectrophoresisTUTOR*, for example, is an interactive computer program that teaches electrophoresis interpretations of proteins in various body fluids. With its illustrations, charts, and tables, the CD is useful for instructing beginning students or evaluating competency levels. *PhlebotomyTUTOR* simply trains individuals in the appropriate methods and techniques of taking blood from a patient.

PedsLink *(www.pedslink.com),* a resource for pediatric health care, produces a series of training videos geared to home health clinicians and nurses who are in charge of providing care for infants and children with various illnesses. Videos, such as *Home Phototherapy for Infants,* take the care provider step-by-step through treatment methods and assessments and use specific procedural demonstrations.

I Am a Convert

During a recent storm, water began pouring into my living room, evidence of a problem with the roof. When I visited Home Depot, a home improvement store in the United States, I found a video explaining how to repair asphalt roofs. It was free with the shingles I bought for the repair. I watched the video twice and felt I was ready to climb up on the roof and start yanking the old shingles to reveal the rotten plywood underneath. During this time, a friend arrived to spend the weekend, an old school colleague turned venture capitalist. I offered him a tool, and we discovered that the damage was much worse than expected. We spent the entire weekend on the roof, but we did manage to fix it. Why this poor fellow remained my friend still baffles me. But coming from countries in which asphalt shingles are unknown objects, I learned from the video how to do a creditable repair on a leaky roof.

When the time came to install ceramic tiles in the kitchen, another video gave me the courage and the know-how—it was lots of work but quite a success. The same happened with laminate flooring in the family room. Changing a toilet and hanging wallpaper also were preceded by a video.

Altogether, videos allow me to tackle tasks successfully that I would not have dared to otherwise. And they truly show how to do things in a way that books cannot. Think of the words and drawings required to explain how to unfold the wallpaper on a table, spread glue, fold it, carry to the right place the entire gooey mess, line it up with the previous sheet, hold it with one hand, squeegee with the other, trim the edges, and so on. Minutes of video tell it all.

Recently, I bought a video from Taunton Press showing 13 different ways to make mortises and tenons. Now I am looking for some task where a mortise and tenon are vitally needed.

Several years ago, I had to visit a dentistry school where I was shown an explicit videotape of surgery of the upper jaw. I hated every minute of it, but I had to agree with the dentist-cinematographer that I could see the surgery in the video much better than if I were a spectator trying to see something from behind the surgeon and the nurses (a completely unlikely event, but a reasonable hypothesis).

Seeing a video of arc welding, one can see a competent welder run a perfect bead of metal on the two surfaces being joined. This is much better than real-life attempts to see the same bead, with sparks flying and burning holes in your pants, all the while standing much farther away than the camera image brings us.

Thus, I am a convert. Videos are a powerful tool for learning practical things, tasks where words are not helpful. Videos are cheap. The ones I mentioned cost US$10 and still provide profits to their producers. There is an endless supply of such videos in industrialized countries.

There are thousands of videos on how to do every possible task on the face of the earth, from tai chi to embroidery. They are so ubiquitous and unassuming that we tend to look down on them, but no high-tech gimmick, no flickering Internet video clip can achieve the same training feats. For teaching such practical endeavors, the Internet is a glorified farce. No other technology can beat a good how-to video; often, not even a live teacher.

Good Videos and Bad Videos

Having praised training videos (and by extension their former incarnation, films), let me add some qualifications to my infatuation. Surely, not all videos are good. In fact, most videos are plain bad and useless. How many silly sunsets have we had to endure before anything interesting happens? How many images of flowers and grass waving in the wind? How many teachers preaching to idiotic-looking students? How many images of busy students sitting in front of computers? How many robots crowding downtown streets or highway interchanges? Unfortunately, too many. The average video is slow, takes too long to deliver its message, uses the medium poorly, and fails to serve any practical purpose. My daughter wrote to several New England preparatory schools asking for information, and just about all of them also sent a video. They were all slick, full of pretty autumn scenery, and utterly uninformative—a complete waste of time.

So, what makes for a good video? We need to understand the language, or languages, of video. We take for granted that printed paper is used for bibles, pornography, novels, newspapers, scientific journals, advertising, and so on. Why would videos have one single specific language or style? They don't. There are many video languages, some better than others, depending on how they are used. A dull speaker—a "talking head"—in a video is worse than a paper saying the same thing, primarily because it takes longer to listen than to read.

Rummaging through mountains of videos, we can identify two cases in which they are particularly useful.

The first is when they are a means to transmit human charisma or magnetism. Some people are endowed with the power to teach, to persuade, to convey ideas. They are the super-teachers. With one of those rare people in front of the camera, the bells and whistles of TV production truly are not necessary; the super-teachers are a show by themselves. Tom Rollins, founder of The Teaching Company, hit on a winning formula along these lines. He finds the most persuasive teachers in American universities and invites them to give a series of lectures on the topics in which they excel. Production is plain and unsophisticated to an extreme, but the personality and charm of the super-teachers is what matters.

The second case is more difficult to explain but no less important. Let us think of two real videos.

- The first video demonstrates how to remove the bones from a trout. The maître d'hôtel, in formal dress, tackles the fish as an actor performing in front of a full house. His movements are swift and precise, not one second is wasted. In no time, the bones are extracted, and the fish is reassembled as if by magic.
- The second video is Julia Child, the upper-class American converted to French chef. She searches for the right word, stops to ponder what she is going to do next, fumbles with the knife, drops the food, looks for a towel to clean her hands, discusses alternatives, and looks a bit worried about the results when removing the finished dish from the oven.

The first is useless as an instructional video. No student can relate to that perfection or even hope to approximate it. The video hides the difficulties and the path to learning the tricks of the trade. It is pure theater when something different is needed. By contrast, Julia Child created a new video/TV language. She was asked to do one or two programs for a Boston education TV in the early 1960s, when such programs were live. Once the cameras were on, no matter what happened, they were not turned off until the end of the program. She had to talk and cook at the same time, thus exposing the viewers to all the real-life difficulties and accidents. She explained, improvised, fixed the mistakes, and elaborated on how to deal with the everyday problems of a kitchen. Not being a professional cook who had spent thousands of hours repeating the same gestures, she fumbled more than a full-time chef would.

The Theory of the Practice

Without suspecting that she was creating a style, Julia Child truly found a very important area between theory and practice. Donald Schon, in a fascinating book, *The Reflective Practitioner*,[4] discusses this intermediate space between theory and practice. Practitioners master a large repertoire of skills and strategies that are strictly required to perform a task. But these skills usually are not verbalized or explained in formal situations. Sometimes there is not even full consciousness of the techniques; they are performed but are not brought to the level of conceptualization and description with formal words. This is the "knowing in action" mentioned by Schon.

Learning a trade means learning this "theory of the practice," usually with the help of someone who is a master of that trade, but not necessarily able to verbalize this in-between knowledge. This is what is not in the books, because it is not part of the official "theory." This is what Julia Child brings to the art of making videos. She probably would not have invented the style had she started with videos rather than live television where one cannot stop the camera and start again. But once invented, her spontaneous, somewhat fumbling style became popular and was imitated worldwide. Being a highly educated woman, capable of expressing with words what most cooks omit; she explored the "theory of the practice." She also made a point of showing details often omitted, such as how to hold a knife, which fingers go where, etc. She was able to bring to her cooking classes what was omitted from the run-of-the-mill cooking lesson, where great cooks showed off their skills but failed to delve into this fuzzy and evanescent space between cold descriptions of procedures and well-rehearsed gestures. Her style is emulated by TV cooks today, to the benefit of all those who expect to learn from television something about cooking.

Hence, good videos on training are those that explore this uncharted territory of the little details, the feeling for the job, the in-between knowledge. The above examples focus on a hobby—cooking—but the ideas apply as well to other areas where theory of the practice is important.

Forgone Media in Less-Developed Countries

Videos are more affordable than computers and the Internet. It is a pity that they have not been used more extensively in poorer countries. While VCRs are found in very modest households in very modest countries, the availability of practical, how-to videos remains quite limited. Arnold Schwarzenegger is easy to find, how to unclog a pipe or how to hang a door is not.

The problem is simple but misleading. Developing countries are not well endowed with cinematographers who like or respect manual or technical work. Hence, the tendency is to sneer at such applications and produce philosophical discourses on the ethics of work. How to guide the piece of wood to the circular saw is too trite a subject for all but those who have lost their fingers in this operation.

MORE THAN WE THOUGHT; NOT WHERE WE THOUGHT

Adult skill training for lifetime is taking place where it is not expected to, and it is failing where it is supposed to succeed. None of the programs and tools discussed above is considered official "adult education," yet, this is what has made lifelong training stronger and more enmeshed in our lives than anybody could have imagined. This effort is not coordinated and defies coordination. There is no planning, no blueprint, and no governance. It is a form of anarchy, perhaps an "organized anarchy." The systems adjust and readjust by the force of markets, quasi-markets, and random events. There is little if any quality control.

What is blooming is lifelong skill training for the affluent, the modest, and the almost poor. Charity and equity failed. The market won, and we are far better off than we would have been without it. But the poor remain illiterate and unable to find the lifelong training promised by different international initiatives. The use of media such as radio and television allows for very low-cost programs with proven effectiveness to reach many times more people than conventional methods. Helping the barely literate poor with some of these programs seems more promising than efforts to produce traditional versions of basic adult functional literary and training.

ENDNOTES

1 This chapter is an adaptation of two articles by the author: Adult Education in the Americas: The Victory of Spontaneous Action, and Why I Love (Good) Training Videos. (September/October 2000). *TechKnowLogia*. Available at: *www.TechKnowLogia.org*. Used by permission.

2 Guaranys, L., & de Moura Castro, C. (1979). *Ensino por Correspondência: Uma estratégia de desenvolvimento educacional no Brasil*. IPEA: Rio de Janeiro.

3 Excerpts from Lewis, J. (July/August 2000). Enhancing Vocational Skills: Interactive Media Training. *TechKnowLogia*. Available at: *www.TechKnowLogia.org*. Used by permission.

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18

E-TRAINING FOR THE WORKPLACE

Sonia Jurich
Kurt D. Moses
Raymond L. Vigil
John Y. Jones

- **Workplace Training in the New Economy**
- **Applications of E-Training**
  - Axa—The French Solution
  - Carrefour—A Brazilian Experience
  - Cisco Learning Network
  - Lucent Technologies
  - Corporate Universities

WORKPLACE TRAINING IN THE NEW ECONOMY[1]

Training within the workplace has become a priority for a majority of firms operating in modern and increasingly global economies, and for countries seeking accelerated development. But training is costly.

One of the biggest factors in estimating training costs is whether the income and living expenses of those being trained is factored in as a cost. For example, 90% of all corporate and government training in the United States occurs on paid time. The cost of a senior executive attending training, at a location different from his or her normal workplace, includes not only the direct outlay for the training activity (speakers, computers, rental site, and other costs) but the cost of attendance as well. This covers the trainee's salary, transportation costs, living expenses, out-of-pocket costs, and, in some cases, business that was not conducted or accomplished, because the person was off being trained. In many instances—particularly for international training—the cost of attendance far exceeds the direct cost of training. The higher the salaries of the persons involved and the more precious their time is, the costlier the training. And yet, most firms in modern economies continue to place an extremely high priority on training. Several factors are driving this type of priority setting:

> Modern economies tend to move from high-volume activities to high-value activities. High-value activities usually involve higher-skilled individuals.[2]

> Speed and agility are keys to maintaining high value. This requires communication and quick understanding—meaning additional training and people who know how to learn.

> Modern firms need a web of relationships to produce what they do. For example, the modern automobile sold in the United States may have parts from 25 or 30 countries, all brought together to create one automobile. In emerging economies, such relationship webs are also important, because the various factors of production are very dispersed. A classic example is flowers produced in Kenya for sale in Amsterdam. The entire activity, including transportation is arranged via the Internet.

This chapter is extracted from articles by **Sonia Jurich, M.D**, Senior Associate at Knowledge Enterprise, Inc.; **Kurt D. Moses, M.B.A.**, Vice President, Academy for Educational Development; **Raymond L. Vigil, Ph.D.**, former Chief Operating Officer for Learning at Lucent Technologies; and **John Y. Jones**, User Services Coordinator, National Clearinghouse for Comprehensive School Reform at The George Washington University. The articles are cited in the endnotes.

In addition, the focus on Web- and Internet-based ways of operating firms has created a new set of needs. Two innovations (used in both service and product economies) have driven much of the recent dialogue on these matters:

> Enterprise Resource Planning (ERP) involves integrating the "back office" of a firm so that one can provide ordered goods rapidly and accomplish all the needed inventory, distribution, quality control, financial transactions, and status updating easily and rapidly. ERP involves reengineering normally separate functions within enterprises so that services and goods can be produced and processed more consistently and rapidly.

> Customer Relationship Management (CRM) involves recording all interactions with a customer/client to track buying patterns, anticipate new purchases or interests, determine changes in lifestyle, and respond to preferences in ordering. CRM is becoming increasingly powerful as multiple firms attempt to become the preferred suppliers of goods and services—not only to individuals but to other businesses as well.

Attention to this level of service and speed requires an upgraded workforce—which in the past may have been used to do one job or several related jobs on a repetitive, moderately changing basis. In more modern economies, change becomes much more the theme of an economic operation. It then comes as no surprise that the key functions that allow firms to operate in the above manner also need to change. Training in a modern economy needs to have the following characteristics:

> highly focused on needed skills in the context of the work enterprise;

> provided at the right time in the cycle of work and travel for an employee;

> structured to respond to personnel who begin at different points in the learning cycle—for example, some people have more mathematics knowledge than others, some need more drill and practice to understand an issue. others need more writing practice; and

> easily modified and quickly mounted—training that can be reconfigured and delivered rapidly.

Traditional training and education, delivered most often in a face-to-face mode, has had trouble adjusting to the above pressures. While face-to-face training can be modified quickly (with good instructors), such training may have a limited audience or access, and cost pressures can become intense, particularly for senior personnel. E-training offers an opportunity to respond more cost-effectively to the pressures noted above. In most instances, as long as e-training can provide equivalent or better outcomes (retention of knowledge, demonstrably better skills, or higher levels of problem solving) at the same or lower cost than traditional training, then the convenience of e-training and its ability to reach a wider audience often will win out.

APPLICATIONS OF E-TRAINING

Axa—The French Solution[3]

The growth of e-training in France has been slow, compared to the United States. While e-training accounts for 60% of the expenses of corporate training in the United States, in France it accounts for only 11%. Surveys of French companies indicate that face-to-face is still the preferred training model, and that many human resources employees are not clear about e-learning's potential as a training tool.[4] Axa is among the exceptions.

Axa is a multinational insurance group with close to 100,000 employees in 25 countries. Providing training to this large and scattered workforce was becoming increasingly complex and expensive. Axa's Human Resources Department in France decided to use its intranet connection to develop a distance learning program that could ensure fast distribution to a large audience. A modular structure was adopted to facilitate frequent but cost-effective updates of the content material. The company entered into a partnership with IBM for the technical aspects of the training and had a number of partners for production of educational material.

Before starting the project, in 1997, the Human Resources Department organized a five-day retreat to ensure the managers' support for the program. Then, the Department met with the employees to discuss the new training and orient them on how to use the intranet for training purposes. Only after ensuring that managers and employees were ready to accept and use distance learning strategies, the Department began to introduce e-training gradually into the employees' traditional training schedule. Training programs vary between 40 and 400 hours per employee, depending on the topic. The employee can go through the training individually or with the help of a tutor. Tutors are experts in the content area who volunteer to work with the distance education experts. They can be reached by mail, telephone, or face-to-face contact. Piloted in one of the French branches, e-training is now available to Axa's employees worldwide.

The pilot stage provided good results and some important lessons for companies that are thinking of developing their own training:

- Developing training materials for multinational workforces is a major challenge, since learning preferences vary across countries. For instance, English speakers preferred lessons that began with anecdotes and moved from the particular to the general, while the French preferred to look at the general before going into the particular.
- It is important to have a place reserved for training and someone to encourage and prod trainees; few individuals have the self-discipline to search for training independently.
- Supervisors' support is essential for the success of any training project.

Carrefour—A Brazilian Experience

Carrefour is probably the largest wholesale chain in Brazil, with almost 50,000 employees. The chain, founded in France in 1963, has a long tradition of employee training. In the late 1980s, Carrefour founded one of the world's first "corporate universities," the Institute Marcel Fournier, and used videoconferencing for employee training. Currently, the chain has three "corporate universities," one of which is in São Paulo, Brazil: *Instituto de Formação Carrefour* (Carrefour Institute for Professional Development).

The reasons Carrefour moved into e-training are similar to Axa's. As the chain spread throughout the country, the distance between stores and training centers escalated costs. E-training was the strategy of choice because it (1) provides economies with traveling costs, (2) reduces the amount of time employees are away from work, and (3) avoids the complex logistics of planning and implementing training for large numbers of individuals coming from many different places. In addition, it is easier and less expensive to update e-learning material than to produce printed material. The company also perceived a need to maintain a technological lead. According to the Institute's training director, "The majority of large businesses in the world are investing in online training . . . and some are well advanced in this area. We could not be left behind."

Carrefour universities offer a variety of training, not only to employees, but also to clients and vendors. The Brazilian Institute provides 114 courses in different areas that include informatics, marketing, management, etc. The programs have different platforms, including multimedia, video, DVD, television broadcast via satellite, and intranet. The training programs vary in length from four hours to 15 days. Some courses are mandatory while others are elective, and participation depends on the interests of the employee and his or her supervisor. Courses can also be provided on site, and the Institute has many training rooms in addition to a large auditorium with simultaneous translation capabilities. At this time, the Institute is serving only employees, but training programs for clients and vendors are programmed to begin in late 2002. Plans for expansion also include courses on the Internet and a mix of online and face-to-face strategies. In less than one year of functioning, the Institute trained about 3,000 employees.

Cisco Learning Network

Cisco Systems is one of the largest network companies in the world, with annual revenues of over US$20 billion. Headquartered in the United States, the company has 225 sales and support offices in 75 countries. For years, its training programs were managed independently at each different unit, resulting in redundant and inconsistent programming. To streamline, expedite, and improve the quality of the training programs, the company developed the Cisco Learning Network (CLN).

CLN training is developed using multimedia technologies and stored in a centralized database. The employee selects either a full curriculum or individual modules and takes an assessment test. The test results guide the adaptation of the module to respond to the employee's specific needs. The employee is evaluated at different intervals to gauge the effectiveness of the program, and results are stored in a personal training file at the Human Resources database.

The programs can be provided in two ways: (1) in scheduled delivery, at a fixed time and place, or (2) on-demand, for individuals who have particular needs. Scheduled delivery uses three platforms: multicasts (videos that are sent over the network to desktops), virtual classrooms, and remote laboratories. On-demand training uses Web-based on-demand content, CD-ROMs, and remote labs. Laboratories, used to supplement complex topics, include simulations that provide virtual access to equipment and techniques too costly to be available for every learner. It was observed that CLN courses reduced the time sales employees spent away from their customers by up to 40%.

Cisco's training expertise has outgrown the corporation and the company is now a major developer of training solutions. The Cisco Networking Academy Program prepares high school and college students in how to design, build, and maintain computer networks. There are more than 6,000 academies spread throughout the 50 American states. The Academies reflect partnerships between the company and private or governmental organizations, including public schools. Cisco also provides online seminars and Career Certification programs. The certification program has grown from 6,000 students per year to 100,000 and is offered online or through more than 130 sites and 750 certified instructors worldwide. Some of the courses are offered by Cisco Learning Partners, which are organizations authorized to deliver Cisco-developed learning content. According to Cisco management, in the current economy, the key to gaining a competitive advantage is the ability to rapidly disseminate information, education, and training.

Lucent Technologies[5]

Lucent Technologies is a spin-off of Bell Telephone Laboratories, which has been at the center of major innovations in communications technology for more than a century. Launched in 1996, Lucent has focused on research, production, and services in optical, data, and wireless networking; optic-electronics; communications semiconductors; communications software; and Web-based enterprise solutions and professional network design and consulting services.

The Global Learning Solutions (GLS) Learning Architecture, developed by Lucent Technologies' New Enterprise Networks Group, combines the Internet, voice network, and small-dish digital video technology to expand the outreach power of traditional training without losing the human interaction aspect. It uses independent, self-directed learning events (asynchronous strategy) with a virtual classroom in which the instructor and most of the learners are at locations distant from each other (synchronous strategy). A typical course operates much like a college class. Learners meet for one to two hours for the live, facilitated part of the course and work on their own until current assignments, exercises, and readings are complete. Often subsequent live sessions are scheduled with the instructor to follow up on assignments and discuss new material. The extent to which this happens depends on the instructional design. During these interactive sessions, the students can present results to the class, have questions answered, pose new questions, participate in group discussions, and receive their next assignment. Between sessions, the learner still has access to the instructor and the other learners through chat rooms, threaded news groups, e-mail, and instructor Web "office hours."

Using the GLS Learning Architecture, Lucent has developed a training approach to reach a large workforce dispersed across the world. Its training branch, LucentVision Interactive (LVI), was launched in 1999 initially to train more than 9,000 direct and indirect sales personnel. LVI was able to deliver over 150 hours of training per month with similar or better results than those obtained by traditional, face-to-face strategies, while reducing the number of contact hours by 35%. LVI is now expanding into a "Sales and Marketing University" with an audience of more than

22,000 direct and indirect sales, technical sales support, marketing, and product marketing personnel. A total of US$3.4 million in capital investment and US$2 million in expense budget have been allocated to expand uplink portals in three U.S. cities and Singapore, with another 120 downlinks worldwide.

Corporate Universities[6]

Jeanne Meister, a leading expert in corporate education, defines a corporate university as "the strategic umbrella for developing and educating employees, customers, and suppliers in order to meet an organization's business strategies."[7] Corporate training has three basic objectives: to develop corporate citizenship, provide a contextual framework to the company, and build core workplace competencies among employees.

Investment in training and education among large corporations is not new. In the beginning of the 20th century, General Motors had already developed its own educational division: the General Motors Engineering and Management Institute (GMI). Other companies soon followed. Most of this initial corporate training was open only to the company's employees, in particular the managerial staff. They were places to groom future managers. In 1961, the American fast-food chain, McDonald's, opened "Hamburger University." As the more traditional education and training division, the University aimed at instilling corporate values and teaching basic business skills. However, it instituted a major innovation—a concern with involving all those connected with the fast-food chain, either directly (McDonald's employees) or indirectly (franchise owners and their employees). Hamburger University, now with branches in England, Germany, Japan, and Australia, started a trend that continues to grow.

While the traditional means for delivering a corporate education has been the classroom, many companies are embracing the Internet as a medium of instruction because it offers many advantages over face-to-face teaching. A Web-based system of instruction allows centralized coordination but dispersed learning, can be adapted to each individual's learning needs, can provide numerous resources without taking space on a computer's hard drive, and is more convenient to incorporate into the workday than traditional classroom instruction.[8] It also usually cuts costs, often dramatically, when personnel would otherwise have to travel to another city for the instruction.

It is not only big companies that can benefit from corporate universities. Verifone, with about 2,500 employees in regional offices in the Americas, Africa, Asia, and Australia, operates its own university. Verifone University created its curriculum using in-house experts when possible and contractors when necessary. They made all course information available on each employee's computer or at office-based learning centers, and are moving toward making all education available on company Websites. Verifone encourages employees to take charge of their own education, going so far as to provide subsidies for employees' home computer purchases.

Estimates for developing, implementing, and maintaining corporate universities vary widely. Large U.S. corporations are estimated to spend an average of US$10-12 million, or about 2.2% of the payroll, on their universities.[9] Such figures are often unrealistically high for smaller companies, but there are several ways in which these high costs can be reduced.

Two professional associations may be of assistance to those establishing corporate universities: the American Society for Training and Development is a professional association of corporate education officers and consultants, and the European Consortium for the Learning Organisation is a network of business and academic professionals that collaborates on learning. The *Corporate University Review* is a journal available online at *http://www.trainingworks.org/pdf/corpuniversities.pdf*. Several Websites now index e-learning firms, such as L-Guide; the Clearinghouse for Training, Education, and Development; and EdSurf. For-profit firms also have sprung up to consult and provide services in this new field. These include the Corporate University Xchange, The Corporate University, The Virtual Corporate University Extension, Woohoo Inc., and McGraw-Hill.

ENDNOTES

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2 Reich, R. (1991). *The Work of Nations: Preparing Ourselves for 21st Century Capitalism*. New York: A.A. Knopf, cited in Moses, op. cit.

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4 Ghys, S., *E-learning, les enterprises françaises restent à convaincre*. In Jurich, op. cit.

5 This description is taken from Vigil, R.L. (July/August 2000). Getting the Most out of Online Training: Integrating the Missing Ingredients. *TechKnowLogia*, 2(4): 14-19. Available at: *http://www.techknowlogia.org*.

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7 Meister, J.C. (1998) Corporate Universities: Lessons in Building a World-Class Workforce, cited in Jones, op. cit.

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CONCLUSION

19

ARE WE THERE YET?

Wadi D. Haddad
Alexandra Draxler

The preceding chapters discussed ICTs for education in the context of the educational enterprise's struggle to be relevant, responsive, and effective in meeting the challenges of the 21st century, by providing the whole spectrum of education services to everyone, anywhere, anytime with a focus on learning acquisition and teacher empowerment—all under conditions of an ever-expanding base of education clientele and limited physical and human resources. Drawing on the wealth of worldwide knowledge and experience, the authors of the preceding chapters outlined the rationales and realities of ICTs for education, examined the options and choices for applying them, and summarized a series of case studies that illustrated modalities of integrating ICTs into learning systems in different settings.

The message is clear: Technologies are only tools—but powerful ones. They have the *potential* to contribute to different facets of educational development and effective learning: expanding access, promoting efficiency, improving the quality of learning, enhancing the quality of teaching, vitalizing management systems, boosting the possibilities for lifelong learning, and offering e-training for the workplace. But there is a distinction between potential and effectiveness. For the potential of ICTs to be realized, constraints have to be alleviated, and a set of co- and prerequisites must be met. The *parameters* for success cover a wide spectrum, including education policies and strategies; physical, hardware, and software infrastructures; human and financial resources; and implementation modalities.

What are the prospects of the process of effectively integrating technology into learning systems, considering global and country realities? Are we there yet? The answer depends on the destination of the future, the coordinates of the present, and the journey from here to there.

THE DESTINATION

If you don't know where you are going, then it doesn't matter which road you take, does it?
—*Cheshire Cat in* Alice in Wonderland[1]

The process of effectively integrating technology into learning is not a simple one-step activity. It involves a series of deliberate decisions and actions:

> *Rigorously analyzing educational objectives and changes*. This step may involve rethinking educational policies and strategies to accommodate the new challenges and to exploit the potential of ICTs.
> *Determining which educational objectives will be pursued for ICT application*. This decision affects the choice of technologies and modalities of use.
> *Understanding the potential of different ICTs for different applications*.
> *Examining the appropriateness of specific technologies in light of educational objectives, desired roles of teachers and learners, and country realities and prospects*.
> *Sustaining a program of investment in the necessary human, physical, and instructional infrastructures*.
> *Implementing the pre- and co-requisites of effectiveness of ICTs for education within the dynamics of educational change and reform*.
> *Continuous evaluation and adjustment*. Despite their potential, ICTs and their use for education and learning continue to be high-risk operations. But because they are so fashionable, highly visible, and often overwhelming, it is difficult to maintain a rational and critical posture regarding their role. However, for the same reasons, it is crucial to incorporate into any ICT program rigorous evaluation, feedback, and subsequent adjustment in both approach and implementation.

THE COORDINATES

Where are we in this endeavor, and how far have we progressed? We are at the beginning of the road. Some of us are dazzled: the familiar technologies are evolving into more sophisticated ones, and many of the new technologies are astonishing. Some of us are hesitant: our empirical knowledge of the effectiveness of different ICTs is spotty, and our experience with what works and when is still sketchy. Some of us are confused: many of our education policies and practices are not compatible with the nature and potential of ICTs, which leaves us unsure of where to start. Some of us are doubtful: we see problems with convincing people, with finding resources, and with ensuring sustainability. Some of us are holding on: the technologies are changing so fast, and costs are dropping so rapidly, and we are waiting for the technologies to stabilize and prices to hit bottom.

Different countries and institutions are at different places. The digital divide, the gap between the ICT "haves" and "have-nots," is there and widening. Many countries struggling with providing minimal levels of educational services to their populations are questioning the suitability of ICTs for them. Unfortunately, no country or institution has the luxury to think in an orderly and sequential fashion about providing educational opportunities in terms of levels of

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education, domains of access, degrees of quality, or ICT modalities. It is always a question of striking a balance between different demands. In the case of ICTs, as noted in the preceding chapters, there are obvious trade-offs, and ICTs—properly selected and implemented—can accelerate educational development and help countries leapfrog.

ICTs are experimented with, introduced, and integrated into many educational systems and institutions worldwide, through educational radio and television programs, open universities, virtual high schools, exciting children's software, computer-enhanced programs, and Web-based learning opportunities. The private sector has entered the field vigorously, with corporate universities, e-training programs, and educational offerings on the Internet. But many of these efforts are on the margin. Most countries are still far from reengineering their educational systems to make the best use of ICTs, and the objective of effective learning for everyone, anytime, anywhere is far from being fulfilled.

THE JOURNEY

The challenges facing education worldwide will escalate, and the struggle between needs and resources will deepen. The quest for radical solutions will intensify, and the pressure to "do something" with ICTs will keep mounting. Yet, questions about the potential of ICTs and their effectiveness will linger. Under these conditions, how can we rationally and realistically maximize the contribution of ICTs to the realization of effective learning to everyone, anytime, and anywhere?

Will we ever get there? We are like the family of nomads roaming the desert on the backs of camels. One of the children asks, "Are we there yet, father?" "We will never get there, son," replies the father, "we are nomads." Likewise, we are on a journey of pursuit, experimentation, and exploration in a domain characterized by changing landscapes, moving targets, elusive destinations, and evolving modes of transportation. We may never get there, but we can certainly get close. Five ingredients are necessary for the journey:

Hard Work

Experience has shown that effective integration of ICTs into education and learning systems is not instantaneous; it takes sustained hard and deliberate effort, keeping in mind three considerations:

- ICTs for education, like any educational activity or reform, require a long gestation period. Therefore, commitments, efforts, investments, and implementation schemes must be sustained over a long period of time. For instance, let us keep in mind that we have been experimenting with Web-based learning for far less time than it takes one cohort of students to go through school.
- Integration of ICTs into education is a radical innovation and should be treated as such. Innovations require building a solid base of knowledge and commitment, interacting with interest groups, generating and testing different options, experimentation, planning for large-scale implementation, critical mass application, and a mind open to modification and adjustment. How radical and comprehensive should an innovation be?

> It is obvious that an incremental issue-specific approach is always superior to a comprehensive strategic approach . . . . A step-by-step approach allows experimentation and adjustment and does not have high political and institutional demands. On the other hand, this approach may lead to "low-risk" quick-fixes, and inadequate investment in terms of political capital and other resources to carry the reform off successfully. The success stories of . . . case studies have shown that to solve sector-wide problems in the context of political and economic demands, it is prudent to start with a limited incremental phase, but this should be succeeded in time by a comprehensive strategic approach. The timing and speed of this evolution should be gauged to the degree of acceptability of the reform by the stakeholders, and the implementation capacity of the system.[2]

- Educators (teachers and education administrators at all levels) are central to ensuring that ICTs will be introduced and integrated properly into the teaching/learning process. One should not assume that educators will be supportive naturally. ICTs transform dynamics of the education enterprise; they change the roles of teachers, administrators, students, and parents. At the same time, ICTs can break school insulation; they connect schools to a world beyond the immediate environment and make them more transparent to parents and communities at large. Educators need to be convinced of the benefits of ICTs for them and their professions and must be brought actively into the early stages of planning and development.

Creativity

Effective application of ICTs requires creativity in exploiting the technologies of today and imagining the potential of the technologies of tomorrow. Current technologies have not been well explored and exploited. Compared to business, commerce, and entertainment, education is very far behind. There is a whole world out there of animations, simulations, digital pads, electronic books, virtual presentations via Webcasting, chat rooms, videoconferencing, machine translation, speech technology, handheld computers, electronic white boards, and virtual reality. Combining these technologies provides learning environments beyond our imagination, but within our reach.[3]

But strategies for using ICTs for education solutions should not be driven by the potential of current technologies alone. The world of ICTs is exploding with new inventions, and the lifetime of many technologies is shorter than the lifetime of educational reform. Yet, it is hard to imagine what technologies will exist in 10 years. Only 15 years ago, the hottest items were fax machines, a slow computer, and a dot matrix printer. There were no e-mail, Web sites, digital radio, or application CDs. Technology is moving faster than our imaginations; however, education strategists need to keep their fingers on the pulse of technological innovation. Four areas are of particular interest to educators:

> sensors connected to computers that can sense speech, physical conditions, and even brain waves;
> Internet 2, with enormous capacity and speed (the entire *Encyclopaedia Britannica* collection could be downloaded in about 15 seconds!);
> wearable PCs that will change the whole notion of computer infrastructure, networking, and configuration; and
> nanotechnology (a nanometer is one billionth of a meter), which may lead to such small computers that, by 2020, we may be able to use the Internet to download not just software, but hardware as well.

Research and Development

ICTs for education call for dramatic changes in education systems, heavy investment, and long-term commitments; yet, the knowledge base to make decisions and choices is not commensurate with the enormity of what is required. Meanwhile, educational technologies are about education and learning. While our knowledge of learning has improved significantly as a result of advancements in cognitive and brain science, research into the effect of ICT interventions on the learning process, including neurophysiology, is nearly nonexistent.

As noted in chapter 3, a significant body of research on ICTs' effectiveness is available, but it is often contradictory, difficult to interpret, and even more difficult to use in the policy-making process. What is needed is more large-scale longitudinal research, policy-related studies, comparative analyses across countries and contexts, cost-effectiveness measurements, formative evaluations of experimental projects, and piloting.

Despite its shortcomings, current knowledge tends to accumulate in the hands of a few, more often than not driven by powerful economic interests and concentrated in the hands of a few institutions (private and public). Such knowledge, to a large extent, is concentrated in economically and technologically advanced countries, and sometimes in institutions that are not traditionally part of the educational or academic community. Local, regional, and international mechanisms must be created to build a solid knowledge base of ideas, issues, research results, case studies, best practices, and resources. Such knowledge clearinghouses will offer up-to-date information and syntheses to assist decision makers and practitioners in the design and implementation of educational technology programs without reinventing the wheel or repeating others' mistakes. They also will help in identifying knowledge gaps and topics for research.

Unfortunately, however, research, broad evaluation, and development have not attracted much funding. Countries and institutions seem to be willing to invest huge amounts of money in ICT projects with little knowledge of their potential benefits, but are unwilling to invest a small fraction of these amounts in research and development to protect their large investments and improve their effectiveness. A review of government support of educational technology research and development (EdTech R&D) produced the results summarized in Table 19.1.[5]

There is a legitimate justification for public funding of EdTech R&D. A knowledge base totally derived from market supply will have many gaps, which will decrease its usefulness. Also, current conditions create distortions in the knowledge "market." For instance, some current players may have no incentive to invest in sophisticated studies. As gaps are identified and distortions in knowledge generation detected, public resources need to be invested to fill these gaps and redress these distortions.

Quality Assurance

As more educational software and entire courses of study become available via radio, TV, the Internet, or some combination of these, whether free or fee-based, the issue of quality assurance becomes acute. Regional and international cooperation is needed to establish standards, guidelines, and accreditation mechanisms. It is in the interest of all partners, including those in the economic sector, to introduce coherence and transparency into this new, mushrooming market. At the same time, ownership of knowledge, and the legal and tariff framework that governs cross-border exchange of knowledge, need to be sorted out.

TABLE 19.1 • OVERVIEW OF INTERNATIONAL INVESTMENT

COUNTRY / REGION	EDTECH R&D INVESTMENT, FY 2000
United States	285,000,000*
Canada	12,000,000
European Commission	65,000,000
South Africa	230,000
Korea	330,000
Japan	11,420,000
Australia	737,000

** Only $40 million was designated specifically for EdTech R&D.*

A Seat at the Drawing Board

The education sector has been using the technologies developed for the business and commercial sectors, and has been caught in a cycle of purchasing ever more powerful computers and software. Technologies for education, therefore, generally have been applications of "generic" technologies rather than unique responses to educational needs.

The question many are asking is: Do we really need high-powered computers, continuous connectivity, and the most up-to-date operating software to use computers for education purposes? There is no empirical answer because there has been no systematic attempt to sit down at the drawing board and set design specifications for an "education machine" that meets the pedagogical and institutional needs of the education sector within the financial parameters that govern this public, nonprofit sector. There have been some humble efforts in countries such as Brazil and India to address this issue and produce a less costly computer with a longer operating life, but what is needed is a more concerted effort in this domain.

The international development community (UNESCO, World Bank, UNDP, etc.), which is providing millions of dollars in support of ICTs in schools, should take this issue seriously and invest a small portion of these amounts in an institute or commission to explore and encourage new technologies that address educational needs specifically, have long lifetimes, and are cost-effective. Such a body should include education planners, technologists, engineers, programmers, and education consumers from the public and private sectors. Unless we take such collective and intelligent action, technologies for education and learning will continue to be vendor-driven, unattainable, and unsustainable.

A FINAL THOUGHT

Integrating ICTs into education and learning systems is an intricate, multifaceted process. The only constant in the process is change: change in the educational landscape and its demands, in technologies and their potential, in the parameters for success. The journey from where we are to where we want to be is long, unpredictable, and challenging. Every day we will be fascinated by a new technology, exciting software, and a dazzling application. We must not lose sight of the destination, however; teachers and teaching, and learners and learning.

Our insurance against this temptation is the child. It is amazing what a child can do for us as adults. We are sucked into the whirlwind of jobs, stocks, houses, recipes, and technologies . . . until we look into the face of a child. Life regains perspective. We see the mystery of life unfolding, and we realize what is important and what is marginal. So it is with technology. We are sucked into the wonders of fast chips, intelligent toys and games, and fascinating virtual domains, and we get taken by the miraculous potential of these technologies for us and our children . . . until we look into the face of a child. There we see the miraculous transformation of life at work. Only then do we see with clarity the distinction between means and ends, between tools and objectives, between touching buttons and touching hands, between technologies and learning.

The most successful technologies are those that become unnoticed. We do not think anymore of the spectacle of printing every time we read a book, the phenomenon of TV every time we watch a movie, or the miracle of the telephone every time we make a call. The ultimate success of *ICTs for learning* will be attained when we stop marveling about the *ICTs* and apply our minds and emotions to the wonders of learning.

ENDNOTES

[1] Available at: *http://www.sabian.org/alice.htm.*
[2] Haddad, W. D. (1995). *Education Policy-Planning: An Applied Framework.* Paris: UNESCO, International Institute for Educational Planning.
[3] As an example, Web technologies that either exist or are being developed create scenarios for second-language instruction that sound like science fiction, but are not. See: Jackson, J., & Costante, G. (November/December 2001). Web-Mediated Second Language Instruction: Will It Actually Work? *TechKnowLogia.* Available at: *www.TechKnowLogia.org.*
[4] Jackson & Costante, op cit.
[5] Bakia, M. (April-June 2002). Government Support of EdTech Research & Development: An International Overview. *TechKnowLogia.* Available at: *www.TechKnowLogia.org.*