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THE DYNAMICS OF TECHNOLOGIES FOR EDUCATION

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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.

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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

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).

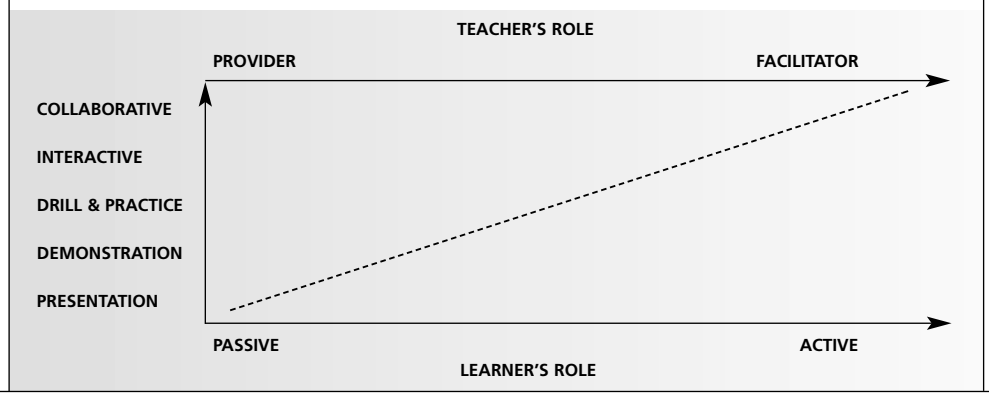
For instance, if teaching is demonstrating and telling, and if learning is memorizing and reciting, using learning technologies and multimedia programs for this purpose will not have the desired impact. Also, if students are not asked to search and work collaboratively, and if teachers function independently, 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

[1] See: *http://www.developmentgoals.org/*.
[2] See: *http://www.unesco.org/general/eng/about/constitution/pre.shtml*.
[3] OECD. (1997). *Literacy Skills for the Knowledge Society*. Paris: Author.
[4] Haddad, W.D. (November/December 2000). Teachers...Training...and technology. *TechKnowLogia*. Available at: *www.TechKnowLogia.org*.
[5] For examples of virtual secondary schools, see: *www.class.com*, *www.Keystonehighschool.com*; for examples of homework help, see: *www.Homeworkhelp.com, www.TopTutors.com*, and *www.Tutor.com*.
[6] Haddad, W.D. (January/February 2001). The Education Enterprise: Is It Manageable? *TechKnowLogia*. Available at: *www.TechKnowLogia.org*.
[7] OECD. (October 2001). *Learning to Change: ICT in Schools*. Paris: OECD.
[8] Quoted in Glenman, T., & Melmed, A. (1966). *Fostering the Use of Educational Technology: Elements of a National Strategy*. Santa Monica, CA: Rand.
[9] See: *www.newdealinc.com*.
[10] Burchinal, L.G., Martinic, L., & Wolff, L. (January/February 2001). Using Technology to Manage Education Information: ERIC and REDUC. *TechKnowLogia*. Available at: *www.TechKnowLogia.org*.
[11] Jackson, G.B. (May/June 2000). How to Evaluate Educational Software and Websites. *TechKnowLogia*. Available at: *www.TechKnowLogia.org*; Jackson, G.B. (March/April 2001). Evaluating Computer and Web Instruction: New Opportunities. *TechKnowLogia*. Available at: *www.TechKnowLogia.org*.
[12] Brown, T. (March/April 2001) scilink: The World's a Click Away. Available at: *www.TechKnowLogia.org*.
[13] Cuban, L. (1986). *Teachers and Machines: The Classroom Use of Technology Since 1920*. New York: Teachers College Press. Quoted in: *http://www.rand.org/publications/MR/MR682/ed_ch2.html#fn30*.
[14] Moses, K. (January 2002). Educational System Computer Maintenance and Support: They Cost More Than You Think! *TechKnowLogia*. Available at: *www.TechKnowLogia.org*.