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ICT FOR EDUCATION: PREREQUISITES AND CONSTRAINTS

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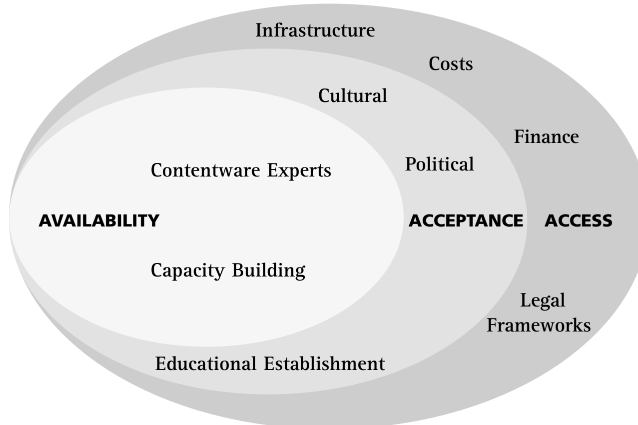
FIGURE 4.1 • PREREQUISITES AND CONSTRAINTS IN THE USE OF TECHNOLOGY FOR EDUCATION

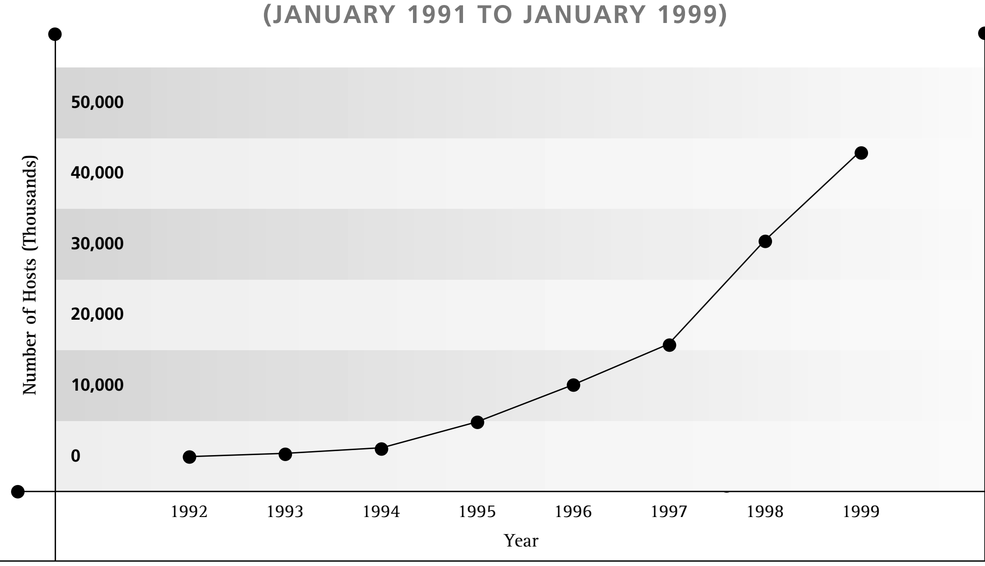


ACCESSING THE TECHNOLOGIES: THE BASIC CHALLENGE

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]

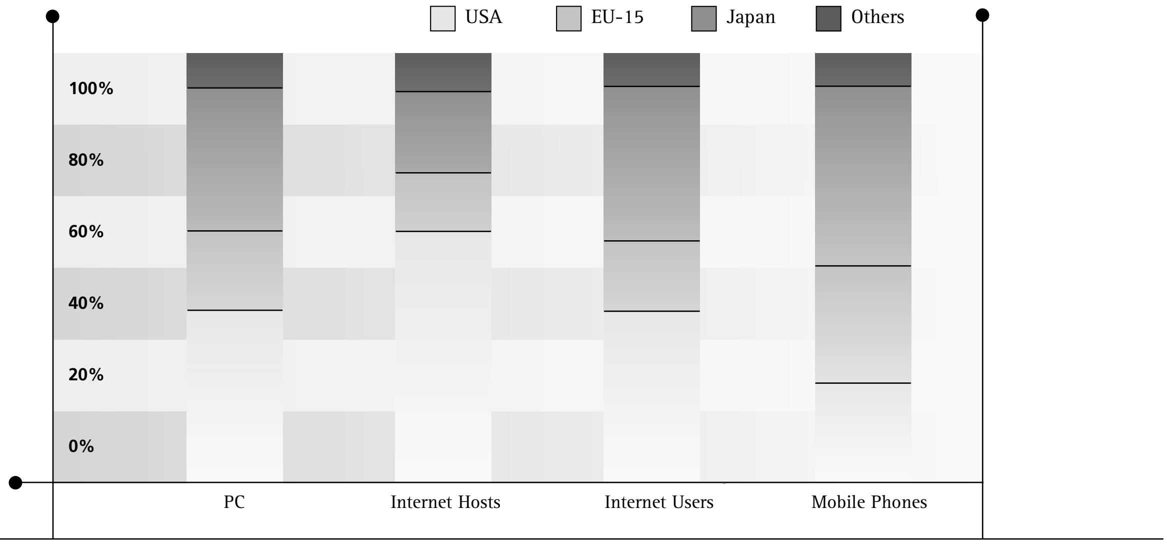
Access to ICTs depends on three basic prerequisites: infrastructure, costs and financing mechanisms, and legal frameworks.

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:

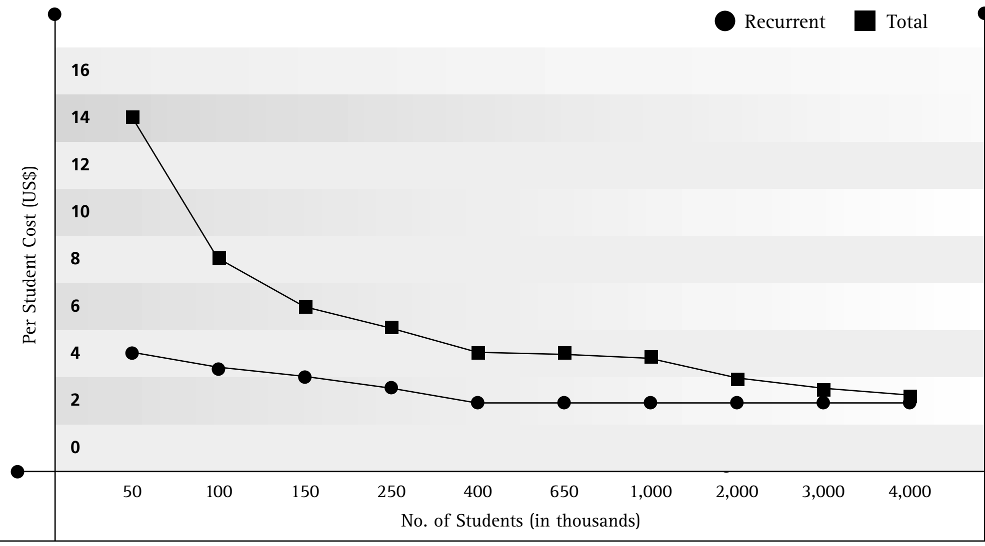
> *TC (Total cost)* is the sum of fixed costs plus the product of variable costs multiplied by the output, N;
> *N* is the project output, generally measured as number of students served, number of graduates, or student contact hours;
> *FC (Fixed costs)* are the costs incurred with the development and 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]

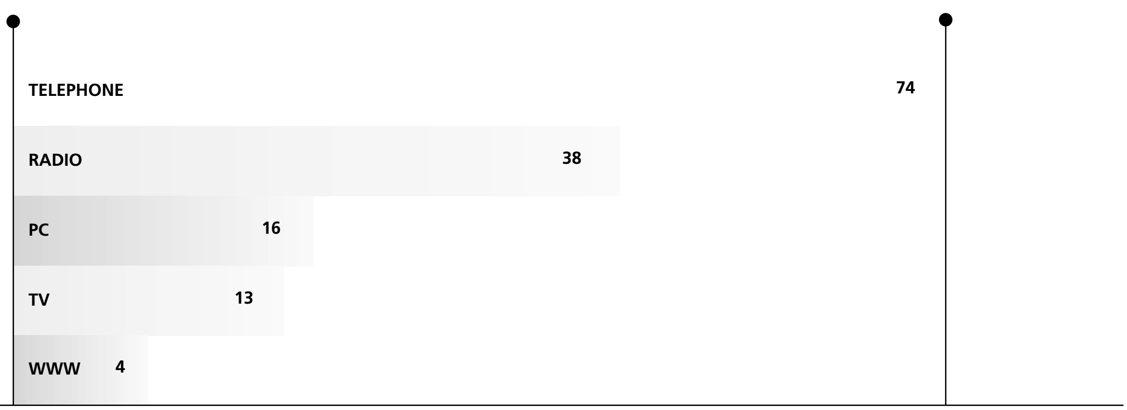
The Elderly

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 air-time, 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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