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Interactive Educational Technologies in Higher Education

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Abstract

This paper, one in a series of studies on science and technology, discusses the status of interactive technologies in higher education programs and provides recommendations for their use in both on-campus and distance learning courses. Two main types of educational technologies are reviewed: (1) computer-mediated instructional technologies which are individual, self-standing units, and of which multimedia technology is the fastest growing example, and (2) technologies based on telecommunication networks. These provide asynchronous communication (e.g. electronic mail, computer bulletin boards, computer conferencing) or synchronous real-time instruction (audioconferencing, audiographics, interactive one-way television with audio return, and interactive two-way and multi-point television). Possible uses of these technologies are illustrated by example, and include those which improve the effectiveness of education, increase efficiency through lower-cost alternatives to conventional instruction, extend access to geographically, economically or socially isolated learners, as well as technologies which produce graduates with heightened capacity to adapt to technological change and innovation. Potential problems and obstacles to implementation are also identified, including those which stem from inadequate technological, educational, economic, administrative and cultural environments. Finally, suggestions and recommendations are given for a successful implementation and a long-term sustainability of interactive technological systems at universities and colleges in industrial and developing countries.



FOREWORD

The current exponential expansion of international networks for scientific, educational and technological communication merit increased attention. At present, high-income countries are the prime developers and users of interactive educational technologies. With the advancement of basic infrastructure and tele-communications, however, increasing number of nations are realizing the potential of this new technology to development.

The World Bank recognizes that the use of interactive technology in research and training could significantly contribute to improved educational effectiveness, higher quality of programs and help institutions to strengthen their global partnerships. This paper examines various uses of interactive technology in both developed and developing countries, illustrating how it has been implemented in different educational settings. It has a special focus on the relevance of this new technology for developing countries, discusses the advantages, opportunities and obstacles of its implementation and provides a number of recommendations for further expansion. The paper draws on comprehensive reviews of scientific research and literature, on original research and personal communications as well as visits to educational institutions. When reading the paper, it is important to recognize its multi-layer structure. Various audiences are addressed, by making use of big and small fonts, the latter of which provides details of technologies, specific applications in selected educational institutions, and their costs and effectiveness.

This paper was prepared to serve as a source of information to both World Bank staff and their colleagues with interest in interactive technology.

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Contents

Abstract	I
Acknowledgments	II
Table of contents	III
Executive summary	VII
Introduction	1
1. The role of educational technologies	2
The importance of educational technologies	2
Policies	2
Technology and education	2
Educational technologies in industrial and developing countries	3
Efficiency and effectiveness	3
Educational technologies in distance learning	4
The generations of educational technologies in distance learning	4
Relevance and use of educational technologies in distance learning	5
2. Educational technologies: main types, characteristics, costs and applications	
Computers	7
Multimedia	9
Types of multimedia technologies	9
Videodisks and interactive videodisks (IVD)	10
Laserdisk-Read Only Memory (LD-ROM)	10
Compact Disk - Digital Audio (CD-DA) and the Photo CD	11
CD-ROM and CD-ROM XA	11
Digital Video Interactive (DVI)	13
CDI - Compact Disk Interactive	14
Commodore Dynamic Total Vision (CDTV) and CD32	14
Video Information System (VIS) and 3DO multiplayers	14
Electronic books and personal organizers	15

Virtual reality	15
A comparison of multimedia systems characteristics	15
Analog and digital formats	15
Storage forms	16
Compression	16
Comparison of main characteristics	16
Educational uses of Multimedia	18
Examples of costs and effectiveness analysis	24
Educational technologies based on telecommunications	28
Telecommunication and transmission systems	28
Microwave Systems	28
Fiber optic systems	28
Satellites	29
Packed-radio technology	31
Compressed video systems	32
An example of a successful approach to telecommunications	32
A cost comparison of transmission system	34
Radio broadcasting and Interactive Radio Instruction (IRI)	35
Broadcast television	36
Facsimile (Fax)	36
Computer-mediated telecommunication technologies for asynchronous communication	37
Computer networks	37
Teletex systems	45
Viewdata systems (Videotex)	45
Electronic mail (e-mail)	45
Computer bulletin boards	48
Computer conferencing	48
Electronic journals	51
Interactive telecommunication technologies for synchronous communication	52
Audioconferences (audio teleconferences)	52
Audiographics (audiographic conferencing)	54
Interactive one-way television with audio return	56

Interactive two-way television systems	56
Examples of electronic classrooms	58
Technological structure of university-level distance education programs:	60
An example: The post-secondary distance learning programs in the USA - the 1990s	60

3. Discussing interactive technologies

Successes	63
Potential dangers, obstacles and problems	64
Inadequate technological environment	65
Inadequate educational environment	65
Inadequate economic environment	77
Inadequate administrative, legal, political or cultural environment	77
Possible solutions and recommendations	68
Improving the technological environment	68
Improving the educational environment	69
Improving the economic environment	71
Improving the administrative environment	72
The vision	72

Appendix 1: Differences between developing and industrial countries	73
--	-----------

Appendix 2: Selected bibliography	76
--	-----------

List of Tables

- Table 2.1: Multimedia matrix: increasing the complexity of applications by adding media (from text towards synthetic images), and by increasing automation.
- Table 2.2: A comparison of multimedia systems
- Table 2.3: Selected examples of commercially available multimedia educational products
- Table A1: Library collections at institutions of higher education: selected countries

List of Figures

- Figure 2.1: CD-ROM titles by subject
- Figure 2.2: Price range of DC-ROM and multimedia CD titles in 1993
- Figure 2.3: The growth of CD-ROM and multimedia titles
- Figure 2.4: Transmission costs compared for various systems and distances: increase of the first year total costs for two sites in relation to the distance between them
- Figure 2.5: Transmission costs compared for various systems and distances: average costs per year for a 5 year period in relation to the distance between two sites
- Figure 2.6: Use of technologies for recorded programs in the American two-year colleges with distance learning programs
- Figure 2.7: Use of technologies for recorded programs in the American four-year universities with distance learning programs
- Figure 2.8: Use of interactive technologies in the American two-year colleges with distance learning programs
- Figure 2.9: Use of interactive technologies in the American four-year universities with distance learning programs
- Figure 2.10: Planned expansion of technologies for distance education in the American post-secondary institutions: pre-recorded and interactive programs
- Figure A1: Public expenditure on education: as \$ per inhabitant, and as % of GNP in 1991
- Figure A2: Gross enrollment ratio at third level of education in 1991
- Figure A3: An indicator of potential expansion of higher education student population: Annual average increase in 20-24 years old population during the 1990-2000 period
- Figure A4: Third level education teaching staff versus student enrollments in 1991
- Figure A5: Television and radio receivers per 1,000 inhabitants in 1991
- Figure A6: Number of telephone lines per 100 inhabitants in relation to the GNP per capita, 1992
- Figure A7: World market development in telephone lines (total for analog and digital technology): 1990 and projections for 2000
- Figure A8: World market expansion in digital telephone lines: 1990 and projections for 2000
- Figure A9: Growth of telephone communication lines: Ten developing countries with highest growth indexes in comparison with selected low growth industrialized and developing countries
- Figure A10: Total annual gross investments in telecommunications (including land and buildings) as a share of GDP in 1992

Executive Summary

Interactive educational technology is used:

- to improve the effectiveness of education by raising the quality of teaching and learning;
- to increase efficiency through lower-cost alternatives to conventional instruction;
- to increase enrollment and extend access to geographically, economically or socially isolated learners; and
- to produce graduates with better adaptability to information-based technological environments.

Developed and developing countries use interactive educational technology for different reasons. In developed countries, technologies are used primarily to improve the effectiveness of teaching and learning, to individually tailor instruction, and to provide specialized education to small groups of learners. Developing countries, on the other hand, seek low-cost alternatives that improve educational and research efficiency and increase access to education while maintaining a high level of effectiveness.

The rapid expansion of telecommunications and computer-related industries has resulted in a variety of interactive technologies applicable to higher education. Generally, they fall into two main groups:

- The first group consists of computer-mediated technologies, which are designed as individual self-standing units. These can be individual microcomputers or, less frequently, a series of microcomputers connected to a local area networks. They are most often used to increase the effectiveness of teaching and learning. Computer-driven self-paced tutorials, educational databases, graphic design programs, three-dimensional viewing and modeling, computer simulations, and expert systems are all example of such technology. The fast growing field of multimedia applications, which include Interactive Videodisks (IVD), Compact Disk - Digital Audio (CD-DA), Photo CD, CD-ROM and CD-ROM XA, Digital Video Interactive (DVI), Compact Disk Interactive (CDI), Video Information Systems (VIS), Electronic books and Virtual reality, is the main formats for such instruction.
- The second group is based on telecommunications. These technologies utilize local or wide area communication networks. These technologies are used to increase the efficiency of distance learning, while maintaining a high degree of effectiveness. The two main sub-categories of this group are: (1) technologies for asynchronous communication, such as telefax, teletex, videotex, electronic mail, and computer bulletin boards, (2) technologies for synchronous communication, which include audioconferencing, audiographics, computer conferencing, interactive one-way television with audio return, and interactive two-way and multi-point television systems.

The main developers and users of interactive educational technologies are high-income countries with strong technological and telecommunication infrastructures, especially the USA, Canada, Western Europe and Japan. The majority of developing countries do not yet use them on a large scale. However, basic infrastructure and telecommunications are improving in many developing countries, along with the managerial and technical capacity for implementing educational innovations. This makes the introduction of interactive educational technologies more feasible. Successful implementation now could spur expanded use of interactive technologies in universities and colleges in middle- and low-income countries in the future.

Several *advantages and improvements* can result from using interactive technologies in tertiary level education and research. If the systems are carefully designed and well implemented, they can result in the following educational and economic benefits:

- 1) **Improved effectiveness of on-campus and distance learning.** Increased interactivity of the programs permits more communication, and may lead to increased motivation, creativity and independence among learners. In addition, students can access much more information, receive quick feedback, and constantly evaluate their progress.
- 2) **Higher quality of instruction.** Interactivity, by overcoming time and geographic constraints, facilitates the inclusion of experts in specific fields to guest lecture in distance courses.
- 3) **Increased enrollment.** The time and place independence which some interactive courses offer provides the convenience which allows students to enroll who would have previously been unable to do so.
- 4) **Improved cost-effectiveness.** Under some circumstances, interactive technology can lower the cost of adding additional students who can be effectively taught. Time and place independence also saves travel time and costs.
- 5) **Better technological and communication skills.** Students learn to manipulate new technologies and to communicate electronically.

However, attention must be paid to potential *dangers and problems*, which can arise due to inadequate technological, educational, economic, administrative or cultural conditions. These include:

- 1) **Technological problems.**
 - Interactive educational technologies will only run smoothly where a sound basic technological and telecommunications infrastructure exists, and where a high degree of technical expertise is available for maintenance and support of operations.
 - Short life spans of computer software and hardware, along with compatibility problems, make upgrading and additional investments necessary.

- Harsh climatic conditions may result in frequent telecommunication break-downs and equipment damage.
- 2) **Educational obstacles.**
- Effective use of interactive technologies requires substantial faculty training and preparation, as well as an increased commitment, flexibility, cooperativeness and readiness to deal with occasional technical problems.
 - Technology *per se* cannot, nor is it intended to, replace teachers or usurp their responsibilities. Increased care and more time in curriculum design is necessary to create or adapt university courses which use interactive technologies beneficially.
 - Insufficient cooperation and coordination between technology experts and curriculum developers, educational policy makers, technical support staff, faculty and students, reduces the effectiveness of interactive instruction.
 - Resistance to innovation can be a major barrier to implementation of interactive technologies. Faculty reluctance may be due to insufficient training with technology, unwillingness to change the established traditional teaching approaches, or both.
- 3) **Economic considerations.**
- Introduction of interactive technologies is initially costly to an educational system. In low-income economies, these costs may be prohibitive. Even middle-income countries which can afford the initial investments may have difficulty meeting recurrent costs.
 - In some cases, positive educational impacts of interactive technologies are not viewed as significant enough to justify large scale investments.
- 4) **Administrative, legal, political or cultural barriers.**
- Administrative regulations and bureaucratic procedures may interfere with efforts to increase communication and cooperation on micro and macro levels.
 - Unresolved intellectual property issues hinder a wider application of certain technologies.
 - In some countries state or political control of computer-mediated communication may make educational uses impossible.
 - Frequent leadership changes, lack of coordination between government agencies, or instability and discontinuity in educational institutions may adversely affect the implementation of interactive educational technologies.
 - Technophobia and resistance stemming from cultural, religious, ethnic or social traditions also inhibit use.

Numerous examples prove that interactive technologies can be successfully implemented and used at institutions of higher education around the world. Based on these experiences, the following suggestions and recommendations are stressed:

1) **Improving the technological environment.**

- A system of technical support and expertise should be established and available to faculty and students.

- Permanent training to maintain the high quality technical support is essential for a long-term success.
- In order to lengthen the life span and increase the effective use of interactive educational technologies, a reliable supply of spare parts and maintenance and repair services must be available.
- Funds must be available for maintenance and regular upgrading of entire systems.
- Equipment and software should be reliable, easy to operate, simple to learn, widely available, expandable, standardized, and compatible with existing systems.
- Leasing hardware and telecommunication lines from commercial users may be an alternative way to begin interactive instruction where investment funds are scarce.

2) Improving the educational environment.

- Planning and implementation of educational technologies should start from a clear educational need or goal -- e.g. to improve quality of on-campus instruction, to supplement the program, to expand access to new students, or to reach distance learners.
- The introduction of interactive technologies should require substantial advance preparation. It should be evolutionary and incremental. It should start with simpler settings or with courses that are easier to develop.
- A cooperative environment among faculty departments and specialists is essential when introducing a new interactive technology.
- Faculty/staff development and training should begin as soon as the introduction of technological innovations begins. It must accommodate different levels of experience with technology, as well as the differences among disciplines. Hands-on, interactive, on-going training programs should be offered.
- Instructors are more motivated when they are well informed and adequately trained, when they participate in planning and decision-making processes, and when they see administrative support and financial or other incentives for increasing development and use of interactive technologies.
- Students using interactive technologies in their studies must receive training.
- Different technologies suit different purposes. A combination of technologies is usually most appropriate. The choice of technology should be based on several factors, such as:
 - * educational form -- distance education programs require different technologies than on-campus courses,
 - * education field -- scientific and technological disciplines require approaches which differ from and educational tools than do arts, social sciences or business education,
 - * degree of interactivity needed -- systems with high degree of interactivity are generally more expensive but also more efficient,
 - * characteristics of learning audience -- numbers and geographical distribution of students, their educational level, age, cultural and technological backgrounds should be taken into account,
 - * local conditions and individual characteristics of instructors should not be forgotten.

3) Improving the economic environment.

- Stable and regular financing must be guaranteed for initial investments in technologies, for curriculum development and adaptations of educational materials, and to cover recurrent costs.
- Educational projects funded with foreign aid donations should consider and plan for domestic funding to maintain the system when the aid project funding runs out.

4) Improving the administrative environment.

- Agreement among policy-makers, administrators, program developers and end users is necessary on topics such as the governance and decision making procedures, financing, implementation methodologies, and evaluation methods for the use of information technology.
- Adequate training and early involvement of key administrators into these processes is essential.

The use of interactive educational technologies will without a doubt expand in future. As large computer systems become available more widely and international communications costs decrease, open electronic universities will offer a variety of distance programs and provide education internationally via global communication networks. Before this occurs, however, several barriers will have to be overcome. Telecommunication infrastructures which meet a minimum uniform standard of quality must be in place in developing as well as developed countries. Standardization of equipment must increase. International intellectual property issues must be resolved and national regulations which inhibit the diffusion of technology must be removed. Impediments due to differing curricula and approaches to education, language barriers, and fear of cultural imperialism must also be overcome. The current exponential expansion of international networks for scientific, technological and educational communication shows that such advances may be realizable much sooner than expected.



Introduction

Interactive educational technologies provide customized education which allows students to interact one-on-one with the media, to learn at their own pace and to determine the depth and breadth of the specific area they want to pursue. Typical examples include multimedia and computer driven tutorials (Malhotra and Erickson, 1994).

Some authors consider radio and TV broadcasting (with a possibility to discuss the topic of instruction with a mediator in a classroom) as interactive technologies. In other literature, the term interactive technologies means educational uses of e-mail, computer conferencing, and audiographics. In its most narrow sense, the term refers to synchronous two-way communication used in distance education (one-way video with two-way audio, and two-way or even multi-point video systems).

This paper discusses interactive educational technologies in a broad sense which includes computer-assisted learning, multimedia technologies, asynchronous computer-mediated communication, and two-way synchronous communication systems. One-way radio and TV broadcasting, however, are not considered interactive.

The intention of this study was to:

- identify the main types of interactive educational technologies used in higher education,
- illustrate how they have been implemented in different educational settings,
- and on the basis of these examples to:
 - identify the advantages, opportunities and obstacles of their implementation,
 - and
 - suggest some recommendations for further projects.

The paper does not provide an exhaustive inventory of the technical aspects of interactive educational technologies or a complete list of their uses in educational institutions. The multi-layer structure of the text tries to satisfy several audiences. The main text gives basic information, the core of discussion issues, and main conclusions. Examples in smaller font illustrate details of technologies, specific applications in selected educational institutions, and their costs and effectiveness. Finally, references to original papers permit more detailed and deeper study of the chosen topics.

The main information sources for the preparation of the study were conference proceedings, discussion papers, technical and research reports, scientific journal articles and monographs, as well as personal communications and visits to selected educational institutions.

1. The Role of Educational Technologies

The importance of educational technologies

Policies

Education policy incorporates technology options to achieve the following goals:

- to improve the effectiveness of education, at affordable marginal costs,
- to improve efficiency through lower-cost alternatives to conventional instruction,
- to extend access to those shut out of the educational process by geography/economics and/or social status,
- to transform education technologically in order to make it more compatible with an information- and technology-based society.

Technology and education

There are two important links between education and technology.

First, the use of technology in education (educational technology) potentially enhances the general efficiency of education and provides a country with a pool of trained and skilled manpower to meet the needs of the labor market. In addition, some of the new technologies improve distance learning and thereby meet growing and previously unmet demand for education, and provide an affordable quality education when resources and qualified personnel are scarce. Students using computer-based educational technologies and communication systems during their studies are better prepared for future jobs in competitive information-based industrial environments.

Second, science and technology education, which is enhanced with interactive technology, provides a labor force with a better absorptive capacity for technological change and innovation, informed entrepreneurs who can make better use of resources, and professional science and technology specialists. These advances, in turn, allow a country to make optimal use of existing technology and to develop new technologies. All of these capabilities are essential to greater productivity and economic growth.

Educational technologies in industrial and developing countries

The rationale for using educational technologies is different for developed and developing countries. Developed countries have well established schooling systems and high enrollment levels. They primarily use technologies to improve the effectiveness of teaching and learning, to individually tailor instruction, and to provide specialized education to small groups of learners. In developing countries, on the other hand, where good schools are affordable only for a relative few, policymakers seek alternatives that make significant improvements in educational and research effectiveness, while at the same time increasing access to education, particularly at the secondary and tertiary levels, at lower cost per student.

The managerial and technical capacity for implementing educational innovations has increased in many developing countries. In addition, the infrastructure necessary for using more sophisticated technologies has been strengthened. Availability of electricity, telecommunications, and computers has increased. Therefore, in spite of educational and technological differences between low- and high-income areas (see Appendix 1), the introduction of interactive educational technologies has become more feasible in developing countries.

Effectiveness and efficiency

Financing, especially that done by governments, significantly affects access, choice, and quality of education. Developing countries, while able to provide access to primary school education to most children, have much lower levels of enrollment at the secondary and tertiary levels. It has been shown that as the quantity and quality of secondary and higher education levels rise, per capita income also increases. Therefore, it is necessary to find the most cost-effective and efficient way to deliver quality education within budgetary constraints.

Interactive educational technologies improve the effectiveness of education in two ways.

- (1) They directly improve the quality of teaching and learning through integrating several educational media, improving structure and organization of teaching units or lectures, increasing interactivity and a higher degree of communication between students and teachers.
- (2) They also help to overcome the cost and/or distance barriers and therefore add a variety of new educational possibilities to conventional educational methods: they furnish access to remote databases, update the knowledge pool, supplement laboratory work by modeling, simulations and expert systems, provide rapid feedback, and enhance counseling and evaluation. Multimedia and telecommunication-based interactive technologies are used to increase the effectiveness of education especially when a very high level of expertise is required. The most rapidly developing application fields seem to be medical education, specialized technical training, and individually-tailored business courses.

Telecommunication-based interactive technologies can also provide an efficient alternative in distance education, because they can use predesigned, high quality and effective educational materials. They can save instructor's or student's travel time and other transaction costs while expanding access to new students. In on-campus courses, interactive technologies can be used as efficient individualized learning tools in large classes. Typical examples of such use are found in business, management and social sciences courses, introductory-level

mathematics and physics courses, writing and language courses, and computer science and programming. Other efficient application of interactive technologies are computerized self-testing and evaluation programs for large groups of students, as well as computer-designed and supported examinations, grading and record-keeping.

Educational technologies in distance learning

The generations of educational technologies in distance learning

Past educational projects and research have yielded substantial information about both the theoretical aspects of using technology for education and about the technical particulars of implementation. Particularly for distance learning, defined as an educational process in which a significant proportion of the teaching is conducted by someone removed from the learner, the effectiveness and feasibility of technology is being accepted by policy makers. The knowledge gained from the past and current educational programs provides an important experience base for planning future investments.

Nipper (1989) and several authors after him (Bates, 1991, Romiszowski, 1993; Swift, 1992) have classified the distance learning approaches into three generations:

The first generation is based on correspondence teaching. It is characterized by little or no production of specialized educational materials for distance learning, by almost no communication between students and correspondence tutors, and by the use of a single media (most often printed materials, sometimes supplemented by radio or television-based courses). Drop-out rates in correspondence education are usually very high.

The second generation of distance education uses educational materials which have been specifically prepared only for distance education. It also integrates several educational technologies and media, such as print, radio, television, audio and video cassettes, and computers, but relies heavily on open broadcast by radio or television. These technologies are still directed only one-way (from teachers to students) -- the two-way communication between students and tutors is provided by correspondence. Educational materials are pre-designed and prepared specially for distance education, resulting in high fixed costs associated with developing courses and relatively low variable costs. Large numbers of students are required to justify the fixed costs, therefore this approach is suitable for a mass production of graduates. Characterized as "the industrial model", it was first adopted by the British Open University in 1969.

The third generation of distance education ("tele-education") is characterized by the use of interactive information technologies which provide a two-way or multi-point communication

between students and professors. The teacher remains a "live instructor". The costs of basic equipment are high in comparison with the first and second generation technologies, and the cost of interactive communication may increase in proportion to the number of points in the network. Typical technologies of this kind are computer-conferencing, audio-conferencing, audiographics, and video-conferencing (one-way television with audio return, two-way television).

Some authors (e.g. Romiszowski, 1993) exclude computer-mediated technologies from the third generation, and introduce them as the basis of the fourth generation of distance education, with an integrated approach to distance learning which combines synchronous use of

- remote audio-visual and electronically stored study materials (online access to text, graphics and image databases),
 - two-way student-teacher and student-student communication, and
 - multimedia/hypermedia computer technology, which enables the integration of all media in the manner that would most resemble real-time interactive instruction in a classroom.
- ◊ In the USA, the Clinton administration strongly advocates building telecommunications infrastructure to support education, research and training. Once built, such an infrastructure could facilitate major changes in educational practices, especially through the introduction of third- and fourth- generation educational technologies to schools, colleges and universities in the near future (Benson, 1993).

Relevance and use of interactive educational technologies in distance learning

The main users of the third generation and the leading developers of the fourth generation of distance education technologies are industrialized countries with strong technological and telecommunication backgrounds, especially the USA, Canada, Western Europe and Japan. Educational institutions in a number of developing countries still fall into the first or second generation of distance teaching, using primarily printed materials, radio and/or television lectures, and occasionally electronically stored media - audio, video and computer programs.

The majority of developing countries have not yet been in a position to apply the complex equipment for interactive distance education, because of the high costs, inappropriate technological infrastructure, and often very high numbers of students involved in the educational process. Several educators share the opinion that this may further increase the gap between low- and high-income countries, while the followers of the industrial model of distance education still do not see a clear empirical evidence that the two-way tele-education is more effective than the traditional one-way educational practices when applied on a large scale.

Traditional educational technologies and media, applied in an industrial model of distance teaching, have several advantages (1) they use pre-designed, accurate and effective learning materials, especially designed for independent study, (2) they do not depend on an individual teacher and can therefore be applied in countries which lack qualified teachers (3) they are cost-effective with large groups of students and are suitable for countries with large student population, (4) the educational materials can be shared between countries speaking the same language. However, the lack of convenient and effective interaction for independent learners has not been completely overcome even in highly computer-mediated distance learning.

The third generation of educational technologies, especially the more affordable ones, such as audiographics, have proven cost-effective and particularly valuable for (1) small groups of students (e.g. elective subjects, specialized graduate studies, geographical remoteness, small island countries), (2) individually tailored instruction (academically very capable students, physically handicapped students, home-bound or migrant students), (3) in-service education (teacher training, on-the job industrial education, continuous education in computers and hi-tech equipment).

Using telecommunications in education is often perceived as being expensive when compared to either face-to-face education or print based correspondence education. According to Romiszowski (1993), this is not a completely accurate perception. Cost calculations that include the communication costs as well as the costs of tutor time in generating feedback messages to students show that telecommunications-based instruction can be more cost-efficient than print-based instruction. The experience of AT&T in utilizing audiographic teleconferencing has demonstrated cost reductions of over 50% in the real costs of training if these are calculated to include the cost of transportation and accommodations of trainees from remote sites. Furthermore, the cost of telecommunication is falling, whereas the costs of educational space, staffing and transport are rising. In addition, as the basic infrastructure for interactive telecommunications comes to be viewed as a necessary part of a modern society, initial costs will be spread among the various uses, lowering education's share of initial investments.

2. Educational Technologies: Main Types, Characteristics, Costs, and Applications

Computers

There are enormous possible and actual uses of computers in education. The most common used applications of computers in higher education include^{*} :

- Word processing and desk-top publishing.
- Data organization, statistical calculations, scientific computation of data, and algorithm performance.
- Visual representation of data (as different forms of charts, graphs, figures and maps).
- Lecturing technology (which generates pictures for transparencies, or to run computer presentations directly).
- Graphic design in arts, architecture and industrial design.
- Three-dimensional viewing and modeling (e.g. in physics, chemistry, medicine, geography, mechanical and construction engineering).
- Simulations (which represent real-world processes and systems that are difficult or impossible to perform in the laboratory, e.g. in medical training, science, technology and engineering studies, military and pilot training, and process optimization in industry).
- Expert systems^{**} (examples of educational use exist in medicine, engineering, environmental and computer science)
- Tutorials (computer-driven self-paced educational programs for self-learning).

^{*} Multimedia technologies and computer-based communication are excluded from the list, since they are presented in separate chapters.

^{**} An expert system is a computer program that emulates the behavior and knowledge of human experts within a specific domain or area of knowledge, and, as a result, performs with proficiency equal to a human expert.

- Learning nodes (self contained units, focused around a single concept, suitable for building lessons in electronic learning networks).
- Educational databases (collections of grouped and structured textual, numerical or graphical information)
- Assessment, testing and reporting.
 - ◊ The United States Air Force Academy in Colorado Springs experienced poor examination results from some 1,200 cadets in the first year physics. By introducing a simple computer network, providing their students access to numeric variable physics problems, improvements of 60% to 100% in examination performance were reported in parts of the curriculum where computer exercises were available. No change in exam performance was reported where computer tutorials were not used. (Ellis and Owen, 1993).
 - ◊ In 1987, The University Queensland introduced a computer based assessment of more than 1,600 undergraduate students in economics. The tests were randomly generated, and covered a number of assignments in several subjects. Commercial computer-managed learning software was used to administer and grade tests and to keep records, generate reports, and provide analyses of students' performance. The project has showed good student acceptance and improved performance, better utilization of resources, and cost-effectiveness (Stanford and Cook, 1987).
 - ◊ As a result of increasing demand for patent searching help, the McKinney Engineering Library at the University of Texas at Austin developed an expert system to guide students, faculty staff and public users in patent searching. The system provides all levels of users with customized instruction and guidance at any time, including nights and weekends. The telecommunications or on-line interface module was designed to be transparent to the user, providing a communication gateway to patent databases. The module automatically selects relevant databases, dials the telecommunications link, selects correct search commands for the database and search chosen, runs the searches, sets up the parameters for displaying and printing, and sends the search results to the printer. The costs of investment in the development of the expert system have been partially recovered through substantial savings in staff time (Ardis, 1990).
 - ◊ Gisolfi et al., 1993, report on an expert system, used as a English language consultant, that enhances the learning process in the field of English grammar. The Intelligent Tutoring System (ITS) provides more dynamic individualization of instruction than did its predecessors. due to an innovative four-module structure: the Expert module (contains knowledge base and generates instructional content), Student model module (assesses student's knowledge and makes hypotheses about his/her conceptions and reasoning strategies), Tutorial module (explicates adequate tutoring strategies), and Administrative module (supports the interface with the student, regulates all the activities within the ITS).
 - ◊ The International Centre for Chemical Studies, University of Ljubljana, Slovenia, is involved in monitoring water pollution in Slovenia. An expert system for the river water classification helped to reduce the number of analyses necessary with no loss of reliability, thereby reducing costs substantially(Kornhauser et al., 1992).

Computers offer several educational motivations: (1) speed -- students can store and retrieve large amounts of data, change/add new information, process data quickly and display them in textual and graphic formats, (2)mobility -- they can exchange data sets, store them on different storage media for later use at school, at home or at a working place, and (3) individualization -- the possibility of individualized self-paced learning and instant feedback.

Multimedia

There was a time when multimedia referred to a slide presentation with audio tapes. Gayeski (1992) defined multimedia as a class of computer-driven interactive communication system which create, store, transmit, and retrieve textual, graphic, and auditory networks of information. Today, multimedia usually means the computer-supported integration and manipulation of at least three of the following media: **text** (ordinary text, tables, dictionaries, indexes, help facilities), **data** (statistics, tables, charts, graphs, spreadsheets), **audio** (human voice, sound effects, music), **graphics** (drawings, prints, maps, computer generated images, artwork, architectural drawings), **still pictures** (photographic images, transparencies, negatives, video still images), **animation** (film or computer generated figures), and **moving pictures** (moving video) (Ayre et al., 1994). Multimedia programs permit non-linear navigation (often termed "hypermedia"). Most multimedia products now use interactivity to allow the user to ask and answer questions, to seek and find information, make choices and decisions, experiment with a range of options, and use data and resources in new and different ways.

- ◇ Borman and Solms (1993) defined the **hypertext** as the grouping of text and/or graphic information in the form of nodes connected through links; **multimedia** as the combining of different media types (sound, animation, text, graphics, video) for the presentation of information via computer; and the **hypermedia** as an extension/combination of hypertext and multimedia.

Types of multimedia technologies

The field of multimedia is developing rapidly – the hardware and the software are in constant flux. In 1993 alone, the multimedia market grew about 40% (Ayre et al., 1994). Producers are trying to agree on compatibility standards for products but with limited success. Standardization and compatibility continue to be problematic. Some companies are promoting CD-recordable products, software and hardware that allows users to develop and playback their own applications on compact disk. A standardization of multimedia systems would be a boom to education applications.

- ◇ The threat of obsolescence has done little to slow the proliferation of new multimedia types. Despite existing hardware systems, the Sony's MMCD player and Commodore's CD32 games console were launched in 1993. In 1994 the first interactive multiplayer for 3DO was launched. Also in 1994 a significant agreement was reached on the video CD: the digital video standard, which enables linear video applications to be played across on wide range of otherwise non-compatible hardware systems (CD-ROM Directory, 1994).

The main commercially available multimedia systems are :

Videodisks and interactive videodisks (IVD)

Videodisks have been used as an instructional tool in regular teaching since the beginning of 1980s, but never became a major force in distance education, because educational institutions and/or students did not purchase the players, principally because they are a "read only" system.

- ◇ The Medical School at the University of Washington, Seattle, put their collection of hematology microphotographs on a videodisk, accompanied them by a printed manual for teaching, and sold them to other medical schools. This was one of the first educational uses of videodisks (Fuller, 1984).

Interactive videodisk systems contain data in the analog form. Analog laserdisks are used when the highest quality video and high storage capacity are required with random access to information. Educational videodisks (an estimate of over 2,000 commercial products) became available in several fields, such as natural science, medicine, biology, agriculture, geography, history, arts, architecture, engineering, aerospace, aeronautics, and industrial training. They can provide an excellent hands-on substitution for sophisticated laboratory procedures, and can contribute to problem-solving and decision-making skills. In comparison with other media, they are rather expensive and relatively slow in seeking time.

- ◇ The IVD systems can be of two types. The first, less expensive, operates with two monitors. A videodisk player and a separate monitor are connected to a computer with its monitor via a standard cable. The second type enables the simultaneous presentation, overlaying and superimposing of the videodisk and the computer signal on the single screen. This type utilizes an interface card, and is usually more expensive (Galbreath, 1992). Adding IVD to a microcomputer costs from \$750 to \$4,800, depending on the components (Brodman, 1993).
- ◇ The Open University of Netherlands, with an enrollment of over 60,000 students (of which a small minority of about 7% opted for a Natural Science course) designed a course on Soil and Environment, based on printed materials and interactive videodisks. The first block (40% of the course) was organized as study-units. In the second block (60%), attention was more focused on applications of knowledge and on the development of student's attitudes and problem-solving skills. This part facilitated self-directed learning. An interactive video program was used to present and illustrate authentic situations and real-life problems on soil functions and environmental issues. Some problem-solving cases were designed to be self-assessed, while the last case in the series functions was a graded assessment (Hummel, 1993).
- ◇ Industries and companies in several developing countries have been using IVD to provide industrial skills and safety training, including India, Malaysia, Saudi Arabia, Egypt, Mexico, and others (Brodman, 1993).

Laserdisk-Read Only Memory (LD-ROM)

LD-ROM is a hybrid between video disk and digital CD-ROM. On a 12-inch disk it combines full-motion video and stereo sound (as a laser disk) and computer data (as CD-ROM).

- ◊ A single disk can hold over 270 MB of digital data while containing 30 minutes of full motion analog video and 30 minutes of audio per side (Galbreath, 1992).

In contrast to interactive videodisks with analog data, the trend in multimedia is to move from analog to fully digital-based storage systems on compact disks. These are: CD-DA (Compact Disk - Digital Audio), Photo CD, CD-ROM and CD-ROM XA (Compact Disk - Read Only Memory Extended Architecture), Digital Video Interactive (DVI), Compact Disk Interactive (CDI), and other producer-specific applications.

Compact Disk - Digital Audio (CD-DA) and Photo CD

Compact Disk-Digital Audio, designed for high quality audio reproduction, was the first in the group of commercial CD products. The single sided disk can deliver up to 72 minutes of high quality audio. Photo CD does for photography what CD-DA does for audio: it offers the reproduction of images that can be of up to twenty times greater quality than conventional TV. The disk is recordable and can be replicated locally in small quantities or in large runs. Several formats are available such as Kodak:, a high quality format to store 100 images from 35 mm film; Pro Photo CD Master, which accommodates larger film formats; the Photo CD Portfolio, to store up to 800 TV-quality images or one hour of sound (or a combination of sound and picture); the Photo CD Catalogue for archival and promotional collections, and Photo CD Medical for diagnostic images (Ayre, et al., 1994).

CD-ROM and CD-ROM XA

Introduced in the middle of 1980s, CD-ROM was designed as a mass-storage medium for computer readable text. Today, CD-ROM disks store digital text, graphics, audio and video images, and are widely used in many disciplines (Figure 2.1). However, CD-ROM cannot store a sufficient amount of digitized non-compressed full motion video. CD-ROM XA (Extended Architecture) was designed to support digital audio, still images, and limited amounts of motion video (as a hybrid between CD-ROM and CD-I). It is increasingly used in portable players and electronic book formats. Both systems are used as computer peripheral devices (a drive is needed, and a special computer card). The most popular uses of CD-ROM in education are full-text encyclopedias, educational and scientific databases, and distribution of public domain software programs.

- ◊ The price of basic CD-ROM equipment is becoming more affordable for developing countries. In addition to a microcomputer (\$800 - 2,000), a CD-ROM drive is necessary, adding about \$170 - \$250 to the costs. Educational off-the-shelf CD-ROMs are available at prices from \$15 to over \$1,000 (Figure 2.2).
- ◊ CD-ROM products are an alternative to on-line databases. They have become of particular interest to institutions in developing countries, because they can operate in harsh environmental conditions, do not require telecommunications links, can be portable and can serve multiple workstations, and because a repetitive processing of a CD-ROM database by students and research trainees does not result in additional costs (Boh, 1993). By the end of 1990s, CD-ROM may become one of the most important technologies to provide regular students and distance learners with access to reference and research materials (Brey, 1991).

Figure 2.1: CD-ROM titles by subject (from CD-ROM Directory, June 1994)

Figure 2.1: CD-ROM titles by subject (from CD-ROM Directory, June 1994)

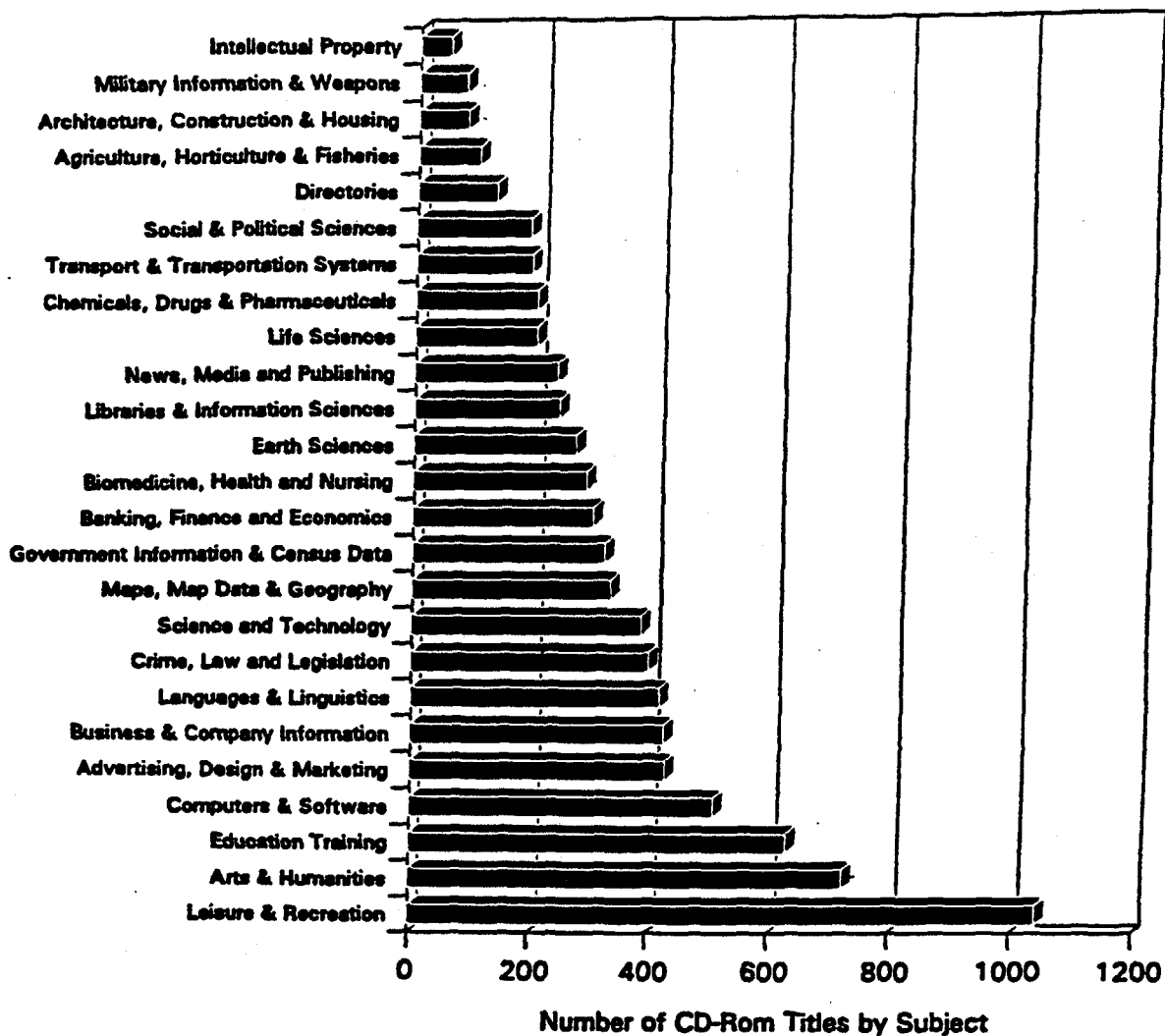
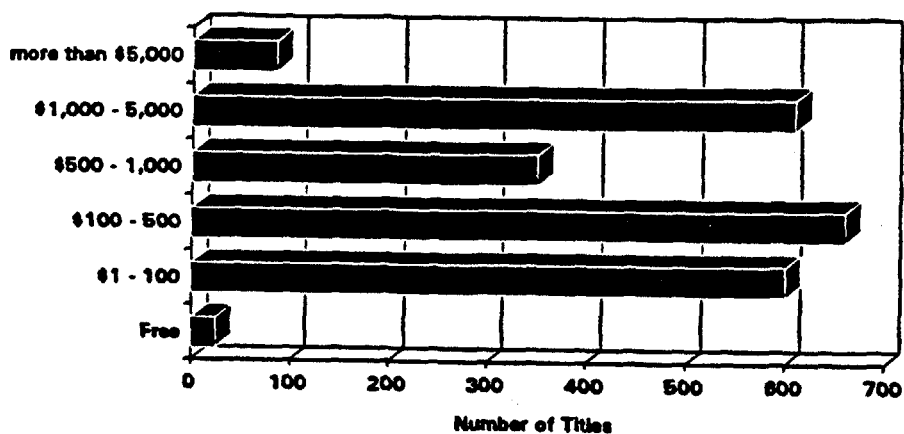


Figure 2.2: Price range of DC-ROM and multimedia CD titles in 1993 (Stoneman, 1993)



A study by Levey (1993) lists the following African libraries with CD-ROM technologies and databases: Addis Ababa University, Cheikh Anta Diop University, Eduardo Mondlane University Agriculture Library, Institute for Agricultural Research, Kenyatta University, Muhimbili College of Medicine, University of Dar es Salaam, University of Ghana (Balme Library and Medical Library), University of Ibadjan, University of Malawi (Bunda College of Agriculture, Central Library Services Unit, and College of Medicine), University of Nairobi, University of Science and Technology, University of Yaounde Medical Library, University of Zambia Medical Library, University of Zimbabwe (Main Library and Medical Library).

- ◇ The American Association for the Advancement of Science (AAAS) - Sub-Saharan Africa Program, launched a three-year CD-ROM pilot project that will provide seven African universities with bibliographic databases in the science, technology and social sciences. The project's objectives is to evaluate how well CD-ROM can replace serial subscriptions, and to assess the costs involved. Participating universities include: Addis Ababa University, the University of Dar es Salaam, the University of Ghana, the University of Ibadjan, the University of Malawi, the University of Zambia, and the University of Zimbabwe (CD-ROM for development, 1993/94).
- ◇ The workshop organized by the Sub-Saharan Africa Program of the AAAS, based at the University of Ghana in January 1993, resulted in a manual for African research libraries on marketing CD-ROM services. The workshop participants have also presented the CD-ROM facilities and activities at the following organizations: Association of African Universities, University of Ghana Medical School, University of Dar es Salaam, University Cheikh Anta Diop de Dakar, University of Ibadan, Bunda College of Agriculture at the University of Malawi, Center for African Family Studies, Central Medical Library in Yaba, Medical Library at the University of Zimbabwe, Institute of Agricultural Research in Ethiopia, and the WHO Regional office for Africa. These examples illustrate the penetration of CD-ROM technology into research, academic, health and agricultural institutions in Africa.

Digital Video Interactive (DVI)

To overcome the problems of digital video storage, compression algorithms were developed to reduce the digital storage space required. DVI consists of a set of computer add-in cards which enable the digitalization, compression and decompression of signals, and of different multimedia applications (graphics, still video, motion video) on computer hard disks or CD-ROMs. DVI has a great educational potential, but educational materials available in DVI form are still scarce.

- ◇ A DVI board and a large hard drive or CD-ROM drive add about \$2,500 to the cost of a microcomputer. However, the costs are expected to drop considerably (Brodman, 1993). Compression permits the storage of more than one hour of full motion, full-screen video on a single CD-ROM, hard disk or other digital device (Galbreath, 1992).
- ◇ DVI programs are generally used for technical training or as kiosks for getting information. For example, in Saudi Arabia and Egypt DVI kiosks are placed in school lobbies to provide information on health practices, such as AIDS-related behavior and illegal drugs (Brodman, 1993).

Quick time is a system offered by Apple Computer Co. in 1992, and is similar to DVI. It allows Macintosh computers to compress and play digitized video movies, and works without any additional hardware (although a digitizing board is required). An educational example of its use is the Animated Dissection of Anatomy for Medicine (Barron, 1992).

CDI - Compact Disk Interactive

CDI can store integrated digital color images, text, graphics, applications software, and audio, and compressed full-motion video on a single disk. It differs from DVI in that CDI is a stand-alone unit – a closed system box to be connected to a television. The system was designed primarily to be a home entertainment unit which can play CDI and CD audio disks. With the development of CDI educational materials this system could be used as an affordable, highly interactive instructional multimedia system.

- ◊ In 1990, Philips offered a base hardware and software system for the production of CDI master tape for \$9,500. From master tape 25 disks could be manufactured for a cost of \$995 (Brey, 1991). With time, the cost of the master and copies of interactive videodisks have dropped, so that an increasing number of institutions can produce their own disks to meet the needs of their specialized programs.
- ◊ The Treasures of the Smithsonian program provides students access to the most popular Smithsonian Institution exhibits. Each is presented through photographs, a narrative with musical accompaniment, text, and graphics. Students have the opportunity to manipulate the graphic representation and to hear sounds associated with museum artifacts (Barron, 1992).

Commodore Dynamic Total Vision (CDTV) and CD32

Another stand-alone system is Commodore Dynamic Total Vision (CDTV), which was built around Amiga technology. It integrates a CD-audio/CD-ROM player and the Amiga's graphics, video, and sound chips, thus providing interactive text, graphics, still video and animation. CDTV has been succeeded by CD32, based on Commodore's own Advanced Graphics Architecture chipset. It provides full-motion video and can be connected to an ordinary TV.

- ◊ Many games are currently available on CDTV, as well as some reference programs. Educational materials for reading and math are also being produced (Barron, 1993).

Video Information System (VIS) and 3DO multiplayers

VIS was launched at the end of 1992 by Tandy Corporation as a home entertainment product, combining CD-ROM properties, the open architecture concept (for development of new features and facilities), and a distinct view toward the integration of facilities (cable TV and telephone lines).

3DO is currently the newest technology. The first multiplayer REAL (Realistic Entertainment Active Learning) was released at the end of 1993. 3DO is a typical consumer entertainment product with a very fast graphics/animation processor and an open architecture to support a range of peripheral devices and video input. One of its potential uses is as a low-cost video editing facility (Ayre et al., 1994).

Electronic books and personal organizers

Electronic books and personal organizers are a new fast developing multimedia form to deliver full-color, full-motion moving video and a range of interactive features. Some products are already on the market, offering the electronic equivalent of illustrated books. The trend is toward increasing compact equipment.

Virtual reality

Virtual reality is a new multimedia technology, which enables three-dimensional computer graphic environments which attempt to simulate reality. In combination with existing simulation systems, virtual reality can offer educational experiences that give the learner a subjective sensory impression extremely close to the real situation, and therefore an experience of how to react, and how to control the object of simulation.

- Educational multimedia simulations for use by trainee aircraft pilots can be cost-effective even if they cost \$100,000 per hour of the developed material, and are delivered on a \$3,000,000 simulator (Ellis and Owen, 1993). Similarly, visual realities have a potential use in medical training (Dede, 1993).

A comparison of multimedia systems characteristics

From the technical viewpoint, the main factors determining basic characteristics, applicability and rate of multimedia technology diffusion in education are the format of data, available storage devices, audio and video data compression techniques, compatibility of technology, formats of disks, and the data transmission media.

Analog and digital formats

Analog technology produces accurate reproductions of sound and pictures, and capably handling large volumes of information. The use of analog multimedia systems (VCR and VDI), although effective educationally, is limiting in a technical sense, because computers can only manipulate digital information. To overcome this obstacle, an extra unit had to be designed and added to the computer to convert analog signals into digital. Treating multimedia as data files in all digital environment brings several benefits (Pinheiro et al., 1993): the video and other signals can be assembled with cut-and-paste simplicity, updating segments is easy and fast, distribution can be via CD-ROMs, the applications can be stored on a network server (thus made accessible to numerous users). Digital technology tends to be more stable and less vulnerable to distortion, and it can be much more efficient in speed. However, transforming a signal from analog to a digital form always results in a small loss of quality. In order to preserve a high quality of digital signals, large storage devices are needed.

Storage forms

Available storage devices for educational multimedia take several forms: (1) **Magnetic storage devices**, such as computer hard disks, removable magnetic cartridges, floppy diskettes, magnetic tapes, digital audio tapes and video tapes. (2) **Laser technology optical media**, including CD-ROM, videodisks, WORM laserdisks (write-once, read-many), and optical tapes. While these media are light, compact, resistant to damage because of their protective coat, and capable of storing massive amounts of data. (650MB for a typical CD-ROM), they can be much slower than computer hard disks. (3) **Magneto-optical drives**, a combination of magnetic and optical storage technology, are available in a form or removable cartridges. They, provide high-capacity, portability and rewritability, but have slower transfer rates than hard drives and are expensive (Malhotra et al., 1994).

Compression

Since a lot of the information in video is redundant, some information can be sacrificed without much degradation in the picture and sound quality. The compression process substantially reduces the size of data files and makes digital video feasible on a personal computer.

Comparison of main characteristics

A good comparison of different multimedia systems was prepared by Galbreath, 1992 (Table 2.1 and 2.2):

Table 2.1: Multimedia matrix by Gayeski (1992): increasing the complexity of applications by adding media (from text towards synthetic images), and by increasing automation.

BANDWIDTH	APPLICATIONS:			
	INFORM =	=	INSTRUCT =	AUTOMATE
text	Electronic mail			Help systems
↓	Information utilities			Performance support tools
graphics	Audiographic conferencing	Hypertext	Computer based training	Expert systems
↓	Telephone conferencing			
audio				
↓				
video		Hypermedia		
↓		Video teleconferencing		
		Interactive video		
synthetic images		Virtual reality		

Table 2.2: A Comparison of multimedia systems (Galbreath, 1992):

Multi media system	Form of data	Storage medium	Media size	Plat-forms	Motion video	Audio	Still images	Gra-phics overlay	Video manipu-lation	Video format	Audio /Video editing
DVI	digital	CD-ROM, hard disk	5.25", CD-ROMs, hard disks	AT and clones, PS-2, Macintosh	72 min. full-screen, full-motion	Up to 40 hours, up to 2 output channels	Up to 40,000, max. res. of 1024 x 512	yes	High speed, hardware-accelerated software driven	Compressed	Yes
CD-I	digital	CD-ROM	5.25", CD-ROMs, integrated	Integra-ted consu-mer player	72 min. full-screen, full-motion	Up to 19 hours, up to 2 output channels	Up to 8,000, max. res. of 720 x 480	Yes	Lower speed, hardware supported	Compressed	Yes
IVD	analog	Video-disk player	12" disks	several incom-patible systems, interfa-ced to a variety of com-puters	30 min./ side	30 min./ side, 2 channels	54,000 per side, about 640 x 480 res.	Requi-res compu-ter add-in board	Additional hardware required	Stan-dard	No
CD-XA	digital	CD-ROM	5.25", CD-ROMs	compu-ters with SCSI inter-face	30 min./ side	Up to 19 hours, up to 2 output channels		Yes			Yes
CDTV	digital	CD-ROM	5.25", CD-ROMs	Integra-ted consu-mer player		2 output channels		Yes		Compressed	Yes
LD-ROM	analog and digital	Video-disk player	12" disks	System inter-faced to a variety of com-puters		30 min./ side, 2 channels	54,000 per side, about 640 x 480 res.	Requi-res compu-ter add-in board	Additional hardware required	Stan-dard	Yes

Educational uses of Multimedia

Some say multimedia represents the biggest revolution in education and communication since the invention of the printing press. Others say multimedia is for the 1990s what the microcomputer was for the 1980s. The third group of education specialists believes that multimedia is just another fashionable highly technical tool which will not seriously effect education.

Multimedia can be used for education with either off-the-shelf or custom-designed (usually by the instructor) materials. The main groups of applications consist of:

(1) Presentation tools for lectures

Multimedia allows for vivid and interesting presentations in a classroom or in a large lecture hall, by combining textual materials, pictures, sound, graphics, animation and video.

(2) Information terminals and automated presentations

Presentation and information multimedia systems may be placed in reception areas of businesses, museums, arts and educational institutions. Touch screen monitors are often used in these instances. In sophisticated presentations, a multimedia system fills an entire wall with an array of monitors for altering and juxtaposing multiple images.

(3) Individualized self-paced instruction

In combination with computer-assisted instruction, multimedia becomes a highly interactive and effective tool, which can be used in individualized sessions during regular classroom teaching, for independent student's work on assignments, reports and projects, and for distance education. Generally, development and testing of educational multimedia materials of this kind require a substantial investment in time, resources and finances. Examples of commercially available educational materials include:

- curriculum products, e.g. Exploring chemistry (University of Illinois/Falcom Software), (Oblinger, 1992^{*});
- reference materials and databases on videodisks or CD-ROMs, such as Archimedia for architecture and design students, Compton's Multimedia Encyclopedia, the Complete Works of Shakespeare, Grolier Encyclopedia, Hypertext Hands-On, Multimedia Birds of America, Multimedia Mammals, the Oxford Textbook of Medicine, and the World Atlas, (Barker, et al., 1993; Millet et al., 1993);
- multimedia conference proceedings, combining voice and video of a speaker, text of the presentation, graphics (charts) and pictures (slides) for each conference contribution. An example is the Gartner Group's Symposium '93"

^{*} For a list of educational multimedia sources and associations involved in multimedia development see Oblinger, 1992).

- **multimedia language learning packages**, e.g. Hyper Chinese (learning Chinese as a second language), consisting of three modules: Chinese pronunciation, Chinese writing, and Chinese radicals (Tzeng and Hsu, 1993):
- **software application tutorials**, e.g. Microsoft Works and Lotus 123 v 4[™].

Selected examples of commercially available multimedia products that can be used in regular higher education programs, for self-paced learning and for research, are given in Table 2.3. Figure 2.3 illustrates the overall growth of multimedia products.

(4) **Multiple task, multi-user networks**

Two groups of networked multimedia applications are under development:

- **Local Area Network (LAN) and file server applications for multimedia communications within a given user group.** Using LAN and file servers users access multimedia information in the same way that they now store, retrieve and transmit text, graphics and software applications. The first applications of local multimedia networking are video conferencing systems within companies or educational institutions.
 - ◊ The showcase for the multimedia LAN concept was the company-wide distribution of IBM's Tele-Report over the IBM Token-Ring Network. Live video sequences were displayed in a window of the screen as the employees worked. Such a continuous central information capability ensured quick intercommunications among divisions. IBM also offered the concept of Ultimedia. Its public availability depends on the installation of broadband networking system called ISDN - Integrated Services Digital Network (Paulissen and Frater, 1992).
 - ◊ In most educational settings, such as universities, it is practically impossible to provide each student with a stand-alone multimedia unit (because of space and money needed). An alternative solution has been offered as a concept of the Central Media Resource System (CMRS) – a network that provides a multiple user, multi-task access to multimedia. The brains of the system is a media resource center, including control system, scheduling computer, communication rack, equipment racks, fiber optic transmitters and video switcher (if optical fiber based) or modulators (if coaxial cable based), and a collection of different kinds of media resources. Theoretically, local networks can be integrated within the CMRS, e.g. to cover the needs of a single faculty, as well as wide area networks (Galbreath, 1993).
 - ◊ The rapid reduction in prices made it possible to buy an entry level video conferencing system for \$14,000. Video PCs will soon permit informal conferences on the desktop, at total cost of less than \$8,000 per seat (Jeffcoate, 1994).
- **Wide Area Networks (WAN).** Newer multimedia systems, using compression techniques, can be transmitted through telephone lines or via computer networks. Together with the improvement of telecommunications infrastructure, these achievements open the door for wide area multimedia networks. Several applications are being developed, such as (1) multimedia conferencing between enterprises, (2) multimedia systems of professional communities (legal procedures, financial trading, publishing, medicine and health care), (3) **real-time multimedia**

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distance education (also known as computer-supported multimedia cooperative learning), and (4) public/consumers multimedia networks. However, lack of software tools and international compatibility standards hinder widespread adoption of these technologies.

- ◊ The Multimedia Electronic Classroom of Indiana University-Purdue University at Indianapolis has been developing a system which can simultaneously use full-motion video, high-resolution still images, graphics, audio and text, all in a digital form for applications through communication networks (Malhotra, 1994, from Elmore, 1991).
- ◊ The Interactive Virtual Campus & Media Laboratory at Illinois Institute of Technology has been testing different possibilities of incorporating multimedia on a distance education platform. Among several systems tested, the Telewriter teleconferencing system (Optel Communication) was selected, which uses a standard telephone and offers the display of text, graphics and video images on a multisync monitor of a personal computer. The system can support up to 99 sites in the network and is used as supplementary aids within a microwave or satellite system. Approximately half of the computer science faculty are using at least some of the multimedia systems via microwave, satellite or phone lines. Engineering and business faculties are in the process of integrating these systems into their teaching (Hewitt, 1993).

Table 2.3: Selected examples of commercially available multimedia educational products (CD-ROM Directory, 1994)

Title	Publisher	Contents	Language	Type, Price
ACT College Search 92'	Cap Disc; American College	Higher education: a database of 1737 colleges with photographs; assists students in the selection of college (location, size, tuition, admission requirements, etc.)	English	CDI \$49.98
Training Management System	CD-I Training Ltd.	Education: An utility to record the progress and scopes of individual students in CDI training courses	English	CDI GBP 350
Practical Toxicological Histopathology	Dutch Open University	Toxicology: detail practical studies, a collection of slides of histopathological sections	English Dutch	CDI
BiblioMed Series: Cardiology, Gastroenterology, Citations	Health care Information Services Inc.	References from medicine to practicing physicians	English	MMCD \$950 per series
In the Veterinary Context	Context International	Veterinary science: scientific communication of world-wide interest	French English Spanish German	CDI c.p.

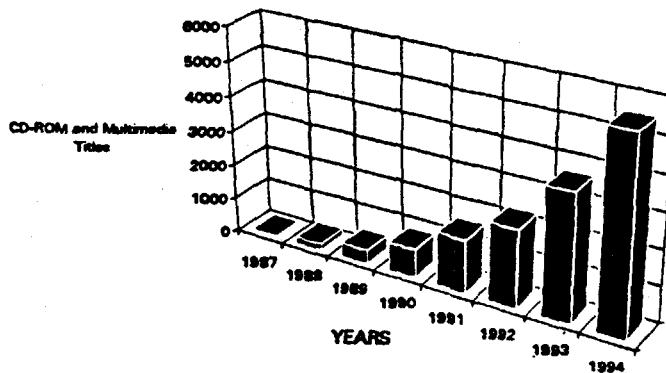
Health and Disease	Infotouch	A medical encyclopedia including anatomy, physiology, diseases and methods of treatment	Dutch English French German	CDTV \$80.00
A Corporate Guide to the Environment	IBM-The Multimedia Publishing Studio	Environment: Environmental issues and information for executives	English	MMCD \$49.95
Audubon's Backyard Birding	Philips Interactive Media of America	Ornithology: 800 birds with emphasis on 125 most common species in North America	English	CDI \$39.98
Insight - Technology	Commodore International	Science and technology: how the advanced technologies work (includes full-screen animations)	English	CDTV \$60
Time Table of Science and Innovation	Xiphias	Major discoveries in science and technology, developments and innovations	English	CDTV \$59.95
Handle with Chemicals	Krist & Ketel	Occupational health and safety: training of skills and knowledge for the textile industry	Dutch English	CDI c.p.
Civil Video Mapping System (CVMS) Laser Mapping System (LMS)	Perceptronics Inc.	Geography: map frames, allows zooming between map scales and the ability to scan across maps		CDI c.p.
GAIA - A Guide to the Earth	The Edge Interactive Media	Earth science: information on the planet, ecosystems, environmental issues.	English	CDI c.p.
The Complete Manager	Epic Interactive Media Co.	Business training course: designed to meet the national standards required for the MCI Certificate of Management	English	CDI GBP 3415
Finance for Non-Finance Managers	CD-I Training Ltd.	Training course: provides fundamentals of financial knowledge, skills and awareness for all types of managers	English	CDI GBP 1750
Developing Competence Through Coaching, Mentoring and Assessing	CDI Training Ltd.	Management information and training course: for managers, professionals and specialists	English	CDI GBP 3450
Training for Business Success	IBM-The Multimedia Publishing Studio	A self-improvement program for business managers in competitive markets	English	MMCD \$49.95

Language Director Series	Harvard University	Languages: a laboratory course to teach communicative competencies in English, French or German	English Frenc, German	CDI c.p.
English Interactive - A Multimedia Programmed Course	Andujar Communication Technologies/Vortex Interactive	English language course, interactive as with the private tutor	English	CDI c.p.
Business Words	EuroTalk Ltd.	Languages: English for international business	English	CDI, CDTV c.p.
Japanese Language Learning for Business Travelers	UK Training Agency	Japanese language course for business people	English Japanese	CDI c.p.
Drawing and Painting	TELAC, PIME	Fine art course: drawing and painting techniques and subjects	English	CDI c.p.
The World of Impressionism	Philips Interactive Media	Fine art, history, music	English	CDI \$39.98
A Revolution in Color - Modern Russian Paintings from Moscow and St. Petersburg	Philips Interactive Media of America	Fine art		CDI \$19.88
Latin America: Discover its history	Sociedad Estatal Quinto Centenario	History and Architecture: Precolombian, colonial and modern developments	English Italian Portuguese Spanish	CDI c.p.
Hutchinson Electronic Encyclopedia	Random Century, ATTICA Cybernetics	Encyclopedia	English	CDTV GBP 249
Compton's Interactive Encyclopedia	Compton's NewMedia, Philips Interactive Media of America	Encyclopedia	Dutch English French German	CDI \$299.98 VIS \$495
The Visual Dictionary	Philips Professional	Dictionary: a reference and learning support in 6 languages, 8000 terms	English French Spanish Italian German Dutch	CDI

Le Dictionnaire Multimedia Hachette	Hachette Livre	Dictionary	French	CDI FFr 990
Desktop Library CD-ROM	Walnot Creek CD-ROM	Library: full text works on classic literature, philosophy, computer manuals, legislation, dictionaries, psychology, etc.	English	CDTV \$39.95
CDPD	Almathera Systems Ltd.	Computer programs, shareware	English	CDTV GBP 19.98*
The CDPD Public Domain Collection for CDTV	Almathera Systems Ltd.	Computer programs, shareware	English	CDTV GBP 125*
Fractal Universe	Almathera Systems Ltd.	Software: fractal generators		CDTV GBP 29.95
Computerword on CD	Emerging Technology	Communications, electronics, telecommunications, information technology		MMCD \$295, \$885 LAN*

*Network price

Figure 2.3: The growth of CD-ROM and multimedia titles (CD-ROM Directory, 1994)



Multimedia has many characteristics which make it well suited for educational uses. Learning is highly interactive; information is presented through the integration of several media, more closely replicating human sense perception; information is easy to access, move and combine; software is generally user-friendly and easy to learn; increased stimulation fosters discovery, students can navigate their own path and explore connections between

diverse subjects; a detailed "hands-on" experience can simulate a complex or dangerous situation, eliminating the need for expensive and sophisticated equipment; learning processes can be self-paced and independent; multimedia systems are quite rugged, durable, and can survive climatic variations; the instruction is usually of high quality, effective and efficient (Brodman, 1993; Malhotra et al., 1994; Oblinger, 1992).

- ◊ Nott et al., 1993, report on multimedia applications to simulate hands-on experiences in a laboratory pharmacology course at the University of Melbourne, Australia. A typical experiment examines the effect of acetylcholine on the smooth muscle of the intestine. The multimedia experiment illustrates the setting up of a biological preparation, the recording of responses (muscle contractions), the application of measurement equipment, and provides the graphing of intensity of response against concentration of a drug, discusses the nature of variation between responses, illustrates the application of statistics to the results, and finally guides the students to write reports and draws conclusions.
- ◊ The OGIS Research Institute in Japan and the Osaka Gas Company have developed two intelligent tutoring systems based on multimedia simulations. The Process Control Training System is based on physical models. It provides instruction by interactive simulations, detects trainee's errors, and sets up an individualized reinstruction program aimed at mastering the process control and at the development of problem-solving skills. The Conversational English Training System is designed to train students in hearing and speaking of English. The system utilizes a voice recognition device for unspecified continuous voices, thus recognizing mistakes in student's pronunciation (Inui et al., 1993).

Despite all its advantages, multimedia should not be viewed as a complete replacement of teachers and traditional classroom methods, but as an important component to improve the instruction and learning processes. As in the case of any technology, its impact depends on designers who create educational applications, and on teachers who will (or will not) use the advantages of a new technology to enhance learning.

Until recently, reports showed that multimedia activities were limited only to a few countries. New studies of geographic markets show that there is a sustained and sustainable multimedia activity spreading almost everywhere (Ayre et al., 1994).

Examples of costs and effectiveness analysis

Computer-mediated instruction and multimedia instruction are documented to be highly effective and efficient:

- ◊ In broad terms, computer-base instruction offers a 10 to 20% improvement in performance over conventional teaching methods, one-third reduction time on task, and up to one-third reduction of the time that a student needs to spend on learning (Oblinger, 1992, from Molnar, 1990).
- ◊ A study on using interactive videodisks for educational purposes by Cushal et al. (1987) found out that the use of interactive video technology contributed to knowledge gains, time savings and cost effectiveness in comparison to traditional lecture methods. In only one of the reported cases, no advantage was found over the use of traditional equipment. All surveys reported positive attitudes toward learning from interactive videodisks by both students and instructors.

◊ Effectiveness of videodisk instruction in higher education (Fletcher, 1989):

Content	Approach	Comparison	Outcome	Effect size
Equipment operation	Tutorial	Branched IVD vs Linear IVD	Component recall	0.56
			Completion time	1.32
			Combined	0.94
			Performance on actual equipment	0.80
Biology	Tutorial	Experiment 1	Biology knowledge	0.48
			Completion time	0.78
			Combined	0.54
		Experiment 2	Biology knowledge	0.56
			Completion time	2.04
			Combined	1.05
		Experiment 3	Biology knowledge	0.70
			Completion time	1.10
			Combined	0.83
Foreign language	Tutorial	IVD vs classroom vs no instruction	Course knowledge	0.62 1.90 (baseline)
Physics (Tacoma bridge collapse)	Simulated laboratory equipment	IVD vs laboratory	Physics knowledge	0.29
Biology (respiration)	Simulated laboratory	IVD vs laboratory	Course knowledge (2 experiments)	-0.29 1.06
Chemistry (kinetics and equilibrium)	Tutorial, simulated laboratory	IVD + Lab vs lab only, IVD vs IVD + Lab vs Lab only	Course knowledge (2 experiments)	0.69 1.08

◊ A quantitative analytic review of interactive videodisk instruction (IVD) applied in defense training, industrial training and higher education (Fletcher, 1989) led to the following overall findings:

(1) IVD instruction has been successfully used to teach, and was more effective than conventional approaches:

Setting	M (effect size)	SD (Standard deviation)	N (number of studies)
Military training	0.39	0.54	24
Industrial training	0.51	0.74	9
Higher education	0.69	0.40	14
All setting combined	0.50	0.55	47

(2) IVD instruction was equally effective for both, knowledge and performance outcomes:

Outcomes	M	SD	N
Knowledge	0.39	0.48	29
Performance	0.40	0.59	21

- (3) The more interactive features of IVD technology were used, the more effective was the resulting instruction.
- (4) Students reached criterion levels of achievement more quickly using IVD instruction than conventional instruction.
- (5) Direct tutorial approaches were more effective than stand-alone simulations in IVD instruction:

Approach	M	SD	N
Tutorial only	0.85	0.23	7
Combined tutorial and simulation	0.60	0.57	26
Simulation only	0.15	0.46	14

- (6) Students enjoyed using IVD.
 - (7) IVD instruction was found to be less costly than conventional instruction in nearly all the studies.
 - (9) All the reported cost ratios were less than 1.0, indicating lower cost in every measured instance for IVD than for conventional instruction. The average across 13 cost ratios was about 0.36.
- ◊ The cost-effectiveness study of interactive courseware (the term includes computer-based instruction, interactive videodisk instruction and instruction using CD-ROM) by Fletcher (1992) reports that (a) student performance was at least good as it was under conventional instruction and (b) students reached the desired levels of performance in about 30 percent less time using computer-based or interactive videodisk instruction. The main advantage of interactive courseware is the possibility to tailor instruction to the individual needs of a student: each student can receive the level of detail, pace, remediation, sequence of topics, and interactions needed to learn the material efficiently within the constraints imposed by time and access to instructional resources. The author uses the effect size as a measure of effectiveness of interactive courseware programs:

Computer based instruction:	Effect size	N (number of studies)
Elementary school	.47	28
Secondary School	.40	42
Higher Education	.26	101
Adult Education	.42	24
Interactive videodisk instruction		
Military Training	.39	24
Industrial Training	.51	9
Higher Education	.69	14

- ◊ An experimental examination of the cost-efficiency of computer-based instruction by Fletcher et al. (1990) found the following month gains on a standardized test of mathematics:

Experiment	Cost of computer-based instruction	Cost of conventional instruction
Third grade students	\$20	\$33

* Effect size is defined as the difference between the means of two treatment groups divided by either the control group standard deviation or a pooled control group and experimental group population. Roughly, an effect of 0.50 suggests an improvement in student performance from the 50th to the 69th percentile (Fletcher, 1992).

Fifth grade students	\$17	\$27
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The author suggests that a much stronger effect can be reached when students are grouped for work on terminals.

Similarly, favorable cost-effectiveness and cost-efficiency ratios could be met in interactive multimedia instruction involving groups of students working with single instructional work station, or in one-to one multimedia instruction through the local area network.

Multimedia presentations mimic the way the human mind thinks and remembers -- it is a non-linear process, moving constantly between words, sounds and images. It can stop for a moment to explore details, skip some known facts, or return to an in-depth exploration and analysis. The combination of media elements enables students to learn more spontaneously and naturally, using whatever sensory models they prefer. Several studies have confirmed that combined interactions using sight, sound and simulated experiences improve the learning process.

- ◊ It is well documented that we have short-term retention of about 20 percent of what we hear, 40 percent of what we see and hear, and 75 percent of what we see, hear and do. Students complete courses in one-third of the time of traditional instruction when using multimedia, while reaching complementary levels of up to 50 percent higher. In most cases the overall cost of instruction is lower, as well (Oblinger, 1992, from Department of Defense, 1991).

Educational technologies based on telecommunications

Telecommunication and transmission systems

Telecommunication is defined as communicating over a distance (Jones and Simonson, 1993). Telecommunications systems can be classified by the

- **medium** (radio waves through the air, electronic impulses over transmission lines, light signals through glass or plastic silicon fibers),
- **type of information** transmitted (audio, video and data signals) or
- **direction of flow**: one-way (simplex, top-down) broadcast systems, and two-way (duplex) systems, which encourage bottom-up and lateral, live, real-time communication between two or more sites.

Microwave Systems

Microwave systems operate at much higher frequencies than standard broadcasting. Because they are point-to-point, there is a control over who receives the signal. Audio and video signals are usually of good quality, but the transmissions can be affected by weather and atmospheric disturbances. Large systems ("long haul") need several repeaters to cover hundreds of miles (thirty miles is the maximum distance between two towers). Short haul systems are used typically for 5 to 15 miles systems to link local educational institutions.

Microwave technologies will probably experience a limited growth in the future -- a lot of frequencies in industrialized urban areas have already been licensed (e.g. for wireless cable companies), and alternate technologies, especially compressed video, are now becoming more competitive.

- ◇ The estimated costs for a duplex microwave system are \$40,000 to \$65,000, plus \$25,000-\$75,000 for each tower. Long-haul, one hop systems over 8-15 miles can cost \$150,000 - \$250,000. Short haul systems are cheaper: \$35,000 plus towers, ranging from \$5,000 to \$50,000. Maintenance costs, including equipment service, repair, and monthly maintenance fees, average 3% to 5% of the system cost per year (Jones and Simonson, 1993).
- ◇ In the USA, some of the point-to-point microwave systems were developed specifically to offer graduate level classes to remote sites where a sufficiently large number of students justified the capital investment (Brey, 1991).

Fiber optic systems

The fiber, made of glass or plastic, transmits laser light signals. In comparison with copper or coaxial cables, which carry electrical signals, the optical cables of the same size can

transmit far more information -- they allow audio, video and data to be combined in one line, resulting in a lower cost per channel. The signal is of high quality even if transmitted over long distances. Optical cables are small, lightweight, and durable (unaffected by weather, electromagnetic fields, or corrosive atmosphere). However, the optical systems have high start-up costs, and the light sources have limited lifetimes, which may negatively affect the system reliability. The maintenance costs are low, but if the fiber is accidentally cut, repairs may be time consuming and costly (Jones and Simonson, 1993). Fiber optic cables are used for two-way audio, data and video transmissions.

- ◊ A typical fiber system consists of the following components: multiplexor (converts the signal to/from an electrical signal), codec (transforms the signal to digital), optical transmitter (converts the signal to an optical signal), optical receiver (reconverts the optical signal), fiber cable (carries the optical signal) and repeaters. Life expectancy of this equipment is 20-25 years. The equipment needed to connect one site to a fiber network would cost approximately \$40,000, and each mile of fibers would add approx. \$9,000-\$20,000 to the costs (Jones and Simonson, 1993).
- ◊ In the USA, the cable industry is installing fiber optics at the rate of 85 miles per hour, 24 hours a day. Phone companies have a similar rate of fiber installation (Benson, 1993).

Satellites

The instructional and training applications of satellite telecommunications networks expanded substantially since the beginning of 1980s. Satellites can cover a large geographic area with several services (television, data, telephone, telex). The links are flexible, reliable and clear, and the costs are distance-independent. Most satellite educational networks transmit one-way full-motion analog video and audio signals. Interactive systems (satellite teleconferences) usually have one-way video and two-way audio with audio return by telephone lines. Multi-site-to multi-site full motion video via satellite still remains an expensive option for regular instructional purposes.

- ◊ An example of a successful use of satellites in higher education is the National Technological University (NTU), a consortium of approx. 30 American engineering institutions, and a blend of distance education, corporate education, and continuing education. NTU offers graduate courses leading to the M.Sc. degree in various branches of technology and applied science (Computer engineering, Computer science, Electrical engineering, Engineering management, Manufacturing systems engineering, Materials science, Management of technology, and Aerospace). Students can also take non-credit short courses to update their professional knowledge or to become familiar with related disciplines. All courses are broadcast by satellite: most are live, only few are transmitted from a prerecorded tape. The programs are designed for professional engineers, who work in the field. The tuition is paid by their corporate employers. In addition to instructional interactive television, the satellite network provides for instantaneous communication between professors and students, exchange of data, homework assignments and other instructional materials. Exchange of documents is possible by two systems: by Space Text (a video tape controller board converts data into TV signals, which are transmitted by a satellite, converted back to data at a receiving site, and stored on the computer or video tape), or by facsimile technology. A strong indication of NTU cost-effectiveness is a growing number of subscribing sites and enrolled students. The model of NTU has also been transferred to Europe, where The Programme of Advanced Continuing Education (PACE) has been established (Mays and Lumsden, 1989).
- ◊ In March 1988, over 300 people in seven US cities and Beijing took part in the first educational satellite tele-conference between the USA and China. Since then the system has been used to

provide students in Beijing with lectures from the USA about new topics in science and research, such as cell biology and expert systems. The system integrates computer communication, graphics, audio and video on a single telephone line, is interactive, real-time, and considered as inexpensive (Paulsen 1992, from Li et al., 1989).

- ◊ The University of South Pacific established the first satellite network (USPNET) in 1974, using a 24 hour a week transmission time on the NASA ATS-1 satellite. In 1985, the university got a permanent access to INTELSAT. The satellite is being used for distance teaching by teleconferencing (enabling students and their lecturers to discuss matters regarding courses, and providing a communication link between university professors and local tutors in the region), as well as for administration programs and regional meetings (Naidu, 1989).
- ◊ The University of Plymouth, UK, has launched a Satellite On-Line Searching Interactive Conferencing Experiment (SOLSTICE) for in-service training of university library staff from 13 UK universities in on-line searching. The project combined satellite television, audioconferencing, data transmission by satellite, and hands-on practice. Each site was equipped with a satellite dish and television receive-only unit, TV monitor, audioconferencing convenor unit, PC with installed data card, and a terminal for on-line searching. Based on the experiences with the project, Hughes and Priestly (1992) suggest the following practical points: (1) There should be an adequate installed base of suitable equipment. It is probably preferable to have well equipped and supported regional centers, to which trainees could travel relatively short distances, than have inadequately equipped individual units. (2) Audioconferencing was an extremely valuable component of the training, but needed to be managed carefully and expertly. (3) Familiarity with the medium is important, so an extended and coherent program of continuing professional education is more likely to be successful than occasional broadcasts.
- ◊ According to Brey (1991), the main limitation to the growth of interactive full-motion analog video satellite networks remains the cost. Uplink facilities can cost \$300,000 or more per site. Although the cost of receiver antennas has declined, they still cost from \$3000 upwards. Transponder time is costly and may increase in future. To become cost-effective, many receiving sites (up to several hundred students) must be linked to a single class, which in practice reduces the interactivity of satellite teleconferences.

Satellite teleconferencing systems are being increasingly used in continuing medical education, through maintenance of contacts between medical colleges and universities, research institutes, and physicians in urban and remote areas.

- ◊ A group of Canadian physicians at Memorial University of Newfoundland and their Kenyan and Ugandan counterparts have undertaken the development of a satellite link between Canada and East Africa with ground transmission between Nairobi and Kampala. The first formal weekly teleconference and informal teaching session in 1986 covered the topics such as nutrition, immune response, hepatitis, and emergency pediatric medicine. The plans were made to use the satellite link also for online literature searches (House and MacLeod, 1986).

Several satellite programs have been developed for teaching languages. Examples include:

- ◊ German language satellite program, applied by North Dakota and Missouri schools (Hobbs and Osburn, 1988),
- ◊ France-TV Magazine, a French language and culture video magazine series featuring cultural and political topics and current events taken from actual French television broadcasts. The series consists of nine 60-minute video units for each school year. Programs are transmitted via satellite as a direct

access service to schools, as well as for regional video distributing centers, where videocassettes are prepared for local distribution, accompanied by extensive print materials available on diskettes or as a hard copy (textual materials are distributed through a computer bulletin board system and BITNET). The series has been used across North American territory in more than 200 curricula with French as a second language. The first project evaluation has shown that while the program has been a resounding success with respect to dissemination and institutionalization, it is not financially self-supporting, due to a relatively small number of registered (and paying) users. Excluding nonpaying users who have been watching and using the program sporadically without registration and in violation of copyrights has been difficult. (DuVerlie and Pease, 1990).

Very Small Aperture Terminals (VSAT) transmit digital video information, which can be compressed. A single satellite transponder can simultaneously transmit many VSAT signals, thus reducing the price of an interactive video network.

- ◊ In the USA, several universities are planning to use VSAT for their distance learning programs, while in non-educational sectors data VSAT systems are already in wide use for credit card verifications (Brey, 1991).

Packed-radio technology

The lack of reliable communication with remote regions has posed a difficult obstacle in the implementation of development projects in rural areas of Africa, Asia and Latin America. While some regions are gradually expanding communication channels through satellites, digital equipment and fiber optic technology, many rural areas continue to be isolated from communication. The development of telephone circuits accessible to low-income communities is still slow in most developing countries. Inexpensive digital technologies, such as packet radio, can be used as a low-cost alternative to reach distant learners. The packed radio technology combines two-way radio and personal computers into an efficient system which enables a computer communication over radio circuits. Packet radio networks can be ground- or satellite-based, relatively simple or complex, and can be used for transmission of messages, letters, spreadsheets and reports in a similar way as computer communication via a modem and telephone lines. The main difference is that a terminal node controller (TNC) is used to link a personal computer with the two-way radio.

Ground-based packed radio networks are generally preferable for intra-country communications, while satellite systems are usually used for international applications, for geographically large countries (e.g. Sudan) or dispersed populations (e.g. Kiribati). Packed radio systems can be interconnected with telephone-based networks, such as Internet, Bitnet and Fidonet. Constant technological advances in packed radio technology and the increasing communication needs in developing countries indicate potential rapid growth of these technologies, however, in several examples they are hindered by regulatory issues and security concerns, even if they are used for humanitarian uses (Garriot, 1992).

- ◊ Excluding the computer, terrestrial packet radio station hardware and software cost from \$2,000 to \$10,000, depending on the quality of the radio. Cheaper radios can be used in deserts, where the interference is low. Comparable fixed or portable satellite stations range from \$1,500 to \$5,000, depending on the quality of antenna and the availability of electricity power supply. Commercial

TNC and radio products for military use are also available from different manufacturers, but at much higher prices that can exceed \$20,000 per station (Garriot, 1992).

Compressed video systems

Compressed video is a transmission system in which video signal is compressed, transmitted by a satellite, fiber optic or telephone line, and decompressed at the viewing site. Video compression is achieved by sacrificing small amounts of color, motion, or resolution information. A wide range of compression devices have been developed to reduce the satellite bandwidth requirements for the transmission of television pictures and accompanying audio signals (Keller et al., 1989). Although there is some loss of quality, compression of video signals can significantly lower the costs and increase the cost-effectiveness of teleconferencing.

- ◊ Each system must have a codec (converts the analog signal to digital format and compresses the signal), transmission line, and the interface unit (channel service unit between the end user and the transmission line). Equipment needed to compress signals costs approx. \$36,000 to \$38,000 per site. General costs range from \$20,000 to \$300,000. A Typical point-to-point system would cost approx. \$100,000 (Jones and Simonson, 1993).
- ◊ Compressed video by telephone lines can use copper or optical fiber cables for the transmission of interactive video, audio and data. In the USA, fiber cables connect all major cities and many towns. Therefore, delivery of degree coursework to distance learners throughout large geographical areas via compressed video over optical fibers is proving to be an economically viable alternative to other technologies (Brey, 1991).
- ◊ Wyoming, a rural state with small and scattered population, uses the compressed digital video network to connect the University of Wyoming with seven other community colleges. An experimental project was launched at the College of Education in fall 1992 to develop a mentoring model for teacher interns over distance (Hakes and Cochenour, 1993).

An example of a successful approach to telecommunications

The Nebraska approach (Foster, 1991) can be taken as an example of how a developed satellite telecommunication system can bring specialized instruction to remote regions affordably. In 1991, the old microwave equipment in Nebraska was replaced by satellite-based transmission (72 MHz wide bandwidth transponder). The overall costs for purchasing the transponder were \$7.18 million, including legal fees and insurance, less than continuing to lease microwave for its public television network. The new telecommunication system covered the needs of public radio and television, as well as the educational needs of the state. The educational satellite and fiber optic networking system, called NEB*SAT, includes four networks providing concurrent transmission capability:

Network 1, available without any additional equipment required, interconnects 9 Nebraska Educational Television Network transmitters and 9 Nebraska Public Radio transmitters. Two educational services are provided over this network:

- ◊ The Schools TeleLearning Service broadcasts five hours per day during the school year as a supplement to elementary and secondary school courses throughout the state.

- ◊ The Nebraska Educational Television Council for Higher Education (NETCHE, Inc.), a consortium of Nebraska colleges and universities, produces and distributes instructional television programs four hours per day (8.30 to 12.30) Monday through Friday.

Network 2 is providing statewide distribution of distance learning and continuing education programs (most of them are non-credit) to more than 200 sites that have the necessary equipment (each receiver costs \$7,000 - \$8,000). Many of the courses are broadcast live and utilize an audio bridge for two-way communication.

- ◊ The University of Nebraska uses the network to train its cooperative extension agents – an example is the Crop Best Briefing teleconference series on problems with crop pest, which is transmitted every other week throughout the state. The agents can use the latest information to educate farmers. Another example is a two hour agricultural home economic video broadcasting series, which can be recorded for the use in local libraries.
- ◊ Corp Net, a partnership between the University of Nebraska, businesses and industries, delivers non-credit engineering and business courses for the employees at their work place. In 1991, only one credit course (degree in mechanical engineering) was offered over Network 2.

Network 3 has the capacity to have 12 one-way or 6 two-way compressed video channels operating concurrently. Total transmitter and licensing costs for each site is about \$91,000 (including a 4.5 meter antenna, coding and decoding equipment, and receiving and transmitting equipment). The network interconnects higher education institutions - universities and colleges, and a regional medical center.

- ◊ Funding limitations restricted the amount of transmission in 1991, when only nursing and graduate engineering credit courses were priority, with other credit courses in the planning stages (MBA program in spring 1992). The University of Nebraska Medical Center plans to use the sites for rural health care education.

Network 4 is fiber optics based. In 1991 it was still in a stage of development. In the initial pilot experiment, five regional schools were linked by a two-way video system to share a variety of advanced classes.

From the experience of Nebraska project, Foster (1991) points out the following drawbacks and recommendations:

1. The choice of satellite transmission appropriate for Nebraska because of its geographical characteristics. In other circumstances (different geography and population), other forms of telecommunications may be necessary.
2. As a large and sparsely populated state, Nebraska did not find fiber optics cost-effective.
3. Nebraska choose to purchase an extra wide bandwidth C Band transponder, which is less expensive and has a wider bandwidth, but needs more costly satellite receivers, and is not as effective as a Ku Band transponder (which cost almost three times more, but can use less expensive antennas).
4. Compressed video significantly reduces the costs, yet the quality is reduced as well, and might be too poor for educational applications which need picture details.
5. Telecommunications technology is changing very fast. If the decision-makers wait for "the best" technology to arrive, they will never develop a usable system. Yet, an educational institution may also be lured into making a huge investment into the newest technology which, in practice, it will not use enough to justify the investment. In the case of Nebraska, an independent consulting firm conducted the needs assessment and provided recommendations based on the state's characteristics, needs and resources.

A cost comparison of transmission system

Transmissions using fiber-optic cable and microwave are directly affected by distance. Fiber optic cable is affected the most: each mile can add \$12,000 to \$20,000 to the cost of a system (Jones and Simonson, 1993). In microwave systems, the longer the distance, the higher the tower and larger antenna dish are needed. Compressed video systems are relatively constant in cost -- they are least affected by distance, because most of the cost of a system is in the codec equipment and at the end points. When selecting a medium, some compromises may be required. The main elements to be considered are the content of the educational material to be communicated, the quality of transmission desired, the ease of system use, and the costs of equipment and transmission.

- ◊ Jones and Simonson (1993) determined the costs for creating an interactive two-way distance education system using optical fibers, microwave, or compressed video. According to their study, digital fiber was found to be the best choice as far as quality and capacity, but also the most expensive and complex. The high costs tended to negate a quality advantage -- still, in many cases it was cost-effectively installed by schools not too far apart. For distances under 10 miles, microwave was a viable and cost-effective way to provide a full motion video connection between two schools. In some cities, microwave frequencies were not available for educational purposes. Leasing instead of constructing a tower decreased expenses. Long haul microwave systems were not cost-effective. Microwave systems were also the most susceptible to malfunctions because of the extreme weather conditions. If the quality of compressed video was satisfactory, this was overall the least expensive and cost-effective solution, especially for longer distances, where both fiber and microwave systems became cost prohibitive. Figure 2.4 shows the increase of the first year total costs for two sites in relation to the distance, while the Figure 2.5 gives the average costs per year for a 5 year period.

Figure 2.4: Transmission costs compared for various systems and distances: increase of the first year total costs for two sites in relation to the distance between them (data from Jones and Simonson, 1993).

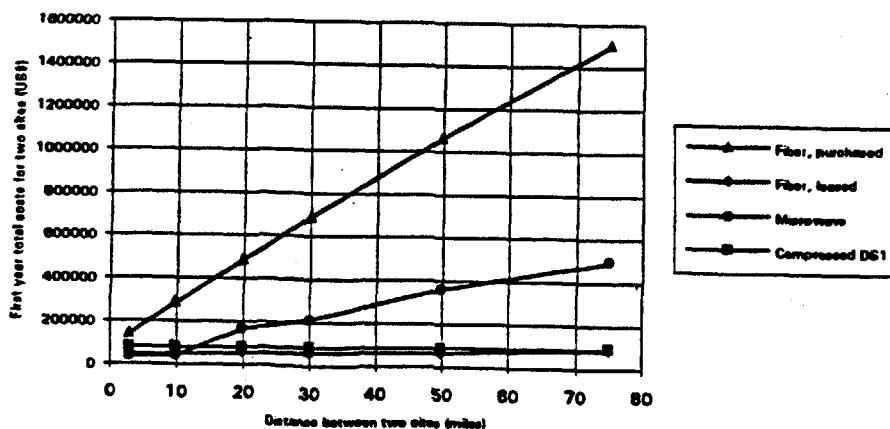
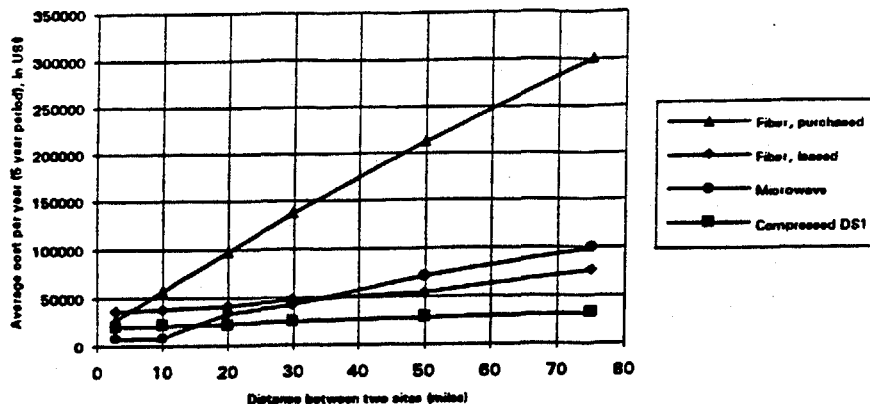


Figure 2.5: Transmission costs compared for various systems and distances: average costs per year for a 5 year period in relation to the distance between two sites (data from Jones and Simonson, 1993)



Radio broadcasting and Interactive Radio Instruction (IRI)

Radio broadcasting and Interactive Radio Instruction (IRI) have become the broadcast medium of choice both for general education and distance learning in many developing countries because of the low cost and flexibility. In remote areas of the world, where students might otherwise not receive a high quality education – or an education at all – radio programs have been upgrading teaching practices and providing students with direct instruction for over two decades. Radio can overcome the problem of distance especially where the population is in scattered villages and where there are natural geographic barriers. Examples from different educational levels (from pre-school to university) are known from several developing countries, such as Bangladesh, Bolivia, China, Costa Rica, Cuba, Dominican Republic, Ecuador, Ghana, Honduras, Kenya, Korea, Lesotho, Malawi, Mexico, Nicaragua, Pakistan, Papua New Guinea, Paraguay, Philippines, South Africa, Tanzania, Thailand, Uganda and Zambia (Anzalone, 1991; Laflin, 1994; Nettleton, 1991).

Radio can be used for a range of different educational purposes: (1) as a primary resource material – e.g. selected and edited recordings for distance education, (2) to record special natural sounds, voices of people, language characteristics, (3) to demonstrate methods or techniques through audio performances, e.g. music, drama, (4) to communicate with students where print cannot reach them quickly enough (Smith, 1986). However, the student is bound to a fixed listening time, and must be in possession of (or have access to) the receiving equipment. Unless the radio emission is tape-recorded, the message is transient. With increasing living standards, the use of direct radio broadcasting for educational purposes is in decline, and is often replaced by audiotapes (Selim, 1986).

Broadcast television

Broadcast television can reach a large number of people and can be a low-cost delivery method, particularly if the public TV system does not charge for air time. In densely populated urban areas, higher institutions of distance learning use a cable television system for their video courses, while the satellite transmission is used to cover large geographical areas. An alternative for very small areas, such as university buildings, campuses or nearby off-campus sites, is the closed circuit television system with originating and receiving equipment linked directly by cable, microwave, or telephone lines.

In regular teaching, television (and video) can be successfully used as an audiovisual tool to demonstrate (1) naturally occurring processes and materials, (2) special cultural, political and historical events or objects, (3) use of different tools, equipment, instruments, (4) scientific experiments that are difficult or impossible to perform in a classroom, (5) abstract principles through animated, slow motion, three dimensional models (Smith, 1986). In addition, television has been used to broadcast live lectures in distance teaching programs.

During the 1980s and at the beginning of 1990s, broadcast television was one of the most promising technologies in higher education distance programs. Its applications are reported from many institutions in the USA (Brey, 1991), as well as from several other countries such as China, Costa Rica, Korea, Pakistan and Thailand (Nettleton, 1991). Educational television is also reported to be used in primary and secondary level distance education in American Samoa, Brazil, Colombia, El Salvador, Indonesia, Malaysia, Mexico, Peru, Portugal, Sierra Leone, Singapore and Zaire (Anzalone, 1991; Nettleton, 1991).

- ◊ With the development of TV network in China, TV universities were established in 1960s in big cities (Beijing, Shanghai, Shenyang). According to the statistics, TV was an effective way of training at a lower cost. To train a correspondence student of college level, only 200-300 yuan was needed per year. The cost of three year higher education professional training was 5,000 yuan for a regular student, and only one third of that sum for a student enrolled in a TV distance education program (Wichit, 1986).
- ◊ Another study by the World Bank (1994) gives an example of the Chinese Radio and Television University, which achieved a 50% cost reduction per student (Y 1,000 in distance education compared with Y 2,000 per student in the conventional university system, data for 1981), and managed to maintain a relatively high graduation rate of 69%.

However, after a number of successful and failed experiments, and with the development of other types of educational technologies, broadcast television is being used less frequently now than it was in the past.

Facsimile (Fax)

Facsimile machines combine a scanner and a modem to send and receive printed or graphic information across the telephone lines. They offer a simple and user-friendly

transmission of visual images, including non-Latin characters, (such as Chinese, Japanese, Arabic, etc. scripts), tables, figures, drawings and pictures. The practice has shown, that even if instructors and students have the opportunity to use electronic mail and other electronic communications, many of them will not do so. The facsimile machine, however, is being widely accepted and used, because it operates from a hard copy which is familiar to all. (Mays and Lumsden, 1989).

Facsimile is usually used in addition to other educational and communication technologies, especially for the distribution of short documents in distance education and for information and library services.

In the first half of 1980s, fax was introduced at an extremely fast rate in Japan and is widely used in the educational systems (Sakamoto, 1986):

- ◇ The large-scale educational use of fax in Japan is the **First Stage Common University Entrance Examination**. Every year in January, approximately 350,000 high school leavers take the examination simultaneously all over Japan. MiniFaxes are used for immediate communication between the examination places and the National Center for University Entrance examination.
- ◇ In **Tokyo Institute of Technology**, fax is utilized for the campus information optical network system.
- ◇ The **University of the Air** started to use fax for tutorials to individual students. On agreed times, professors respond immediately to students' questions by fax. In 1986, 1300 students used the system in eleven courses.

Computer-mediated telecommunication technologies for asynchronous communication

Between the sophisticated technologies for synchronous interactive communication, and the traditional correspondence by mail, there are computer-mediated telecommunication technologies for asynchronous communication which use computer network systems. The research into educational applications of computer-mediated communication discovered their **positive effects**: freedom from time and distance constraints, amplified teacher and student inputs, increased teacher-student and student-student interaction, more independent learning, instant feedback and self-monitoring, improved writing skills, experience with computer-supported cooperative work, and lower communication costs for distance education. Also noted were some common **problems**, such as technology barriers, inappropriate integration of technologies into courses, insufficient training for the use of new technologies, and potential for information overload (Johnston, 1992; McMurdo et al., 1992).

Computer networks

As computer networks continue to grow and expand, they provide an effective tool for scientific and educational communication, exchange of research results and data sets. Computer-mediated communication offers significant advantages over telephone, fax, telex, and mail services in that they are lower cost, have higher speed of data transfer, high

reliability and flexibility. They also offer the possibility of different services, varying from relatively simple to complex and sophisticated applications. The development of electronic networks in industrial countries is very rapid, sometimes even exponential, while in developing countries the process occurs more slowly -- but the trends show a positive growth.

The majority of low-income developing countries are facing serious problems in the development of their local and international networking systems, such as lack of telecommunications capacity (e.g. insufficient number and poor quality of telephone lines), relatively few modems and computers concentrated in a few university departments, lack of formal training in computer applications and networking, and hinderance of administrative procedures required for networking. However, there are examples that indicate a progress in computer-based scientific and educational communication in low-income countries.

Wells (1992) collected data on 216 educational networks based on computer-mediated technologies from all over the world. Among them, more than 90 operate in the USA, about 30 in Canada, 45 in Europe and 7 in Australia. Some educational computer networks exist in Asia, and a few in Africa and Latin America. In addition, there are about 15 educational computer networks interconnecting two or more continents. Following are selected examples of educational and research computer-mediated communication networks from developing countries (Wells, 1992):

Countries involved	Network	Implementation/Activities
Australia, Thailand, Indonesia, Malaysia, Singapore, Brunei, Philippines	AUSEAnet	joint microelectronics network
Africa (Cote d'Ivoire), Europe	Cote d'Ivoire	IBM-Europe is funding a link from Cote d'Ivoire to European Academic Research Network (EARN)
Indonesia, Canada	Sulawesi Regional Development project	daily communication between Indonesian and Canadian project partners
Mexico, Argentina, Puerto Rico, USA	Project Orillas	promotion of Spanish language literacy for bilingual or foreign language students
Senegal (link to Cameroon, Morocco, Nigeria, Kenya)	CRAT/ARCT (African Regional Center for Technology)	food technology network
USA (nodes in North and South America, Africa, Middle East, Europe, Australia, Asia)	VNET	IBM's company network
Network of Universities in southwestern USA and Mexico	BESTNET	instructor - student interactions
USA, Argentina, Puerto Rico, Australia	FrEdMail	teachers, administrators, students
USA, Mexico, Canada, Puerto Rico, Japan	McGraw-Hill Mix	conferences for teachers and school administrators

Workshops in 1992 and 1993 on electronic networking in Africa revealed that the situation has been gradually improving. Some examples of international networks cooperating with (or based at) African universities and research organizations are given below (AAAS, 1993; AAU/AAAS, 1993; AAS/AAAS, 1992):

- ◊ **AFRINET** has nodes in Kenya, Zimbabwe, Tanzania, Uganda. The technical arrangements are diverse – e.g. AFRINET connects the University of Zimbabwe to the Internet via the California State University network using packet-switched lines.
- ◊ **ARCCNET** is providing high-level computing training and research for industrial applications, academia and policy-making institutions. It connects about 150 sites in Kenya, offering e-mail, computer conferencing and file transfer services.
- ◊ **ARCTIS** is promoting the development and use of information technologies in industrial, technological and R&D institutions in Africa. It is a system and an electronic network with several national, regional and international facilities and information sources, based on LAN (Local Area Networks) and WAN (Wide Area Networks), including telephone based and packed radio technologies. The main system components include TIES (global network of 35 countries, 11 of which are in Africa), INTIB (African sub-network of 21 participating African institutions), Food Technology Network (Cameroon, Kenya, Morocco, Nigeria, Senegal), and on-line access to database hosts (Telesystem, ESA-IRS and DIALOG) and e-mail systems (GE QUICK COM, COSY, DIALOG, PADIS).
- ◊ **ARSO-DISNET** is a network of documentation and information systems on standards and technology transfer in Africa. The center in Nairobi is connected to 49 other points.
- ◊ **ARSONET** links institutions in Ethiopia, Senegal, Kenya and Egypt.
- ◊ **CGNET** is an electronic data communication system in international agricultural, food and health-care research, using commercially available public switched data networks (PSDN), such as BT Tymnet, Telenet, and KENPAC. Most of the users are international agricultural research centers and their collaborating institutions. CGNET has established over 50 mailboxes in 18 African countries.
- ◊ **CIBECA** – the project for Capacity Infrastructure Building in Electronic Communication in Africa - - is a joint effort by Canada's International Development Research Center and the Pan African Development Information System (PADIS) of the UN Economic Commission for Africa. CIBECA has been established to provide training, documentation, equipment and support for selected Fido-based network sites in Africa.
- ◊ **EARN** is the European academic network with African nodes in Tunisia, Morocco, Egypt and Algeria.
- ◊ **ENDA-Dakar** is an environmental training program and electronic network promoting endogenous development in Third World countries. Based in Dakar, it connects 60 institutions from Senegal, Burkina Faso and Gambia.
- ◊ **ESANET (The Eastern and Southern Africa Network)** was established as a research project funded by the International Development Research Center of Canada, trying to investigate technical and institutional requirements for potential further networking in Kenya, Uganda, Tanzania, Zambia and Zimbabwe. At present the system combines telephone and packed radio communications, and provide e-mail and access to international on-line databases.
- ◊ South Africa's Foundations for Research Development (FRD) administers UNINET and provides support in electronic networking for several nodes in Africa.

- ◊ **GHASTINET** (Ghana National Scientific and Technical Information Network) offers e-mail service to academic and research institutions in Ghana. To reduce the cost of international telephone bills, the Gnfido Greennet gateway in London is used once a week.
- ◊ **HealthNet**, administered by the USA-based organization SatelLife, is a telecommunication system designed to facilitate the exchange of information among health professionals in developing countries, and to link them to their colleagues in the North America. The system is based on digital radio and a low-earth-orbiting satellite, and is focused on the exchange of health-related information. The African nodes are located in Cameroon, Ghana, Kenya, Tanzania, Uganda, Zambia and Zimbabwe.
- ◊ **IGADD-INFONET** is a comprehensive sub-regional information system for collection, analysis and distribution of information on natural resource management, environmental protection and desertification control . The headquarters are located in Djibouti, with nodes in Ethiopia, Kenya, Somalia, Sudan and Uganda.
- ◊ **MANGONET** (Micro Access for Non-Governmental Organizations) links individuals and organizations from Zimbabwe and South Africa.
- ◊ **MUKLA** is the electronic network of the Makerere University, Kampala, connecting 165 sites in Uganda, and a few users in Kenya, Europe and USA.
- ◊ **NGONET** links non-governmental organizations in Tunisia, Senegal, Kenya and Zimbabwe.
- ◊ **PADIS-NET** (Pan African Development Information System) was established by the UN Economic Commission for Africa (ECA) to assist African countries in collection, storage and utilization of data on development, and to promote information exchange in Africa. Examples of nodes include academic, research, government and private institutions in Botswana, Canada, Egypt, Ethiopia, Ghana, Kenya, Morocco, Rwanda, Senegal, South Africa, Tanzania, United Kingdom and Zambia. The system is based on Fidonet technology and offers e-mail, computer conferencing, and on-line access to several bibliographic and referral databases maintained on its mini-computer. PADIS-NET has participating centers in 36 African countries.
- ◊ **RINAF** (the Regional Informatics Network of Africa), a project of UNESCO and the Italian government, is helping the existing African nodes to move towards full Internet connectivity. At present there are several hundred network users in Sub-Saharan Africa.
- ◊ **RIONET**, using UUCP technology, is a global network of the French research organization ORSTOM. In Africa it presently links 25 Unix hosts in 10 countries and has about 270 nodes in Senegal, Mali, Niger, Burkina Faso, Togo, Cameroon, Congo, Cote d'Ivoire, Madagascar and Mauritius.
- ◊ **UNINET** is a research and academic network in South Africa, using primarily UUCP (and sometimes Fidonet) protocols. There are currently more than 35 South African sites connected to the network. UNINET has a direct link to NSFNET in the USA, and is also fully integrated into the Internet. In Africa, there are connections to Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Swaziland, Zambia and Zimbabwe. Most of them are used for communication and exchange of data sets several times a day. In 1993, the daily UNINET data traffic was about 400 megabytes, with the average cost of approx. \$0.01 to send or receive a 3000 byte e-mail file anywhere world-wide. This was calculated to be much cheaper than fax: the amount of \$0,01 would only cover 1.67 to max. 10 bytes of faxed text (Lawrie, 1993).
- ◊ **UNZANET** is a national academic and research e-mail network developed at the University of Zambia in Lusaka, linking 182 sites countrywide. In an arrangement with Rhodes University in South Africa a link to Internet and some other international networks has also been provided. UNZANET has been using a Fidonet system of dial-up telephone lines to transmit messages from use to user via dedicated host computers.

- ◊ WEDNET is includes nodes in Senegal, Burkina Faso, Ghana, Nigeria, Sudan, Kenya, Zambia and Zimbabwe.
- ◊ ZIMNET is the Zimbabwe national public packed-switched network.

Many of these networks are using Fido technology. Other solutions are based on mini Unix systems connected to X.25 public network. Several personal computers are connected to mini computers, sharing access to e-mail and all other services available on Internet (Abba et al., 1992).

Following are some examples of recent networking achievements and activities from the African universities (AAU/AAAS, 1992 and 1993):

Institution	Network links
University of Sierra Leone	LAN (Local Area Network) in place; stand-alone Fido host planned; later UUCP connection to RIONET is considered
University of Cheikh Anta Diop in Dakar	a digital telecommunication system in use, and a connection to RIONET
University of Zambia	the center of UNZANET with 182 sites; the first African country authorized to use SatelliLife low orbit satellite for HealthNet; participating in ZANGONET network of NGOs; discussions to establish AGRINET and EduNet systems
University of Zimbabwe	e-mail system with links to British and Northern American universities; a dial-up link to Internet via UNINET (the South African university network); links to ESANET, HealthNet, AFRINET, ZIMNET, NGONET, MANGONET
several institutions in Djibouti	links to INTELSAT and ARABSAT networks, SEA-ME-WE (undersea cable connection to Singapore and Marseilles (France), IGADD, ISERST packed-radio communication,
ICIPE (International Center for Insect Physiology and Ecology), Nairobi	International communication links: CGNET (through CGNET also BITNET, JANET, etc.). National links: Mbita, BMRU and LIDS. ICIPE activities cover a wide geographical area of Kenya, Somalia, Zambia and Ruined.
The African Regional Center for Technology Information System (ARCTIS)	The mother institution of a large ARCTIS system and electronic network
Kenya Computer Institute	KCI-NET (an e-mail system for intra- and inter-country communication)
University of Ouagadougou	connected to RIONET, plans to generalize the system
University of Yaounde	connected to RIONET and IRISA; plans to connect all university departments (optical fibers have been installed through a French-sponsored program PAESRUC), and later also other five universities and international organizations in Cameroon

University of Ilorin (Nigeria), Faculty of Health Sciences	a stable communication link with McMaster University, Ontario, Canada, since 1990 (e-mail, telex, fax).
University of Ibadan	a telephone linking to Fidonet is underway with a promotion of e-mail applications at the university
University of Ghana-Legon	GHASTINET link (Fidonet node in Accra) and a networking of three Ghanaian universities via a satellite uplink are planned
University of Cape Coast	HealthNet link is planned; a link to RIONET in Abidjan is also considered

The Internet is the most widely used international network for electronic communication in the academic community. Its initial objective was to link educators and researchers. Internet is designed as an interlinked set of regional, national and international computer networks, and offers five kinds of electronic services: e-mail, computer conferencing, remote log-in, file transfer and synchronous communication. Therefore, through Internet one may access remote computers, search the databases, exchange computer data files, obtain free software, send e-mail, order electronic journal articles, and use electronic catalogues (Paulsen 1992; Pollard and Akeyo, 1991).

- ◊ BITNET is a general purpose academic network, but is not a part of Internet. It connects over a 600 higher education institutions in the United States and around the world, encompassing also the NetNorth in Canada and the EARN network in Europe. These combined networks include over 3,000 computer sides in Mexico, Canada, West Germany, Israel, Japan, Korea, and other countries (Pollard and Akeyo, 1991).
- ◊ TENET, established in August 1991 by the Texas Education Agency, can be regarded as an example of a new, fast growing educational network, covering the local needs (in this case of the public educational system in Texas). It offers e-mail, electronic bulletin board, electronic conferencing, online databases, workstation communication software, resource sharing between networks, remote file transfer, and a gateway to several other major networks. During the first 14 month of its operation, 15,000 users accessed TENET, with average 20,500 logins per week. More than 1000 new users apply for an account each month (Stout, 1992).

Internet has already profoundly altered professional communication in academic and research institutions in developed, as well as in developing countries. However, an Internet host institution must lease a data line in order to connect to the Internet network. This may involve significant costs, especially in developing countries. Since a leased line costs are fixed (and there are no additional usage-based charges), there has to be a sufficient number of Internet users in order to reach the cost-efficiency.

- ◊ At present, Internet access in Africa is available only in South Africa and Egypt, while other countries (e.g. Kenya) are planning to establish Internet services soon. For instance, the university of Zambia estimates it will require a minimum of \$75,000 per year (including staff) to lease a line to the nearest Internet connection in South Africa. In sub-Saharan Africa there are relatively small numbers of network users, therefore, to date, the Internet connectivity has not been economically feasible in most cases. Some nodes, however, such as Zambia, are approaching the cost-effective size (AAU/AAAS, 1993; AAAS 1993).

Lower-cost "store-and forward" networking alternatives to Internet are available, based on dial-up access over normal telephone lines, that allow basic network services. Examples include UUCP (Unix to Unix Copy Program), which is the most common system in Latin America, now spreading also in francophone Africa, and the PC-based system Fidonet, the most widespread protocol in Africa. For both systems, a computer, a modem, and a software (inexpensive or free for non-commercial uses) are the sufficient minimum requirements.

- ◊ Fidonet is a point-to-point and store-and-forward wide area network (WAN). The technology combines several important advantages for developing countries: (1) low cost of implementation compared to other technologies, (2) efficient protocols optimized for use on low-quality telephone lines (high resiliency to line noise and satellite delays, automatic file compression and crash recovery), (3) the ability to support more users (50-100) on a single telephone line, (4) the possibility of being multilingual (in view of the language diversity in developing countries), (5) it has sophisticated off-line message readers and mailers, (6) the Fido software is available on various environments, including Macintosh, Amiga, Atari, and can also be upgraded to the UNIX environment. Fidonet system is used for transfer of textual and standard graphics files, but cannot provide online database searching. In 1992, Fidonet had more than 13,000 nodes for e-mail and bulletin board applications (Adam and Hafkin, 1992; AAAS, 1993).
- ◊ Initial start-up costs for Fido systems (AAAS, 1993):

Software and documentation on disk	free
Installation and limited on-site training	\$50,00
Monthly subscription (payable 3 month in advance)	\$10,00
Subsequent on-site support trips (2 hours)	\$10,00
International traffic, first KB	\$0.50
Subsequent KBs	\$0.20
International conference messages, per KB	\$0.20
Monthly modem rental	\$5.00 - 10.00
Local traffic and conferences	free

- ◊ UUCP (Unix to Unix Copy Protocol) is designed for mini and mainframe Unix computers. The system can run on different network media, e.g. on dial-up telephone lines, packet-switching X.25 line, or special leased lines. Like Fido, UUCP is still batch-based and may only be suitable for low volume data transmission (AAAS, 1993).

Computer networks have been used to enable several distance learning programs and courses. Selected examples of permanent programs and experimental projects include (Paulsen, 1992; Wells, 1992):

- ◊ institutions of higher education from Australia (Deakin University, Riverina-Murray Institute of Higher Education), Canada (Athabasca University, Tele-Universite du Quebec, University of Guelph), China, Denmark (Jutland Open University), Finland (Helsinki University), The Netherlands

* Additional and more detailed examples are given with specific technologies and media.

(The Dutch Open University), Norway (The Electronic College), USA (Connected Education, New Jersey Institute of Technology, New York Institute of Technology, Nova University, Rochester Institute of Technology, University of Alaska), and U.K. (British Open University, Lancaster University),

- ◊ projects linking individual schools or classes of elementary, secondary and high school students from various countries, e.g. Intercultural Learning Network, National Geographic Kids Network, and
- ◊ community education programs, such as National Public Telecomputing Network (Cleveland Free Net), Big Sky Telegraph (USA), Nordic Telecottages, and French Teletel and Edutel systems.

In addition to Wide Area Networks (WAN), Local Area Networks (LAN) are in rapid expansion, connecting computer hardware and software applications into a more effective system. Products providing a remote access to LAN have also been developed for distance users. They enable an easy and reliable connection of personal computers to a corporate local area network through a modem, using conventional telephone, cellular or radio connections. Thus, in educational settings, remote students and faculty can run applications in the university LAN, e.g. access library databases, transfer and process data files, send or receive e-mail messages, and perform other tasks just as if they were located at the university. International versions of remote access equipment and software are also available, which enable access to the home-university network from all over the world.

Computer networks can substantially improve the accessibility and use of educational, scientific and technological information via on-line databases and enable the exchange of data sets. Cooperative systems linking large academic communities may be more cost-effective than traditional separated information systems.

- ◊ OhioLINK is a statewide network that cost-effectively links information resources of 18 Ohio's academic institutions. Based on cooperation and driven by economic constraints, the data storage issue was solved by the construction of cooperative regional high-density sites (rather than by additional library construction on individual campuses). The library collections of all state-assisted colleges and universities are linked by an electronic network so that all library holdings are available to each library. A 48-hour delivery of materials (full-text and bibliographic databases, journal articles) between libraries has been implemented, using different technological and communication tools (ARIEL and CICNet, Internet with GOPHER navigation software, and telefax). The central database of the system offers a union catalog of holdings for all participating institutions, and searches on commercially purchased databases. While locally born costs were far greater than planned, this arrangement brought a major automation subsidy to local campuses (e.g. the saving at the University of Cincinnati from moving off the university mainframe to OhioLINK hardware is more than \$600,000 per year). It has been calculated that statewide, the system has added about \$20 million to support library automation hardware, and an annual average of about \$2 million to support operating costs (Kohl, 1993).

Computer-mediated telecommunication technologies for asynchronous communication via computer networks typically include teletex and videotex systems, electronic mail, electronic bulletin boards, computer conferencing, and electronic journals.

Teletex systems

The pages of text and graphics are created by a central computer, transmitted via the chosen medium, and displayed on a TV screen;

- ◊ The educational impact of Teletex has been minimal (Zorkoczy, 1984). Some universities have been using Teletex for announcements, short textual units, and overviews of study materials.
- ◊ Examples of teletex subscriber lines in 1992 (Siemens, 1994): Germany 10800, South Africa 1232, Turkey 677, Austria 546, Denmark 197, Switzerland 125.

Viewdata systems (Videotex)

Videotex allows users to access information stored in a remote computer via the public telephone service. The information can be displayed on a domestic television set.

- ◊ Examples of the first public viewdata systems include Prestel in UK, Teletel in France, and Telidon in Canada. Optel is a Videotex system of the British Open University (Bacsich, 1984).
- ◊ The number of Videotex subscriber lines in selected countries in 1992 (Siemens, 1994): France 6,270,793; Spain 390,000; Germany 340,000; Italy 178,283; Finland 170,000; Japan 139,027; Taiwan 13,500; Croatia 330; Hungary 383; Malaysia 640; Turkey 143.

Electronic mail (e-mail)

E-mail is used to communicate computer-based textual information using a computer (mainframe, mini or micro), a modem, a telephone line, and communication software. Participants are not linked directly to one another, but indirectly through the host computer. Initially, e-mail was viewed as a clerical tool. The business world was the first to realize the advantages and benefits of e-mail: an overall cost reduction, reduced paper handling, faster communication, improved communication effectiveness, and integration of data communication with records management (DeSouza, 1992). In academic institutions, e-mail was until recently primarily used for scholarly activities, especially for research communication in joint project work. However, e-mail can also be used in educational applications, such as (1) distribution of textual teaching units in distance education, (2) access to databases and other files stored in dislocated computers, (3) fast distribution of database search results and full-text documents from information centers, (4) dissemination of assignments, home works, tests, announcements, and returning of test results and grades, (5) active communication between faculty on sabbatical with students and professors at home university, (6) individualized communication between professors and distance or on-campus students. In scientific research, in addition to communication on research problems, e-mail can be used to exchange, discuss and finalize research proposals, submit articles to journal editors for review, and provide advice and guidance to graduate students on their research work and thesis. Finally, e-mail is useful in university daily administrative operations.

Despite of these opportunities, e-mail is not used to its full potential. The reasons may be that: (1) the software is not simple enough for an average user, (2) access to a computer network is not provided for all potential users – a computer terminal is located in a distant place of the campus, in a professor's office or in a locked room, (3) saving messages may

consume a large amount of disk space, (4) a lot of irrelevant announcements tend to be widely distributed via e-mail, and users do not have time to read them.

- ◊ DIALOG, one of the largest hosts of online accessible databases, offers an electronic mail service (DIALMAIL) for the delivery of database search results and full-text electronic articles (Gillikin, 1990).
- ◊ Simpson and Pugh (1992) call attention to the user-friendliness of e-mail software and robustness of hardware in educational programs. Widely-used e-mail software packages are quite demanding and difficult to use for correspondence instruction. The US Army Research Institute tested the utility of e-mail to support reserve officer training. This Army experiment demonstrated that e-mail systems can be difficult to operate, support and use successfully in training. On the basis of this experience, The Instructional Support Network (US Navy Personnel Research and Development Center) used a user-friendly e-mail software and low-cost, robust, simple hardware for the continuing education program at the US Naval Postgraduate School (NPS). A software company developed a turnkey program, characterized by simplicity (minimum number of functions necessary), visibility (explanatory menus display, help options), consistency (common template), and unbreakability (no matter what the student does, the program does not crash). The software and hardware were shipped to dispersed and remote students, which were required to set up the system and make it work using an instruction booklet. The e-mail system linked postgraduate students to an expert tutor at the NPS. The correspondence course offered in a six-month test was difficult (mathematics - calculus), but successful. The ISN group results were comparable to those in traditional instruction.
- ◊ The Japan Education System Co. set up a computerized distance teaching system LINES (Learning Information Network System). Educational software is transmitted from the host computer in the Center to microcomputers of students at remote places every day. Students study the programs and send their materials back to the host computer for immediate analyses (Sakamoto, 1986).
- ◊ University of Minnesota, Science and Engineering Reference Unit, developed a model for providing customized weekly literature updates to over 350 of their faculty staff. The system use their own specialized microcomputer databases, a high-speed campus network, mainframe computing and electronic mail to expedite dissemination of search results. User's search profiles for the Selective Dissemination of Information (SDI) are sent electronically via Automail. After processing, the search results in a form of microcomputer text files are uploaded to the WAX, using high-speed connection to the campus Internet, and finally sent to the users by Automail (E-mail system). The system has proved to be an effective way for providing customized current awareness services at relatively low cost (Butler, 1993).
- ◊ Other examples of e-mail use in university courses include: The Ohio State University for students in the industrial technology education program (Post, 1991); University of Alaska for four large courses and several workshop classes, depending solely on e-mail, and as an additional system to several other courses using video, cassettes, satellite broadcasting and audioconferencing (Fredrickson, 1992).
- ◊ Discussing the advantages of asynchronous communication by e-mail in comparison with telephone conversation, Pollard and Akeyo (1992) quote the following statistics by Michigan Bell Telephone Company: 55% of all business communications are only one way and 75% of all business calls are not completed on the first try; 76% of business calls are not time sensitive, and in average one half of a business call is not business related; 60% of all incoming calls are less important than the work they interrupt.

High prices of international telephone services in developing countries may work as the main prohibitive factor to international communication, resulting in isolation of university professors and researchers, students, physicians, health-care and other professionals from each other and from other colleagues around the world.

- ◊ For example, in Zambia an international call costs \$6,00 per minute, in Kenya fax costs \$7,70 per outgoing page, in Tanzania the minimum cost of a telex is more that \$25,000 (Shakakata, 1992).

Even though costs are complex and difficult to quantify, e-mail is usually cheaper than other forms of existing transmission media.

- ◊ The e-mail/fax cost ratio becomes smaller as the message size grows, and the compression and high-speed correction reduce the ratio by the factor of compression multiplied by the modem speed ration, as shown in the following comparison of transmission times and costs of fax vs. e-mail between Addis Ababa and London (AAU/AAAS, 1993):

Media	4 pages (10K file):	24 pages (60K file)
FAX	8 minutes (\$14.00)	48 minutes (\$84.00)
e-mail with no compression, 2400 bps	2 minutes (\$3.20)	5.6 minutes (\$9.00)
e-mail with compression, 2400 bps	1 minute (\$1.60)	3.7 minutes (\$6.00)
e-mail with no compression, 9600 bps	30 seconds (\$1.60)	1.2 minutes (\$3,20)
e-mail with compression, 9600 bps	20 seconds (\$1.60)	40 seconds (\$1.60)

- ◊ The **Satellife** was established as a relatively low-cost solution to the communication problem of expensive telephone lines in developing countries. The system works on a similar bases as the amateur radio communication – it has adopted a packet-radio technology combined with a low-earth-orbiting satellite to store, forward and distribute medical information. The cost of such satellites is relatively low (only about 1/400th of a geostationary telecommunication satellite). In Africa, a **Satellife** ground station is located at the University of Zambia Computer Center to provide the **HealthNet** services. Satellite-based messages can be transferred to(or from) the PC-running **Fidonet** e-mail system, connecting several nodes in Zambia, Zimbabwe, Tanzania, Uganda and Kenya (university hospitals, ministries of health, WHO and Unicef offices, Tropical diseases research centers and other hospitals). The **HealthNet** information services provided by **Satellife** include (1) library partnership programs for requesting/exchanging health information – e.g. a twinned program of the University of Zambia Medical Library and the University of Florida Medical Library, and the CD-ROM **Medline** database at the University of Zambia Medical library, providing literature searches for other health professionals, (2) **HealthNet News** – the electronic publication transmitted over **HealthNet** to health workers, (3) consultation – **HealthNet** provides physicians and health-care workers in developing countries with on-call access to organizations and institutions (e.g. Harvard School of Public Health, the Liverpool Schools of Tropical Medicine, and the Oswaldo Cruz Institute in Brazil; in Africa consultations have taken place among the universities in Zambia, Dar Es Salaam, Mozambique and Makerere, and several health institutions in Zambia). However, the **HealthNet** project is still on an early stage and has to solve several technical and human resource problems before it can be implemented on a large scale for a wider community of medical practitioners (Bennett, 1992; Shakakata, 1992).

Computer bulletin boards

In the hierarchy of computer-mediated asynchronous communications, computer bulletin boards reach one step higher than e-mail. They are a type of database which can be accessed using a computer with a modem, and are designed for handling public communication.

- ◊ The total number of bulletin board systems is estimated between 20,000 and 100,000, covering business, research, education, community information and hobby fields (Dewey, 1992)
- ◊ Starting in 1989 with 480 students in business and management courses, the University of Phoenix has successfully graduated the first classes of MBAs, who have obtained their credentials via the Online distance program. For this purpose, a customized bulletin board service has been designed specifically for the needs of accredited online education. Of the 480 students, 30% were middle managers, 44% technical or licensed professionals, and 20% executives and business owners. The average students age was 38, and 79% of them were males (although the distribution in on-campus courses was 56% males, 44% females). The University of Phoenix offers four business degrees via online: BA in Management, BS in Business Administration, MA in Organizational Management, and MBA (Ashley, 1992).
- ◊ The Queen Margaret College, Edinburgh, has developed an electronic publishing and communication bulletin board "Jimmy" on a Vax minicomputer. The system is used by arts, business and health care students and staff, mainly as a library of electronic publications (McMurdo et al., 1990).
- ◊ Gardener and Tillman (1986) report on an experimental use of the electronic bulletin board in an off-campus program for health professionals, offered by the University of Georgia. Prior to the experiment, each participant received a two hour basic training. The use of a bulletin board was advertised, but was not obligatory. Analysis of data indicated that only half of the students used the bulletin board during the fall quarter. Other students found it unnecessary and not easy to access (not all of the students had the necessary hardware to link up with the system).
- ◊ On the basis of experiences with distance education delivery of the Certificate Program in Computer Information Systems at the University of Victoria in Canada, Muzio (1992) compares computer-mediated communication via the university mainframe computer with a PC-based electronic bulletin system. In both cases the use of the system was not compulsory, students needed a PC and a modem to participate in the network, and had to pay the long-distance telephone charges. However, for the faculty the PC version was cheaper (no mainframe usage charges), less time consuming (less help was needed due to fewer problems with hardware, compatibility and telecommunication). Students found the PC network system easier to learn and more user friendly.

Computer conferencing

Computer conferencing contain all the facilities provided by e-mail and computer bulletin boards, but is designed with more features for organizing and storing text files to support instructional discussions. The conferencing software provides an environment similar to a real classroom discussion, but much slower, because of its asynchronous nature. Since the late 1980s, a number of distance education courses taught via computer conferencing have become available to distance students.

- ◊ The College of Computer Science, located in Oslo, Norway, has established The Electronic College for computer-mediated distance education. The program has been designed for future specialists in computers and software applications. All communication is based on computer conferencing. The first experimental program started in fall 1987. From 1988 to 1992, the Electronic College has sold about 800 courses on information processing, programming and system

analysis. The student completion rate of all courses was 71%. The grades of on-campus, correspondence and Electronic College students are based on the results of the final four-hour essay examination. Under this strict regime, students from the electronic college class achieved better grades than the other two groups. The positive difference may be a result of a better educational and work background, of more compulsory assignments, and of improved writing skills due to the increased writing which computer conferencing requires. (Paulsen, 1992).

- ◊ Boise State University (USA) offers an entire graduate M.S. degree in Instructional and Performance Technology through computer conferencing. The distance program is fully accredited by the Northwest Association of Schools and Colleges (NASC). Students from all over the North American continent, and few from overseas, participate in the program from their home locations, using personal computers and telephone connections. In addition to computer conferencing, additional media are used: e-mail, bulletin boards, computer-assisted instruction, databases, video and audio tapes, slow-scan video, print, fax and telephone conversation (Eisley, 1991).
- ◊ The Open Learning Program of the University of Maryland, University College, is based on a concept of time and place independence. The main learning materials are textbooks and other written materials, supplemented with video cassettes. The communication consists of regular mail, voice mail, and computer networking, used especially for computer conferencing. The voice mail system is used for mini lectures, questions and answers, short oral assignments and for announcements. A new computer network system was developed on a UNIX system, which provides access to online library, Internet, computer-based training, computer conferencing, E-mail, on-line technical support, distribution of course materials, downloading and uploading of assignments. The system has sound and graphics multimedia capability for future applications. The computer conferencing software was developed at the university, because there were no suitable off-the-shelf products available. The experience of establishing computer conference based courses has taught that a cooperative environment is absolutely essential in introducing a new technology. Several specialists/departments have to cooperate in setting up and running different components of the system: (1) technical part - hardware, software, and a user-friendly interface, (2) documentation - on how to use the system (for students, instructors, technical staff), (3) faculty development - training to design/adapt the courses and teaching materials, and to use the new technology properly to make the maximum benefit, (4) faculty and student technical training - to make them feel confident using the system, (5) permanent technical support for trouble shooting. A special free telephone line was established (with two full time technical advisors), which is available to students and professors as a permanent technical support service. From the educational point of view, computer conferencing greatly improves teaching and learning processes, but requires more work for the faculty, as well as commitment, flexibility, cooperativeness and readiness to deal with occasional technical problems. At present, 10 to 20 courses per semester are taught through computer conferencing, including various disciplines, e.g. management, computer science, fire science, languages, writing (Davies, 1994).
- ◊ In Europe, The Open University in the UK pioneered the use of computer conferencing in mass distance education. The use of computer conferencing system CoSy on the course DT2000, An Introduction to Information Technology, was started in 1988 with about 1500 students and 65 tutors. The course combined different software packages: word processing, database management, spreadsheet analysis, and communications. Since then, a variety of other courses have adopted CoSy: the Open Business School's MBA program, and optional extra courses for students with suitable equipment, e.g. Computers and Learning undergraduate course. Campus 2000 is another provider of group mailing facilities in the UK and can be accessed from anywhere in the UK at local telephone charge rates. It has been connected by a gateway link to Edutel, the educational information service supplied by the French Education Ministry. Several educational institutions from UK, France and Germany use this links in foreign language learning programs. Campus 200 provides access to FELINE database, including selected authentic texts from French, German and Spanish satellite TV broadcasts. PLUTO is a loose cooperation of individuals and institutions involved with teaching and teacher training in Europe, used for the exchange of educational materials, experiences and ideas, and for the communication between the educational projects' partners (Mason, 1991).

- ◊ Harasim (1991) reports on computer conferencing used in Canada at the Ontario Institute for Studies in Education (the Graduate School of Education for the University of Toronto) since 1985, and at Simon Fraser University, since 1986, for a variety of educational applications, including undergraduate and graduate credit course delivery, in-service training of teachers, curriculum enhancement, online workshops, and communication on research and project work.
- ◊ The Electronic University Network (EUN) is a commercial enterprise that provides online services for organizations in the USA with distance education programs. EUN also promotes flexible transfer of credits among colleges. In 1991, EUN provided access to the following degree and certificate programs: Bachelor of Science in Business Administration, Bachelor of Arts, Associate in Arts, Associate in Science in Management and several Certificates in Business from Thomas A. Edison State College; Masters of Business Administration from Saginaw Valley State University; and BS in General Business from Regents College of the University of the State of New York. In addition, 78 individual courses were offered through EUN by 7 universities and colleges (Paulsen, 1992).
- ◊ CompuServe is a commercial, general-purpose international conferencing system with about 800,000 users (Paulsen, 1992). Via CompuServe, university students can access bibliographic databases, such as ERIC and Dissertation abstracts, Peterson's College Database, Magazine Database Plus, the Academic American Encyclopedia, buy mail-order computer equipment, consult a travel agent, or take courses in different domains, e.g. computer training or foreign languages.

Computer-mediated communication can be used for distance learning programs, as well as to gain the hands-on experience with computer mediated communication.

- ◊ The University of Idaho and the University of Nebraska-Lincoln launched a project for students enrolled in Administrative Office Procedures class and in Business telecommunications class to gain telecommunications concepts and skills needed for their future professional lives. The project objectives were to exchange messages and search other institution's libraries, using BITNET and Internet, and at the same time understand the telecommunications terminology, hardware and software, and gain the practical skills in computer-mediated communication (Pollard and Akeyo, 1992).
- ◊ At the National Technological University, the computer serves as an instructional tool, as a method to facilitate the instruction, and as the object of study itself. The computer network is available to students, faculty, site coordinators, and institutional representatives. Students may use interactive computer linkage for various purposes: to apply for admission, to communicate with their professors or fellow students by electronic mail, or to exchange data sets, diagrams and pictures. Information that would ordinarily be posted on bulletin boards or publicized through student newspapers is communicated to all personnel at a distance by an electronic bulletin board. NTU also uses Videotex system to communicate with the university administration. A project (ELAN) has been underway to enable students nationwide to dial in to a main school computer, submit a program for batch computation, and obtain a return later in the day. In addition, this opens the possibility of remote access to super computers and specialized databases (Mays and Lumsden, 1989).

Many of the early computer conference courses attempted to replicate traditional teaching in a new medium, with little innovative use of technology. However, some documented examples give evidence on innovative methodological approaches (Paulsen, 1992; Scott et al., 1993):

- ◊ The International Business Negotiation Simulation Course (developed jointly by the University of Maryland, University College and the University of Maryland, College park) introduced a computer-

managed, text-based simulation to teach business executives via computer conferencing how to negotiate successfully in specific cross-cultural business environments.

- ◊ The Management Practices course (New Jersey Institute of Technology) integrated a Business Simulation Game with computer conferencing.
- ◊ A system of microcomputers interconnected with electronic conferencing software linked 20 undergraduate business students at the University of Northern Colorado for collaborative problem solving. The statistical comparison of students' results in comparison with a control face-to-face group showed that students were more productive in accomplishing task objectives and participated more uniformly when working together using computer-mediated communications.
- ◊ The Living on Purpose course (Awakening Technology) used computer conferencing to provide safe and supportive environment for human relations. The program included self-discovery exercises and group sharing.

Electronic journals

Some journals are now available in an electronic format only, or in addition to a paper format. They are normally offered through large database hosts for downloading or distribution by electronic mail. Their advantages are (1) shortened turnaround time for publication of articles, (2) a quick access to full-text documents via computer networks, (3) the possibility of full-text searching, providing retrieval capabilities beyond those found in abstract and index databases, and (4) as subscriptions to hard copy serials continue to increase, a cheaper alternative to obtain selected articles (the trend is having access to materials rather than owing them). As advances in technology continue to reduce the cost of sophisticated computer hardware, such equipment is becoming more affordable to a large scientific community, making electronic publishing possible.

In addition to relatively few online electronic journals, several on-line "full-text databases" contain selected articles in the full-text format, without the whole periodical appearing in the database. However, a larger number of full-text with full graphics periodicals and books are available on CD-ROMs.

- ◊ The world's first electronic, peer-reviewed science journal, with completely searchable full-text and graphics, "The Online Journal of Current Clinical trials", was launched on July 1, 1992, as a joint venture of AAAS (American Association for the Advancement of Science), which developed the editorial content, and OCLC (Online Computer Library Center), contributing the interface and distribution on its international telecommunications network. Subscribers may access the journal via direct dial to OCLC or CompuServe host, via OCLC's network, and through the Internet. A graphical user interface (GUIDON) provides graphical display of full text, figures, and equations in a high quality typeset format. Subscribers using GUIDON can print the entire article or any screen on a laser graphics printer, while other subscribers may order offline prints to be delivered by fax or regular mail (Keyhani, 1993).
- ◊ Examples of periodicals, that are available online the same day or earlier than in a hard copy format include several daily papers: American Banker, Daily Mail, Daily Telegraph, Financial Times, Japan Times, Montreal Gazette, The Wall street Journal), as well as some technical and scientific journals: Agrow World Crop Protection News, Clinica World Medical Device, Education Daily, European Chemical News, Inpharma, Journal of Commerce, New England Journal of Medicine, Scrip World Pharmaceutical News, Telecommunication Reports (Orenstein, 1993).

Interactive telecommunication technologies for synchronous communication

Sophisticated technologies for synchronous interactive communication (computer-conferencing, audio-conferencing, audiographics, video-conferencing) still seem to be affordable only for the high-income economies. The leading developers and users of these technologies are industrialized countries with strong technological and telecommunication backgrounds, especially the USA, Canada, Western Europe and Japan. The majority of developing countries have not yet been in a position to utilize the complex equipment necessary for interactive distance education, because of the high costs, inappropriate technological infrastructure, and often very high numbers of students involved in the educational process. Several educators share an opinion that this may further increase the gap between low- and high-income countries, while some dispute evidence that the sophisticated interactive tele-education is more effective than the traditional educational practices when applied on a large scale.

However, interactive educational technologies which provide synchronous communication, especially the more affordable ones such as audiographics, have proven cost-effective and particularly valuable for (1) small groups of students (e.g. elective subjects, specialized graduate studies, geographical remoteness, small island countries), (2) individually tailored instruction (academically very capable students, physically handicapped students, home-bound or migrant students), (3) in-service education (teacher training, on-the job industrial education, continuous education in computers and hi-tech equipment).

Audioconferences (audio teleconferences)

Audioconferencing is a relatively low-cost interactive technology that uses telephone lines for the audio interaction among more than two sites. In distance teaching, the telephone (as the only tool of communication) has been used especially for tutoring and counseling individuals, only seldom for group teaching. However, the audio teleconferencing is gaining the importance from its use with other media, especially microwave and satellite slow-scan and full-motion video systems. Its applications in combination with computers resulted in audiographic systems.

There are examples of instructional teleconferencing (in combination with other media) from several universities in the USA, Canada, Europe, Australia, and from some higher education institutions in developing countries, such as the University of South Pacific, University of the West Indies (Caribbean islands), and Universidad Estatal a Distancia (Costa Rica) (Fredrickson, 1992; Robinson, 1984, Sakamoto, 1986, Shaw, 1987).

- ◊ The University of the West Indies serves a region covering 17 Caribbean countries. Its first telecommunications experiment in distance learning begun in 1978 with the Satellite Project. A feasibility study had stressed the need of a combined use of print, audio-visual and other media, and gave the priority to interactive rather than broadcast systems. As a result, a system was developed, consisting of a telephone link-up between seven countries (including cable, microwave, and satellite

transmission systems). Each study center had a teleconferencing room equipped with microphones, loudspeakers, slow-scan TV (to transmit and receive still images), a telewriter (a substitute for a traditional blackboard, consisting of a pad with a special pen for writing, a microprocessor and a video monitor), and a microcomputer for document transmission. An additional room was provided on each campus for private conversation between students and professors and for examinations. The spectrum of distance learning programs in the project period 1982-1987 included B.Sc. courses in social sciences, in-service teacher training, health and agriculture courses, and programs for the university administration. The final assessment of the project recognized its success: (1) the system reached a larger audience spread over a wider geographical area, (2) the performance of distance students was comparable to regular students, (3) the cost per student was only about one-half (J\$7,400) of the cost for regular students (J\$15,000). Despite its success, several difficulties were identified: (1) frequent and frustrating breakdowns of the telecommunication system, (2) print materials sometimes arrived too late for the students to prepare in advance for the interactive sessions, (3) some students had difficulty working in groups because they could not find transportation to the study centers, (4) a major difficulty cited by students was lack of time for study – travel from remote areas to study centers was very time consuming, (5) the program has not met enrollment expectations and participation is declining. (Jennings, 1990).

- ◇ Because of its geography, Indonesia became the first Third World country to establish its own domestic satellite system in 1976. In 1982, the US Agency for International Development initiated the AID Rural Satellite Program in Eastern Indonesia, which focused on higher education. Each site in the system was equipped with a telephone terminal, audioconferencing equipment (convener, microphones, loudspeakers), facsimile, graphics system (monitor, microprocessor, light pen, modem), and an emergency power supply. A large component of the project was training, which included upper-level decision-makers, central project staff, telecommunications technical staff, site staff (local maintenance and operation), program developers (educationalists, scientists), program presenters (teachers), and program participants (students). The audioconferencing network supported several developmental activities: university teaching to a large student audience (60 undergraduate courses were delivered in two years (1984-86), in-service training of teachers, animal husbandry training for extension agents, technical training for telecommunications personnel, coordination of child health campaigns, and administration of rural institutions. The main problems encountered during the project implementation were: (1) poor quality of local lines – in some places cables from colonial times were still in use, (2) variability of telecommunications network, (3) equipment failures, (4) personnel problems in maintenance and operations. The final review of project results concluded that (1) the audioconferencing network was highly reliable, while the graphics support channel was less so, (2) students were satisfied with the quality of audioconferencing and with the wide choice of courses and materials offered, (3) teachers felt that courses were more demanding for them, because they had to modify their teaching style, but after some time they felt comfortable teaching over the tele-system, (4) an overwhelmingly positive response was received from the remote users (doctors, school teachers, government officials), who had not had access to new information and expertise before the system was introduced, (5) the costs of installing and operating the network were substantial; plans were made to increase the cost-effectiveness by reducing the graphic channel and by improving the management to increase the number of programs and participants (for project details see Shaw, 1987).
- ◇ In Peru, the AID Rural Satellite program provided basic telephone service to seven rural communities and established an audioconferencing link for in-service training of health workers, agriculture extension agents, and teachers. 658 audioconferences were completed in a two-year period 1984-85, including medical consultations, in-service training of medical personnel, coordination of a national vaccination campaign, in-service training of education officials, teacher training in special education (learning disabilities) and science (in a combination with videotape), and a series of agricultural audioconferences (for project details see Mayo et al., 1987).
- ◇ The Great Basin Project (Utah, USA) for distance learning has been designed to provide more cost-effective instruction to students in small, remote settings. For this purpose, a special telephone

- circuitry was developed that allows multiple schools to network over a single telephone line. A special modem splits frequencies, transmitting two-way signals simultaneously. A slow scan video and hard copy transmission by fax were also made compatible on one telephone line. The first courses were offered in fall 1988, including applied physics, advanced math, English, French and computer-assisted drafting (Murphy, 1989).
- ◊ Tokyo Institute of Technology utilized three telephone lines for interactive transmission of audio (professor's voice), still images (professor's face) and handwritten characters (shown on a second TV monitor) between two campuses at a 30 km distance. The project was interrupted after the experimental phase (Sakamoto, 1986).
 - ◊ The Japan Management Association started a similar program - Tele-Learning College - with audio, still pictures, and handwritten characters, for in-service industrial professional education. In 1986, more than 200 people in 12 different industries (average 10 to 15 learners per a study center) took the courses offered for 12 weeks, 90 minutes per day: Sample course titles include Innovation Practices for Managers, Fundamentals of AI, New Techniques in Biotechnology, and Fundamentals of Electronics. The approximate cost of the system was \$10,000 for purchasing terminal equipment and for telephone fees (tuition fees and costs for textbooks are excluded). The average cost per person per course was about \$230 in Tokyo area, and much more in remote places. The problems encountered during the first year were mainly related to insufficient interactivity of the system, e.g. when several course participants wanted to ask questions simultaneously. A still picture limited the lecturers - they could not illustrate concepts with a movement of hands or use a special behavior. The cost of telephone lines in an interactive multi-point network was also considered as a drawback (Sakamoto, 1986).
 - ◊ At the University of Alaska, audioconferencing has been used to conduct the university-wide meetings, such as the Academic Curriculum Committee, the Faculty Senate, and the Strategic Planning Committee (Fredrickson, 1992).

Audiographics (audiographic conferencing)

Audiographics is a combination of audioconferencing in conjunction with computer technologies to include graphics or still images. Students and an instructor can communicate by a simultaneous two-way voice and a still visual transmission over a single telephone line.

- ◊ An audiographic computer-based integrated system typically consists of 1 or more personal computers, a modem, standard telephone line, device for voice amplification (speakerphone), and of an audiographic software package. A telephone bridge provides communication of multiple training sites. A graphics tablet (digitized or light pen) is optional, or a telefax for transfer of materials. A projector for displaying the contents of the computer screen on a wall screen is also recommended. To input still images, computer graphics may be replaced by video camera, VCR or videodisk player.

Several authors agree that audiographics is the most cost-effective and efficient of the interactive technologies enabling transfer of images. The operating costs are tied to long distance telephone rates, and the maintenance can be handled by the instructor with some training.

- ◊ According to Bradshaw et al., (1989), the audiographic installation costs about \$6,000 per site, and the daily operating costs are tied only to long-distance telephone rates. Fredrickson (1990) reports on similar costs: between \$3,000 and \$8,500 per site. According to his calculation, this is markedly less expensive than an interactive satellite delivery system with the initial equipment investment of \$15,000 to \$25,000, and annual subscription fees of \$4,000 to \$10,000.

- ◊ Brigham (1991) compared the costs and effectiveness of two alternative delivery systems (audiographics and interactive television) for advanced high school courses in the Otselic Valley Central School, NY. The calculated unit costs for interactive television were about two times higher than for audiographics:

Unit costs	Audiographics	ITV via cable	ITV via satellite
Cost per course per year (2 courses, 5 students each)	\$1,269	\$2,241	\$2,641
Cost per student	\$254	\$448	\$528

However, while audiographics had an apparent cost advantage, the interactive television system was more effective and offered a wider variety of educational programs.

To pay back the initial system investment, reach cost-effectiveness and high efficiency, teleconferencing is recommended for long-term training and/or consulting on a frequent basis where multiple remote sites are identified e.g. (1) for distance education programs where students and/or instructors are geographically dispersed, (2) for continuous in-service and on-the job training, (3) for consulting on a frequent basis when information is new or changes quickly.

Audiographics has been used by several educational institutions in industrial countries:

- ◊ One of the early audiographic networks was Cyclops, introduced by the British Open University in 1981 (McConnell 1984). The standard set of equipment for the Open University study centers consisted of a Cyclops terminal with light-sensitive writing pen and an electronic digitizing pad, two telephones (one for voice and one for picture transmissions via modem), and a standard TV set. The cost of the first version of Cyclops was high, especially because of the high prices of terminals and microcomputers in the beginning of 1980s. Later versions of Cyclops were developed at lower costs.
- ◊ The Community Colleges of Spokane Institute for Extended Learning in Washington State has introduced an interactive computer graphics teleconference network for educational programs in geographically isolated areas (Munro, 1986). 16 college classes were successfully completed during the school year 1985-86. The monthly charges for telephone lines varied from 35\$ to 259\$. With a typical class duration of 10 hours per day, the per hour costs varied from 0.16\$ to 1.14\$. At this hourly rates, even a large network cost substantially less to operate than would cost an alternative system on the \$300-400 per hour charge for satellite video transmissions. The equipment used in audiographic classrooms has varied from inexpensive \$200 telephone sets to \$1500 for more elaborated systems.
- ◊ Blinn et al. (1989) reported on pilot tests on teletraining via audiographic teleconferencing. The experiment indicated microcomputer teletraining can substantially reduce training costs without sacrificing training effectiveness. The Telecommunications Development Center and the University of Minnesota launched four audiographic courses to provide on-the-job microcomputer training to staff and natural resource professionals. The basic system components were personal computer, modem, standard telephone line, voice amplification device and a commercial teleconferencing bridge. The cost comparison of teletraining (long-distance fees and bridge costs, shipping and installation of hardware and software, instructor salary, voice amplifier) and of traditional courses using an instructor traveling to each remote site (travel expenses, instructor salary) has shown an average 60% cost reduction for audiographic telecourses (50%, 51%, 64% and 65% cost reductions in four telecourses). However, the analysis did not consider the purchase prices of hardware and software. The evaluation of training effectiveness has indicated that the course

participants had learned as much during the audiographic session as if the instructor had provided face-to-face training.

- ◇ Similarly, Bradshaw et al. (1989) quote a study of the Pennsylvania system Wydra, concluding that a system based on interactive audiographics is at least as effective as live teaching and in certain instances more effective. According to the same authors, The Pennsylvania State Department of Education has invested heavily and successfully in audiographics.

Interactive one-way television with audio return

The system is similar to a conventional educational television, except that in addition participants can interactively communicate by telephone or FM radio. The interactivity of a system can be increased by telefax (exchange of hard copy materials) and computer networks.

Costs for setting up receiving sites are not extremely high (Bradshaw et al., 1989): the minimum equipment consists only of a TV and telephone (under \$1000 per site), but a satellite or microwave receiving station may also be needed, and fees have to be paid to a central broadcast studio.

- ◇ TI-IN is a one-way satellite TV network with telephone return, with the main center located in San Antonio, Texas, USA. In 1988, TI-IN transmitted 25 different high school credit courses to more than 200 high schools in 14 states, and the system is still expanding. The network also broadcasts extensive in-service courses for teachers. Similar active and successful networks include Arts and Science Teleconferencing Service of the Oklahoma State University, the Eastern Washington University Satellite Telecommunication Educational Programming Network (STEP), and the SciStar Satellite Series of Talcott Mountain Science Center in Connecticut. These networks offer different programs, e.g. advanced language courses, trigonometry, calculus and chemistry (Bradshaw et al., 1989).
- ◇ The Utah State has built a complex microwave network capable of transmitting two-way or one-way television with several added channels of audio and/or data. The University of Utah operates two broadcast channels, with one signal extended over 95 percent of the state by a translator system. The Central Utah Educational Service Center, with the cooperation of the University Media Services Department, has launched a one-way TV with audio return statewide distribution system to extend the services of its best teachers to central Utah and other remote areas (Murphy, 1989).
- ◇ A well known interactive video systems via satellite is also the educational network of the National Technological University, USA. The system is located on the campus of Colorado State University and has participating universities and businesses throughout the USA. It offers masters degree level courses by one-way full motion analog video via satellite with two-way audio by telephone (Mays et al., 1989; Brey, 1991).
- ◇ Benson (1993) reports on a project, designed by The State University of New York and Instructional Systems, Inc., combining a computer assisted instruction and live, interactive videoconferencing. The program is conducted via cable and is used at student's home for extended learning in mathematics. The model can be applied to a number of other areas in basic and higher education, at the work place, in community organizations and correctional settings. The project shows the promise of the integration of real-time interactive video, voice, and data in combination with computers to improve the quality of distance learning.

Interactive two-way television systems

Two-way television is the most complex and costly to operate and maintain. Activities are transmitted simultaneously from all points of the network, so that teachers and students can

both see and hear each other (as they would be in into the same classroom). To achieve this, each site in a system requires a small TV studio with camera, microphones and monitors. Because of high investment and operating costs that rise with numbers of sites and the distance between them, the two way television is used for educational purposes only rarely (even in industrialized countries), and only within a limited geographic area. The transmission is usually by microwave or cable.

- ◊ According to Bradshaw et al., (1989), a minimal two-way TV system starts at around \$14,000 per site. Central broadcast studio construction and equipment cost at least \$35,000. Transmission costs depend on the distance and medium, e.g. \$6,000 per one mile of fiber optic, \$25,000 per 20-mile microwave hop, and \$85,000 per 50-mile hop.
- ◊ In Tokyo Institute of Technology, two campuses 25 km apart were linked by optical fiber cable for two-way audiovisual and data communication. The system includes eight channels available simultaneously, a pair of TV lecture studios, and 29 tutoring rooms. The total investment in hardware and adaptation of buildings was approximately \$7 million (Sakamoto, 1986).
- ◊ In the USA, two-way educational TV has been promoted in Minnesota. Each district in the state has been encouraged to join with others and develop their own distance learning programs. Initial evaluations are positive. Response to the system has been favorable, although some difficulties appeared, related to personal contacts, space and movement restrictions, technical problems, and conflicting school schedules. The students in remote classes learned as well or better than those in regular classes (Bradshaw et al., 1989).
- ◊ A duplex video (two-way TV) project in Carbon School District, Utah, reported similar results. In 1985, funded by a grant of \$120,000, students from three secondary schools in a poor area of east-central Utah were integrated into a single class. The signals were transmitted via coaxial cable and microwave, with a satellite downlink. All classes were totally interactive. Classroom learning was managed by an aide. The final standardized test ranked the students, as a class, in top five among 28 other schools. In 1986, the system connected by cable with the College of Eastern Utah, and in 1987 the cable was replaced by fiber optics. The educational program was enlarged, and the participating sites receive both college and high school credit. A third-party evaluator found that the students at remote sites outperformed the college students in all three courses evaluated. The project has finally joined the Utah State microwave system to receive interactive television programs from other regions (Murphy, 1989).
- ◊ The School District San Juan, Utah, contains some small, very remote high schools within Navajo Nation lands. Good teachers were hard to hire and keep, and the curriculum offering were inadequate. As a result of several grants, a \$600,000 interactive television system was developed with two-way video and multi-channel audio. The classes begun in 1987, but were temporarily shut down after six months because of a strong lightning strike that seriously damaged the transmitter system. The damage was repaired and since then the system has been operating without interruptions. Courses include Business English, College English, French, Calculus, Science, Marketing, History and Psychology. The students' performance equals that of traditional face-to-face classes.
- ◊ The Hawaii State Department of Education offers university credit courses in English as a second language to all public school teachers. Because of the scarcity of teaching staff and the distance between schools, three distance education models have been developed as the in-service training opportunity: (1) a closed-circuit TV with two-way audio and video (not all sites have these facilities), (2) one-way video and two-way audio, and (3) one-way video via cable TV on a public access channel, with the possibility to use a telephone line for audio conversation. Fax and e-mail are used for the exchange of paperwork and texts (Power, 1993).

Examples of electronic classrooms

In January 1993, the Western Illinois University opened a special classroom for visual presentations and electronic interactions in the College of Education, with advanced technologies for large-image video projections and interactive discussions (Barker and Harris, 1993). To justify the investment in a sophisticated electronic classroom (approximate total costs \$150, 000), the following educational needs were considered: (1) students and university staff should to understand, accept and use computer and multimedia technology; (2) the knowledge and skills can be used for the improvement of teaching methodology and for development of different teaching styles, as well as for the improvement of curricula, and development of new, technology-rich instructional materials; (3) the facility can also be used as for distance education.

Components of the electronic classroom and approximate costs* (Barker and Harris, 1993):

Large projection screen	\$800
Audio/video/computer podium with electronic controls for the instructor (controls all media equipment, lights and sound), two multisync monitors for displaying the images sent to the large screen projector, and a preview monitor	\$12,000
Video projector mounted on ceiling with multisync capabilities (for computer and video display)	\$20,000
PC microcomputer with keyboard	\$1600
Macintosh microcomputer with video spigot, CD-ROM drive, and additional cards	\$5,500
Laser disk player with interface cable to PC and Macintosh computer	\$1,200
Videotape player in VHS and S-VHS	\$1,500
Color slide projector	\$2,400
Visual presenter - electronic opaque overhead projector (uses a wide angle camera which allows documents or three-dimensional objects to be projected on the large screen)	\$3,500
30 wireless, remote key-pads (used by students to respond the questions posed by the instructor -- the responses are immediately transformed by the computer and projected in a form of a graph or chart on the large screen)	\$22,000
Microscope camera (to project microscopic views to a large screen)	\$3,500
Two robotic cameras mounted from the ceiling (can record and send full-motion images to the university's satellite uplink, or can be used for compressed video via telephone lines)	\$7,000
Peripheral hardware	\$4,000
Site preparation (materials and installation for sound, lighting, electrical wiring and controls, structural changes to accommodate handicapped, carpeting, acoustics, fiber optics connection, multi-plexer units, etc.)	\$65,000
Approximate total costs	\$150, 000

* Prices of computers and computer-related products have decreased and may be much lower today.

The University of Maryland at College Park has two teaching theaters with a special computing and audio/visual capacity. The classrooms have been used for different on-campus programs (e.g. Anthropology, Business, Chinese, Computer Science, Engineering, English, History, Housing and Design, Information Systems Management, Library Information Service, Mathematics, Psychology, and Zoology), as well as for multi-point teleconferences (at one occasion four universities were interconnected via microwave full motion video), satellite classes, symposia, and faculty staff development (Gilbert, 1993; Stone, 1994).

- ◊ **Physical environment.** The 1993 classroom (32x32 feet) can accommodate 40 students at 20 desks in an "U" arrangement. Each of the student desks is supported by a computer, a high resolution color monitor, keyboard and a mouse. All the computers are attached to the campus optical fiber network and the AT&T StarLAN network to have access to information sources and collaborative software applications. The audio/video equipment consists of two high resolution projectors, slide projector, overhead projector, two video tape players, laser disk player, audio tape and CD player, stereo speaker system, broadcast TV antenna, connection to campus video cable, and a closed captioning decoder. All equipment is controlled by a touch screen on the instructor's desk or by a hand-held control. Video equipment, even the overhead projector, produces standard television images that can be projected to the two large projection screens. The images from the instructor's or from any of the student's computers can also be projected either on one or both large screens. The teaching theater has three remotely controlled video cameras for recording and teleconferencing. Computers and audio-visual equipment that needs cooling are physically removed from the classroom to adjacent areas to avoid heating and noise pollution. For guest lecturers from distant locations a video phone can be used (a model with a screen and built-in camera costs \$900 only), which operates on a normal public telephone line. The picture can be projected to the screen, and the voice is amplified through the loudspeaker system.
- ◊ **Costs.** The first classroom, designed and constructed with the support of AT&T, has been in use since 1991. It cost approximately \$800,000. The second electronic classroom, first used in 1993, cost less (\$550,000), primarily because of the lower prices of technology (486 PC were installed instead of 386, but were still less expensive). The present cost of 20 486 PC with multimedia is about \$50,000, which means about \$2,400 per unit. However, the continuing operation costs (development and improvement of educational programs, education of instructors, technical support, maintenance, a constant need for hardware and software upgrading, etc.) can even exceed the initial investment into hardware.
- ◊ **Software.** Most of the commercially available software products are designed for self-paced individual computer-mediated instruction and are not suitable to support a collaborative instruction and learning in a classroom setting. Therefore, the majority of software for collaborative applications had to be developed at the university, primarily by students from the computer and engineering departments. Examples include: software for immediate feedback from students (gives a statistics of students' answers), class directory (pictures and basic personal data of students, which helps to collaborate between distance students and to built teams via electronic environment), a class map (who is sitting where, class participation, etc.), and distribution of class notes (the instructor prepares and distributes a basic structure of the lecture, each student can add his/her notes and save them as his own file). Several thousands of slides (history, architecture, arts, astronomy) were digitized and made available to all students via the computer network.
- ◊ **Operation and use.** The classroom is fully booked and used 33 hours per week for lectures. The other time is spent on the preparation of lectures, on technical support and maintenance. To meet a rather high degree of technical and educational expertise needed to use the media rich environment to its full potential, several specially trained student assistants are available (employed part time) to help the professors in preparing their lectures, and to operate and maintain the electronic classroom. Professors generally need twice as much time to prepare for lectures and presentations in the electronic classroom as they would for the traditional lecturing. Their main motivation for using

technology rich environment is to offer better lectures, provide higher quality of teaching, and increase their effectiveness -- through the increased interactivity and collaboration, improved access to different learning resources and media, and better organized teaching and learning processes.

The Western Connecticut State University received a grant by the IBM Corporation, which included The Advanced Technology Classroom, previously used for in-house training of IBM's corporate executives. The results of the survey on the effectivity indicated a high degree of student satisfaction with the classroom. 90 percent of students (or higher) rated the advanced technology classroom as being better than the traditional one. The instructors reported 5 to 15 minutes time savings per class period (Fischer, 1993).

- ◊ The classroom is an integrated multimedia interactive instructional delivery system, comprised of a large high resolution video screen, a specially designed electronic podium with a central microcomputer to orchestrate multimedia presentation, and a spectrum of different media equipment. Students desks are arranged in U-formation and equipped with response units to answer multiple questions, and with personal computers, mounted under the desk to enable an undisturbed viewing. The computers are networked within a classroom and connected to the university mainframe.

Technological structure of university-level distance education programs

An example: Post-secondary distance learning programs in the USA - the 1990s

In an effort to identify the telecommunications and electronic technologies that currently are and will be used in the USA post-secondary distance learning programs in the 1990s, Brey (1991) analyzed the responses to his questionnaire from 368 two-year colleges and 184 universities with distance learning courses. The study revealed that during the 1980s and at the beginning of 1990s broadcast television was the most important delivery method in both types of institutions. Videotapes, either used in the library or available for check-out, were also frequent (see Figures 2.6 and 2.7). In institutions starting distance learning programs after 1991, other technologies are likely to replace public television programs.

The overall use of educational technologies in the USA is in rapid expansion (Figure 2.10) - between 1991 and 1994 an average number of technologies has been planned to double. It is interesting that the average increase per institution is greater for interactive live systems than for pre-recorded programs. This is especially evident for upper level and graduate courses, which rely more heavily on student-professor and student-student interactions, have highly specialized instructors and smaller number of students.

Figure 2.6: Use of technologies for recorded programs in the American two-year colleges with distance learning programs (data from Brey, 1991)

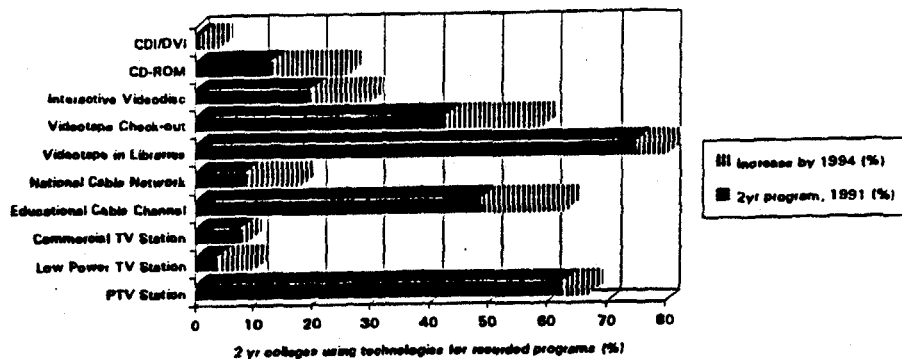


Figure 2.7: Use of technologies for recorded programs in the American four-year universities with distance learning programs (data from Brey, 1991)

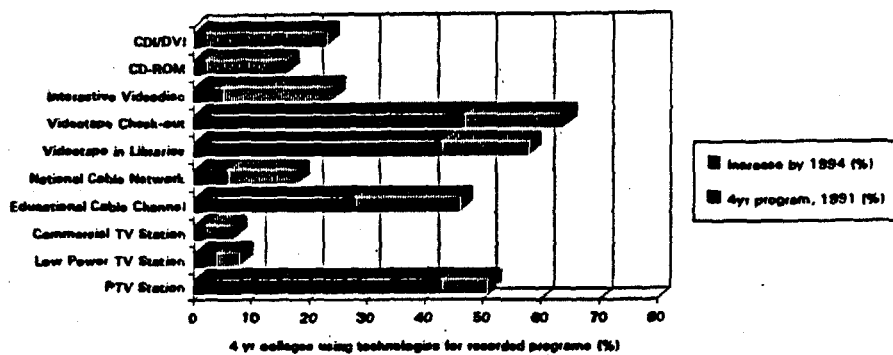


Figure 2.8: Use of interactive technologies in the American two-year colleges with distance learning programs (data from Brey, 1991)

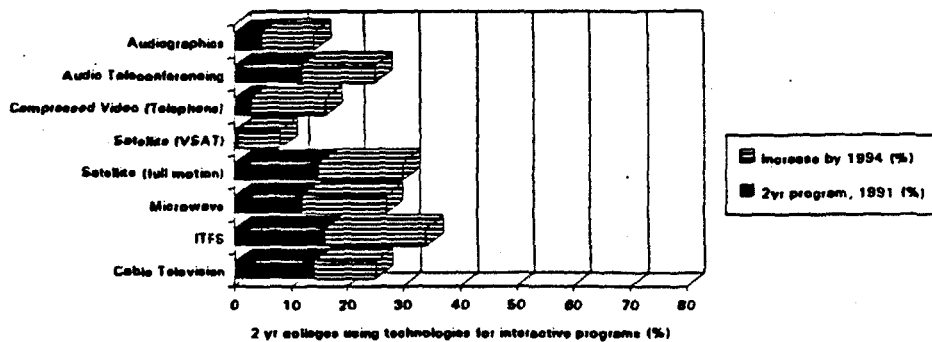


Figure 2.9: Use of interactive technologies in the American four-year universities with distance learning programs (data from Brey, 1991)

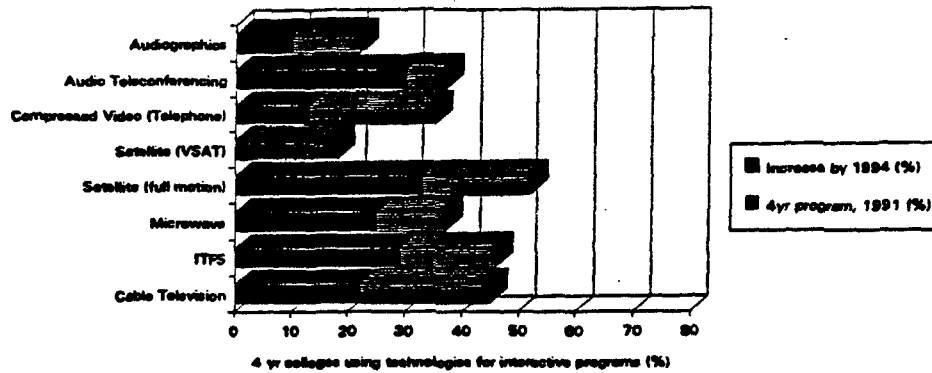
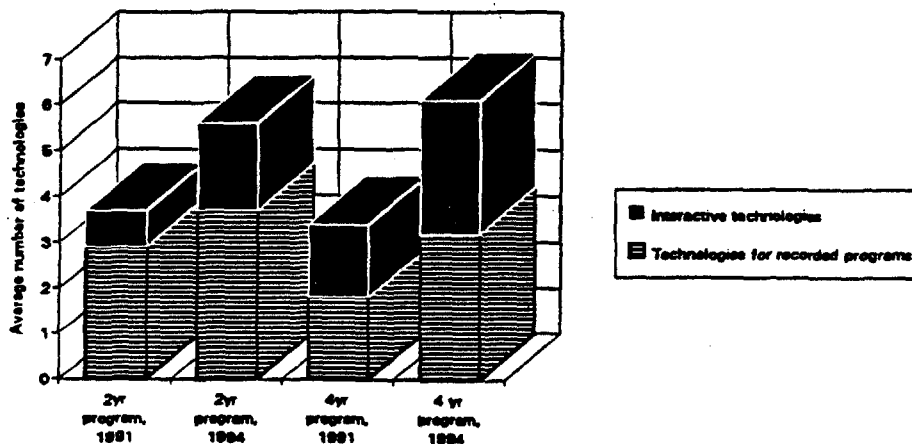


Figure 2.10: Planned expansion of technologies for distance education in the American post-secondary institutions: pre-recorded and interactive programs (data from Brey, 1991).



3. *Discussing Interactive Technologies*

Successes

The success of interactive distance education technologies has been documented by several authors (see Baker and Harris, 1993; Jones and Simonson, 1993; Polutrak, 1991). The analysis of reports leads to the following summarized conclusions:

- ***Improved effectiveness.*** Students achievements in on-campus courses using computers and interactive technologies are better than of students learning by traditional teaching methods. In distance education courses, the effectiveness is at least equal to traditional face-to-face instruction. The main reasons for improved effectiveness are (1) the high quality and increased interactivity of the programs, (2) better structure and compactness of teaching units or lectures, (3) information is offered through the integration of several media and therefore more easily apprehended by the multisensory human mind; (4) learning process supports self-paced studies and research, a higher degree of communication between students and teachers, rapid feed-back, and increased student independence.
- ***Higher quality of instruction.*** Courses which use interactive technologies are often of higher quality than traditional instruction, especially because (1) the instructors prepare themselves better, (2) classes can be taught (or the units are prepared) by different experts in specific fields, (3) the knowledge pool can be updated regularly, (4) students can access several sources and databases, and (5) feedback and evaluation are enhanced.
- ***Increased enrollment.*** Interactive technologies in on-campus or distance teaching help individualize instruction and tailor it to the needs of individual students (each student can choose the level of pace, sequence of topics, detail, and depth of knowledge he/she wants). In addition, technologies used in distance education allow instruction to take place at a time and place convenient to the learner. Students are more likely to enroll in courses if they are nearby and convenient. This is especially important for employed, part-time and home-bound students.
- ***Cost-effectiveness.*** The cost-effectiveness depends on the type of technology and on characteristics of the teaching/learning environment. Interactive technologies and media, designed for large number of students, are cost effective because they can use pre-designed, accurate, high quality and effective learning materials. Other interactive technologies, which are meant for small groups of students, are cost-effective because

they substantially improve the effectiveness of teaching and can save on travel and time. These are especially successful in cases of geographical remoteness or dispersion of students, for small island countries, for students with special needs (academically very capable students, physically handicapped students, home-bound or migrant students), for elective subjects, specialized graduate studies, in-service education (teacher training, on-the-job industrial education, continuous education in computers and hi-tech equipment), and other individually tailored instruction.

- ***Technological and communication skills.*** The use of telecommunications, computers and multimedia technologies in education can also be justified by the need to adapt to the demands of today's industrialized society. Youth in industrial countries are used to a variety of entertainment technologies (video and computer games, karaoke, comedy TV channels, etc.). In this sense, the traditional teaching has fallen behind, and an average student shows less interest in listening to traditional lectures. On the other hand, student's exposure to computers and interactive communication technologies develops technical and communication skills needed for future professional life.
- ***Positive acceptance by learners and instructors.*** Students and professors involved in interactive on-campus or distance education classes have expressed positive feelings about their teaching/learning experiences in most of the analyzed reports.

Potential dangers, obstacles and problems

Carefully designed and well implemented interactive educational technologies are generally successful, while poorly designed systems with inadequate support fail. It is expected that several early projects were unsuccessful. The literature includes only few reports on failures.

- ◊ One unsuccessful example of the interactive learning is the Learn Alaska Network. \$30 million was invested to purchase and install statewide telecommunications technology, but four years later the system was closed down (Bradshaw, et al., 1989). According to the evaluations, the main reasons for failure lay in planning and operation - the system was too costly, its operations under-funded (only \$200,000 was allocated annually for programming), and the governance structure was ineffective. Educators and broadcasters clashed over program content versus production quality. Different departments struggled to control the network and use the funds. The audience of 30,000 native Alaskans was not large enough to justify the magnitude of the system.

The potential dangers, obstacles and problems related to implementation and use of interactive educational technologies can be summarized and structured into the following four groups:

(1) Inadequate technological environment

- **Technical expertise.** Interactive educational technologies need a high degree of technical expertise to work successfully. It is necessary to coordinate networking, maintenance, adaptations, hardware and software upgrading, and compatibility. If the technical expertise is not adequate, the system will fail.
- **Maintenance and upgrading.** Even if the system starts up successfully, lack of spare parts, lack of accessories (e.g. toners, paper, floppy disks), components for hardware and software upgrading, and insufficient/improper maintenance, may cause long functional interruptions, diminish the system's effectiveness and finally lead to a failure of the whole educational program. Geographical remoteness can add to the maintenance problems in developing countries. Hardware and software suppliers tend to avoid the responsibilities of providing regular repair and upgrading of services in remote locations. Where such services are available it may be at prohibitively high prices.
- **Short life-time and incompatibility.** With the development of computer networks, the compatibility becomes more crucial. Another effect of the rapid development is that computer hardware and software become obsolete in a few years and therefore need constant upgrading. However, upgrading of only one system component may result in compatibility problems and frustrations deriving from non-transferability of data files between the new and old versions.
- **Infrastructure and telecommunications.** In an inadequate technological environment, such as an absent or unstable electrical power supply, or non-existent telecommunications systems, the implementation of interactive educational technologies is not feasible.
- **Climatic conditions.** Harsh climatic conditions (humidity, high temperatures, dust, hurricanes) may cause so many telecommunication break-downs and equipment damages, that the educational program will have to be terminated.

(2) Inadequate educational environment

- **Qualified faculty.** An innovative application, such as interactive educational technology, requires a great degree of specialized expertise. If faculty are not qualified to use new educational tools, hardware sits idle. Several authors share the opinion that nothing has crippled technology-based innovations in education so much as inadequate training of instructors. There has been some fear that technologies will replace teachers and automatically educate large numbers of students at low costs. Experiences with interactive technologies show that while they can substantially improve the effectiveness of teaching and learning, and even multiply the teaching effects, they cannot replace instructors. On the contrary, the effective use of interactive technologies requires more training, preparation and initial work for the faculty, along with increased commitment, flexibility, cooperativeness and readiness to deal with occasional technical problems.

- **Instructional design.** Sophisticated hardware will not guarantee effective applications; time, care, and experience are needed in instructional design. Interactive educational technology *per se* cannot serve as an efficient educational tool if the courses are not designed/adapted to use its benefits to the full potential.
- **Interactivity.** Despite the capabilities of the medium, instruction may still fail to be sufficiently interactive for several reasons: technical problems (e.g. telecommunications breakdowns or disturbances), organizational problems (too many participants included in a network), or psychological reasons (students do not take advantage of the opportunity to communicate with instructors).
- **Choice of media, technologies and methodologies.** There is no single educational technology or methodology that covers the whole spectrum of different educational needs. Those suitable in face-to-face teaching are not necessarily best for distance education and *vice versa*. Similarly, the choice of educational technologies has to fit the specific needs of different subjects and instructors.
- **Cooperation.** Insufficient cooperation between hardware and software developers, broadcasters, curriculum developers, educational policy makers, technical support staff, or faculty and students may lead to a series of problems, such as hardware/software incompatibility, duplication or absence of essential programs, misunderstandings about system's capacity, improper or ineffective use of available technologies, reduced access to telecommunication networks, etc .
- **Resistance and rigidity of educational systems** to innovation. Administrative structure may be a major obstacle to the adoption of interactive technology. Educational innovations which use complex interactive technologies may run into competition with existing practices and policies. Some individuals and groups in educational institutions may resist any technological innovation that requires increased flexibility, additional efforts and disrupt their established positions and working habits.
- **Faculty reluctance.** Faculty may be reluctant to use interactive technologies for many reasons: ignorance about how interactive technologies can enhance teaching and learning; insufficient skills to use the hardware and software; inability to tailor a technology to the specific discipline and integrate it into the course curriculum; lack of time for creation of new interactive technology-based teaching courses, or simply because of the unwillingness to change the established traditional teaching style. Instructors may also regard interactive technology as a threat to their jobs, or may be skeptical when technicians rather than faculty direct its use.

(3) Inadequate economic environment

- **Investment costs.** Initial investments in interactive technology are substantial, regardless of overall cost-effectiveness. This is not a major problem in countries with

functioning capital markets . However, for low-income countries, the initial costs of equipment and educational materials development may be prohibitive.

- **Recurrent costs.** Even when the initial investments are covered, there is a danger of insufficient and/or irregular funding of maintenance, spare parts, software upgrades, fees for accessing on-line databases, licensing of telecourses, phone or satellites costs, etc. Inability to cover the recurrent costs may cause a project's demise. In practice, projects initially funded by foreign aid often collapse because domestic sources are not available to fund recurrent costs.
- **Unconvincing evidence of the cost-effectiveness.** In some cases the cost-effectiveness issue is still debatable. Even though a program may have been satisfactorily implemented, the educational impact does not justify the expense.

(4) Inadequate administrative, legal, political or cultural environment

- **Administrative barriers.** Local administrators may interfere with efforts for increased communication and cooperation between different faculty departments or universities, and between the administration and teaching systems. On a larger scale, rigid bureaucratic procedures and flexibility may make implementation of technological innovations impossible.
- **Intellectual property issues.** The ability to make simultaneous transmissions, record lectures and copy computer programs can increase educational effectiveness, but it also raises complications for ownership of intellectual property. The rights to reproduce, distribute, perform, display and prepare derivatives of the copyright software or educational materials are not protected in practice, discouraging participation of some owners of software in networks.
- **Political problems.** Political barriers to the free import or use of computers and telecommunication networks still exist in countries. Interactive technology projects may become closely identified with a specific political or administrative group and discontinued if that group loses power. Changes in top leadership, instability and poor continuity in educational decision-making institutions, and political gaps between agencies, adversely affect the implementation of educational technologies.
- **Technophobia and resistance because of cultural, religious, ethnic or social traditions.** The introduction of sophisticated educational technologies may arouse opposition for political, philosophical and religious leaders, or individual instructors, students and parents. Some people view computer-related technologies as having dehumanizing effects, as repressing intellectual development of students, as a tool of introducing unwanted materialistic/technocratic thinking, as a way leading to unwanted dependencies on foreign resources, or as a opportunity for mental colonialism.

Possible solutions and recommendations

(1) Improving the technological environment

- **Technical support and expertise.** A support system has to be available to operate and maintain interactive technologies, to keep the equipment and software functioning correctly, to run the required programs, and to provide consultation and advice in trouble shooting to both, instructors and students. Permanent training to maintain the high quality technical support is essential for the long-term success. In addition, the following solutions may be helpful at universities: student assistants specialized in technical issues, a permanent support "hot line" available via telephone or through the computer network, easy to use manuals designed for students and instructors, and user-friendly help systems incorporated in computer-mediated programs.
- **Maintenance and upgrading.** Spare parts and maintenance are indispensable to the effective use of interactive educational technologies. Since the hardware and software are constantly upgraded, funds must be available for regular upgrading of whole systems. Irregular upgrading may result in serious compatibility problems, lack of computer memory, communication difficulties, or frequent break-downs.
- **Hardware and software characteristics.** Regardless the type of educational environment, equipment and software should be reliable, easy to operate (user-friendly), simple to learn, expandable, standardized, compatible.
- **Telecommunications infrastructure and hardware.** In most projects, the initial purchase of equipment is not the main problem, if a basic telecommunications system exists. Hardware problems may be creatively overcome- e.g. laptops may be provided by the faculty for student's home use; the university may even ship portable computers and software to remote students for distance courses; on-the-campus computer classrooms may be available to students 24 hours a day. Commercial satellites and telecommunication lines may be leased for educational purposes. Telephone lines may be free of charge for educational purposes or substantially subsidized.
- **Harsh climatic conditions.** The harsher the climate, the simpler and more reliable should be the technology.

(2) Improving the educational environment

- ***Planning.*** Planning and implementation of educational technologies should start from a clear educational need or goal, not from a particular type of educational technology (projects should not be technology driven). Institutions have to define the main objectives (e.g. to improve the quality of on-campus instruction, to supplement the program, to improve access to new audiences, or to reach distance learners), analyze the characteristics of the courses, faculty and students, and on the basis of all these select the appropriate technologies in relation to their effectiveness, cost, relevance, and compatibility. There must be a strategic plan for the incorporation of interactive technologies into the university courses – the introduction has to be well prepared, and, if possible, evolutionary or incremental, starting with either simpler settings or with courses that are easier to develop.
- ***Cooperation.*** A cooperative environment is absolutely essential in introducing a new interactive technology. Faculty departments and individual specialists have to cooperate in setting up and running the system. Computer science departments must develop/adapt hardware and software and provide technical training. A faculty development department should train faculty in general instructional design for computer mediated learning.
- ***Faculty expertise.*** Faculty staff development and training in early stages of the technology-based innovations is essential to the success of the program. Faculty development programs must accommodate different levels of experience with technology. Training should be comprehensive, including: (1) basic training to overcome the initial fears and perform simple operations; (2) training in more sophisticated uses of interactive technologies for their efficient introduction into teaching courses; and (3) comprehensive training in technologies and methodologies to develop original course materials and search for new, creative applications. Written tutorials and guides are usually much less successful than hands on training.
- ***Technical training of students.*** Training to provide basic technical knowledge and skills is essential for students to function successfully during the program. Remote students may be provided with easy-to-follow, step-by-step written or video tutorials.
- ***Selection of media, technologies and methodologies.*** No single educational technology covers the spectrum of educational needs. A combination of technologies is usually most appropriate. Achieving the right balance depends on several factors: (1) **Educational form.** Distance education programs differ from on-campus courses. (2) **Scientific discipline.** The choice of educational technologies have to fit the specific needs of different subjects – science, technology, agriculture and health require different approaches and educational tools than arts, social sciences or business education. Classes requiring a lot of hands-on activities and laboratory experiments are not the most suitable for computer conferencing, but can make an effective use of multimedia instruction and computer simulations. (3) **Degree of interactivity.** Interaction is crucial to the success of any course. Increased interactivity leads to a higher effectiveness. (4) **Learning audience.** Educational technologies must be tailored to the needs of learners. Learners'

characteristics, such as educational level, age, cultural and technological backgrounds, geographical distribution, numbers, etc. have to be taken into account to reach educational goals and cost-effectiveness. (3) **Individual characteristics of instructors.** A chosen educational technology has to fit the specific educational methodology and teaching style of the instructor.

- **Motivations and incentives for instructors.** Faculty will be motivated when they are offered the possibility of using more effective instructional methods and when they see the results of enhanced student learning. They need to appreciate that interactive technologies can support individualized teaching and enhance communication, and are not meant to replace them. Faculty must also have administrative support and financial or other incentives for their increased efforts and work involve in the transition to computer mediated instruction.

(3) Improving the economic environment

- **Financing.** Stable and regular financing has to be guaranteed not only for initial investments, but also for the development/adaptations of educational materials to be used with technologies, and to cover spare parts, software upgrades, fees for accessing on-line databases, licensing of telecourses, telephone and satellite charges, etc. Foreign aid or any other educational programs in developing countries have to find alternate domestic sources and establish the mechanisms to maintain the local coverage of recurrent costs, when the project funding runs out, otherwise even the initially successful systems will collapse.
- **Cost-effectiveness.** Once a system is up and running, it can usually pay for itself. But in most cases educational organizations or individual users have to bear the hardware and software costs. Usually, a compromise which balances the costs of interactive technologies and their impact on increased learning effectiveness is necessary. Lower cost per student can be achieved by using one-way audio (radio, audio tapes) and one way video technologies (broadcast TV, video tapes), however, these technologies are the least interactive and much less effective than the more expensive multimedia-, computer-network-, and two-way video-based technologies.

(4) Improving the administrative environment

- Administrative commitment to appropriate necessary funds for initial investments, recurrent costs and an faculty incentives programs is vital. Governance and decision making procedures have to be made clear.

The vision

Interactive educational technologies will improve the quality of teaching and reach more distance learners in the future. Educators, on the forefront of electronic teaching have a vision for national and international Open Universities providing affordable education via global communication networks. Falling costs of technology encourage this vision.

However, several obstacles to this vision remain. Internationalization of telecommunication networks may be slowed down by national regulations, standardization problems, intellectual property issues, differing curricula, language barriers, and fear of possible educational and cultural imperialism.

Despite these dilemmas, the possibility to participate in international networks for scientific and educational exchange and worldwide access to information and educational sources presents new opportunities for the industrial and developing countries alike. Access to information and quality higher education has strong effects on advancement of scientific research, and industrial development. Remaining outside communication and knowledge networks may lead to isolation, deeper underdevelopment and stronger dependency on foreign resources.



Appendix 1: Differences between developing and industrial countries

Figure A1: Public expenditure on education: as \$ per inhabitant, and as % of GNP in 1991 (Unesco, 1993)

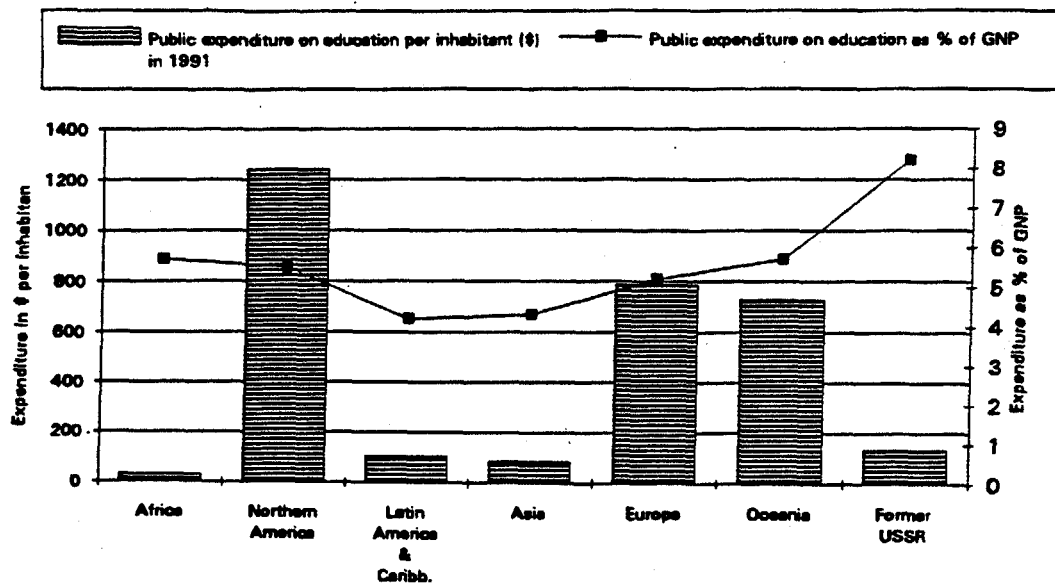


Figure A2: Gross enrollment ratio at third level of education in 1991 (Unesco, 1993).

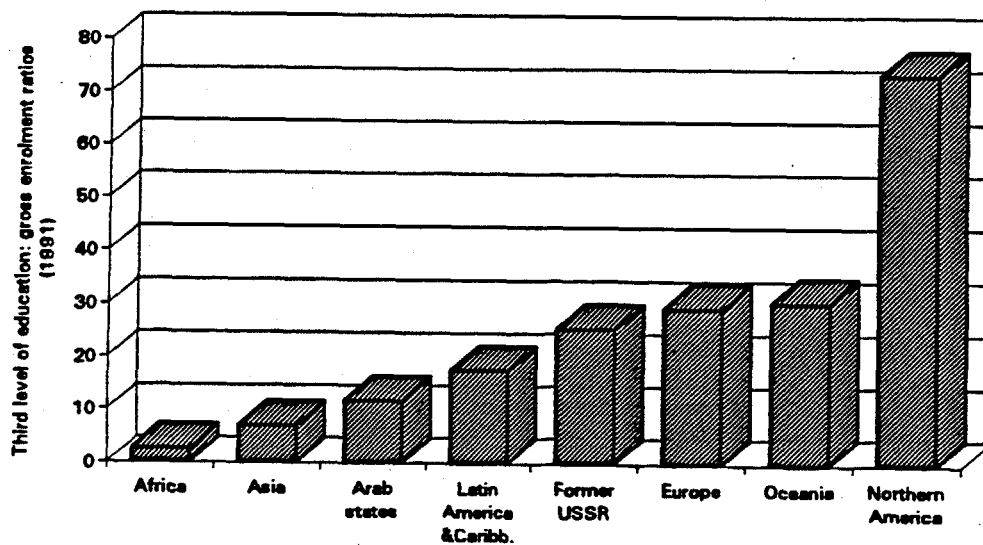


Figure A3: An indicator of potential expansion of higher education student population: Annual average increase in 20-24 years old population during the 1990-2000 period (Unesco, 1993).

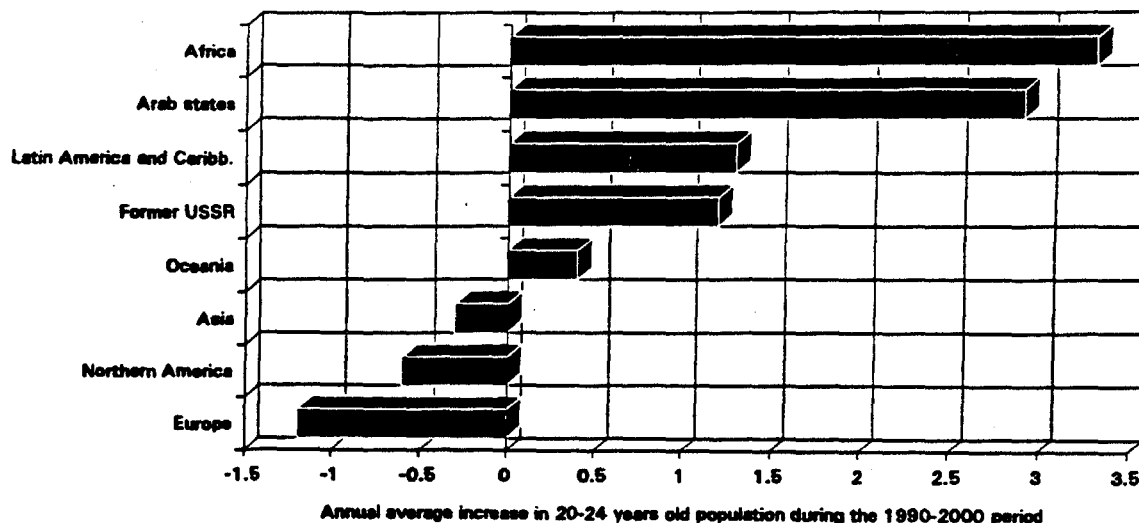


Figure A4: Third level education teaching staff versus student enrollments in 1991 (Unesco, 1993)

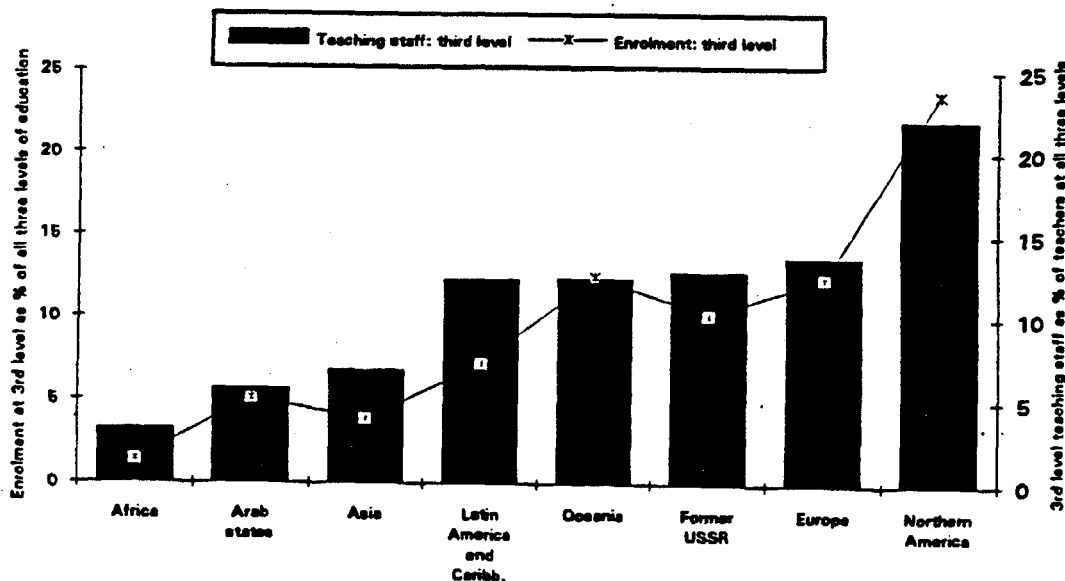
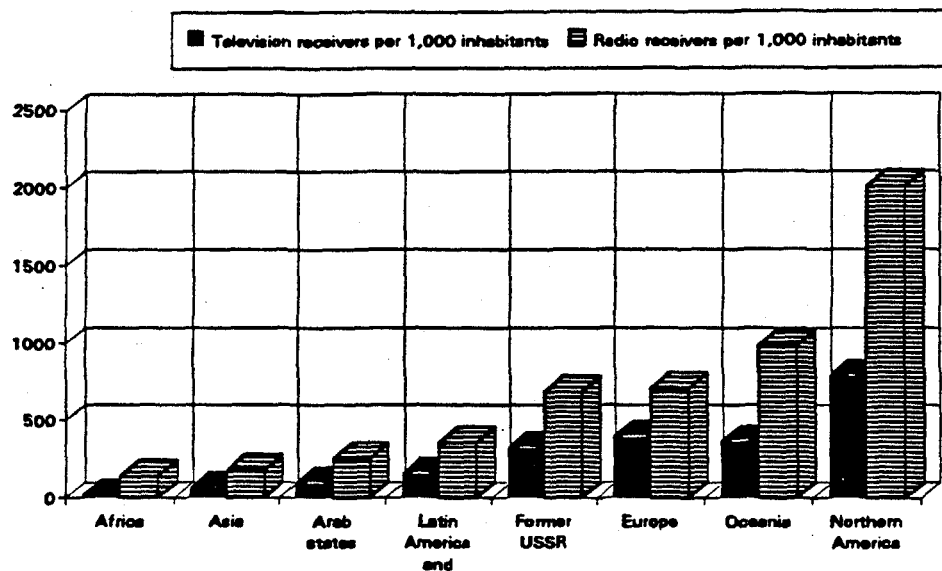


Table A.1: Library collections at institutions of higher education: selected countries* (Unesco, 1993)

Country	Book volumes (thousand)	Micro-forms	Audio-visual documents	Other materials
Bulgaria	7043	10074	29776	299053
Chile	5669	317353	104623	608112
Denmark	11247	1103996	770652	11687044
Egypt	35790	9700	6700	57800
Ethiopia	530	85950	20145	82239
Guyana	166	7110	1613	980
Italy	5642	54190	13268	20555
Jordan	1227	34105	11390	2736
Kuwait	453	9680	80500	58188
Mexico	8347	1844056	545288	246285
Poland	39557	1512133	395953	9243100
Senegal	380	1431	994	43
Singapore	2354	255809	75967	3987
USA	718503	652738071	15606951	15000000

Figure A5: Television and radio receivers per 1,000 inhabitants in 1991 (Unesco, 1993)



* Data for the latest year available (for individual countries 1986 to 1991)

Figure A6: Number of telephone lines per 100 inhabitants in relation to the GNP per capita, 1992 (Siemens, 1994)

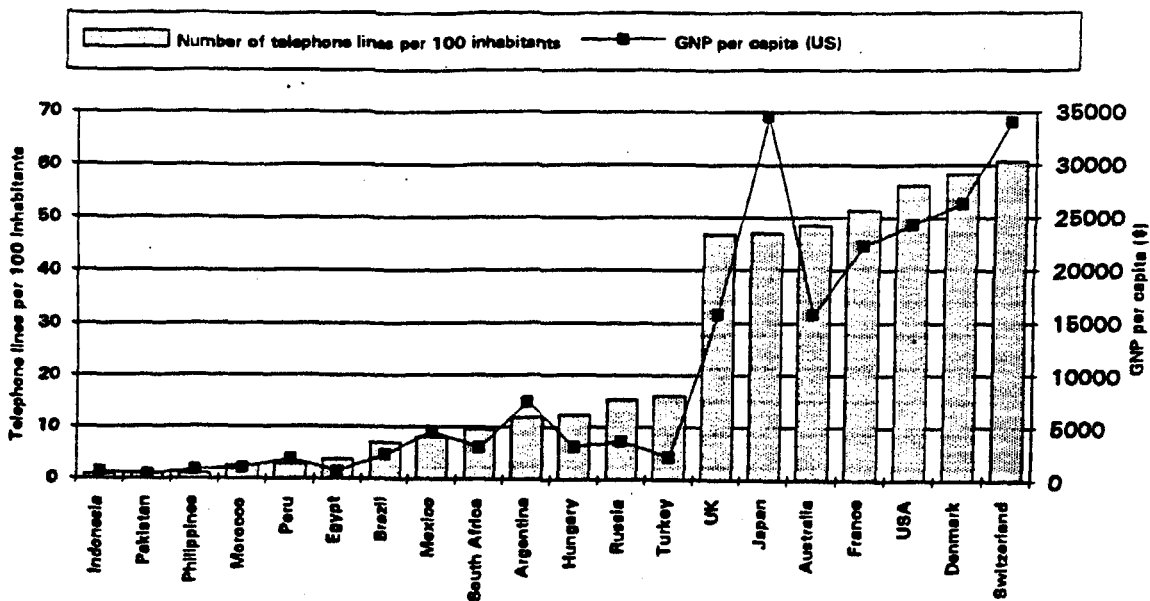


Figure A7: World market development in telephone lines (total for analog and digital technology): 1990 and projections for 2000 (Siemens, 1994)

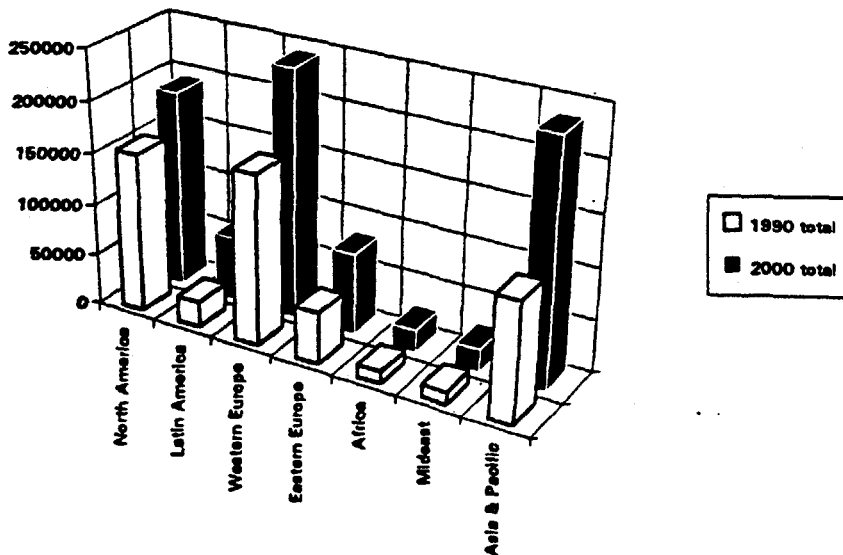


Figure A8: World market expansion in digital telephone lines: 1990 and projections for 2000 (Siemens, 1994)

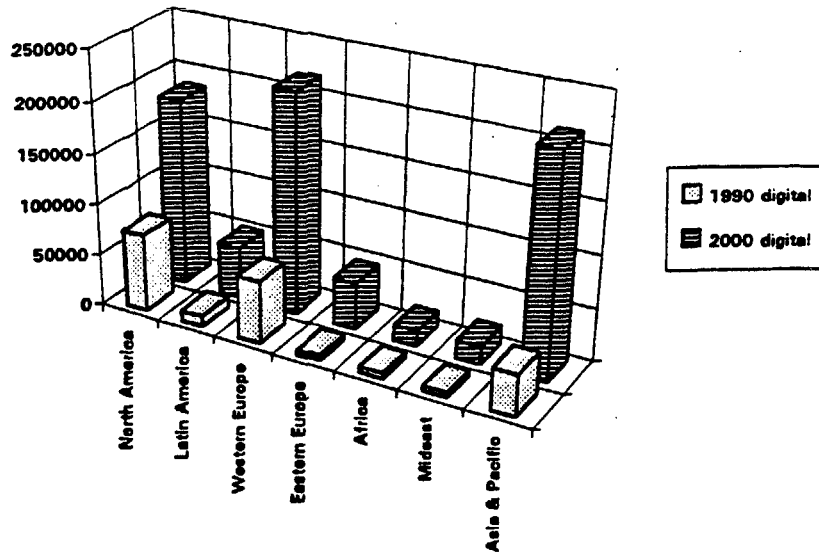


Figure A9: Growth of telephone communication lines: Ten developing countries with highest growth indexes in comparison with selected low growth industrialized and developing countries (data from Siemens, 1994)

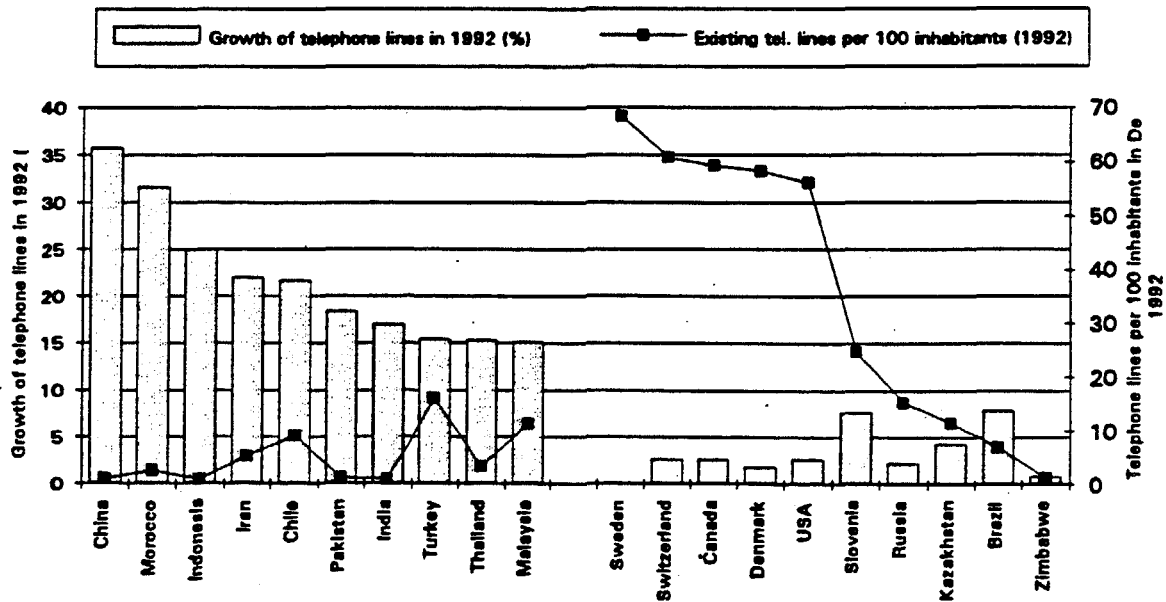
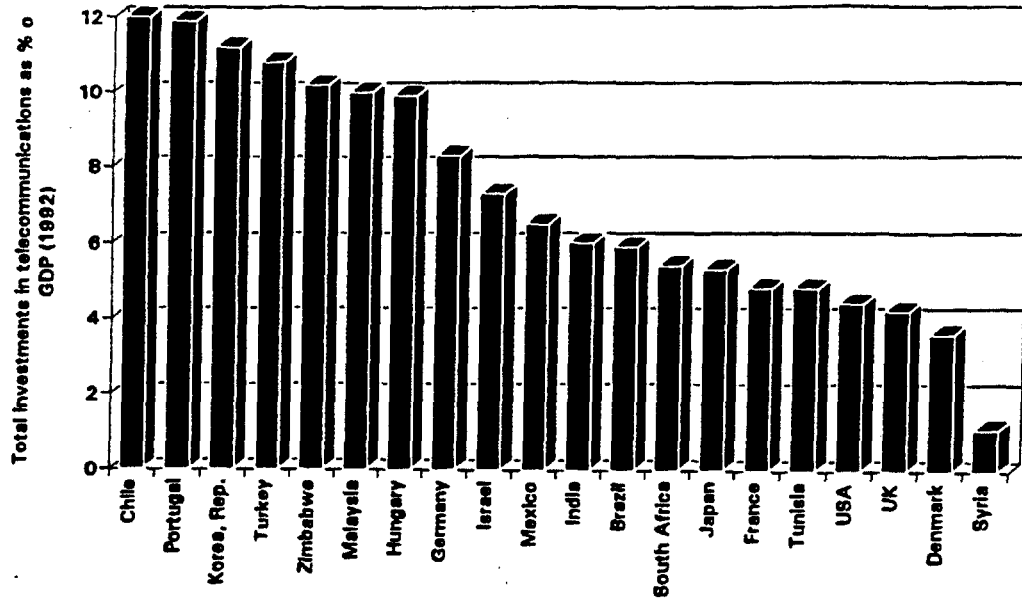


Figure A10: Total annual gross investments in telecommunications (including land and buildings) as a share of GDP in 1992 (data from Siemens, 1994)



Appendix 2: Selected Bibliography

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