

# Los Libertadores: Science and Technology Education in Latin America

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**Abstract** — The world has become dependent on information, technology, and telecommunications. Better known as Information Technology and Telecommunications (IT), a term that encompasses the fields of Electrical and Computer Engineering and Computer Science. Increasingly, IT is an effective indicator that can measure the difference between developed and developing nations. The competitiveness and economic growth of a nation are directly related to the incorporation of clear policies on IT. It requires a substantial restructuring of the initiatives and programs implemented in attempts to generate an adequate base for development of science and technology. To achieve this, it is important to revise the education of human technical and scientific resources.

**Index Terms** — Backbone, Centers of Excellence, Information Technology and Telecommunications.

## I. INTRODUCTION

IT has shortened effective time and distances, facilitating the exchange of products, ideas and services. No country can ignore the benefits and opportunities to transform society that are available with the tools based on IT. For maximum benefit adequate and appropriate policies in IT are essential requirements for productivity growth and development in private and public sector. This must take place with total participation from society in a suitable environment can be counterproductive when facing the challenges of this new century. Metrics involved with IT policies are necessary instruments to induce market forces to ensure development goals and generate public and private investment. IT is an effective indicator of the difference between developed and developing nations. More than ever, governments, industry, academia, and international organizations have a social responsibility to their citizens reallocating resources to dedicate them to science and technology in order to rise standards in education, mobilize market forces and secure a better development for the new generations of the XXI century. For nations to compete successfully, it is imperative that they place at their disposal elements of this technology. The degree of success that they experience in economic and social development will be directly proportional to strategic investments in science, technology, information systems and human capital. Those countries in Ibero-America that do not adapt to the new technological paradigm will face insurmountable difficulties trying to keep pace socially and economically with the rest of

the world, and will be marginalized from the process of integration and globalization.

For a country to be competitive at an international level it must:

- Utilize state-of-the-art technology
- Assured human and financial resources to sustain a systematic program in education of Science and Technology (S&T)
- Reform, adapt and enhance curricula considering the new trends in S&T to improve technological abilities
- Increase capacity for Research and Development (R&D)
- Give incentives to the academia to promote national and international R&D projects
- Secure adequate funding and active involvement from private sector
- Enhance existing and create new infrastructures in Information Technologies
- Improve the capacity to access information in real time (without time differences)
- Develop Continuing and Advance Education programs
- Increase post-graduate programs

A key factor in the success in this endeavor is the instigation of effective procedures for searching, processing, and distributing information in a minimal amount of time. As the evolution occurs from absolute and centralized systems to distributed systems, we find ourselves at a new “renaissance”. Resources must be shared at a national, regional, and global level. These are becoming more limited in the amounts and by the number of growing institutions that compete for them. Strategic alliances (consortia) among academia, industry, government agencies, and international organizations are essential. These must promote project identification, partnering and funding to diversify and expand the capabilities of projects. If done correctly, these alliances will improve the Latin American profile in S&T by increasing the quantity and quality of publications, production of science, and participation and organization of international forums. These alliances are also important to promote and raise the awareness on the need to create/enhance S&T sustainable policies and infrastructure. S&T needs to form an integral part and be top priority for the economic development and sustainable growth of the region. Why do it? It is a problem of economies of scale. The Ibero-

American countries has a second change to integrate them through Science and Technology, this agrees with the new multilateralism being supported by all nations. By integrating the region we are placing the region in a leading role and provide a response to the challenges from other regions. This new renaissance will create new opportunities for business, academia and governments, will help reduce the existing inequalities and create/enhance the human capital needed for the future. With every day that passes, computer networks become more and more important to the lives of every person. This can be clearly observed in the areas of medicine, education, commerce, the environment, economics, finance, engineering, and security, among other sectors.

## II. IMPORTANCE OF INFORMATION TECHNOLOGIES

Information Technology is critical in the following areas:

- Academic activities: Education and Research & Development.
- Economics, commerce, finance and banking.
- Linking national and international networks (Internet, Internet2, NGI, vBNS).
- Linking private networks (Intranets).
- Collaborative technologies, from electronic mail to videoconferencing.
- Health: telemedicine, remote access to distant areas.
- Education: distance education, digital and virtual libraries, virtual universities, new technologies.
- Scientific investigation: climate, energy, biomedical investigation.
- National Security: high performance global communications, dissemination of information.
- Environment: early warning, prediction, alarms and responses.
- Government: provide services and information to citizens and social sectors of production.
- Emergencies: response to natural disasters, crisis administration.
- Design and Manufacturing: production and design engineering.

## III. TRENDS AND NEEDS IN INFORMATION TECHNOLOGIES

In the US, statistics indicate that 35% of all families have a PC, 50% of teenagers have a PC, 65% of computers sold are for the home and 90% of them come with a CD-ROM because the users demand multimedia applications. The average new car comes with 50 micro controllers for its control. The Internet has more than 140 million users and it is growing at a rate of 10% per month [1]. Moore's Law indicates a doubling of performance in computing power every 18 months, and in telecommunications, bandwidth is doubled every 9 months. In Latin America, there are 10 million estimated users, and Internet growth in 1997 was at 250%. With similar projections for future growth, in the year 2000 the number of users will surpass 35 million. The fastest growing area on the Internet is Latin America.

Telecommunications and computer equipment are constantly becoming more powerful, less expensive, and more accessible to all. For this reason, we can tackle more complex problems, like climate simulation and modeling, including the effects of weather patterns such as El Niño or La Niña. This increase in compute power permits the processing of large amounts of data such as that obtained by remote sensing. This can be used for the identification and proper administration of natural resources. The solutions to many of the problems of this nature require costly and specific resources that not available to everyone; advanced computer networks are needed to provide access to resources like supercomputers available at distant locations.

Currently, the volume of available information is being doubled every 5 years, and it is estimated that by the beginning of the next century this information will double every 72 days. In order to effectively utilize this information, the solutions to problems require multidisciplinary work teams and collaborative technologies that allow both synchronous and asynchronous interaction. These solutions must the results of projects that take a minimum amount of time from the genesis of an idea and to its actual implementation. In the system solution, we are referring to projects labeled both "hardware" and "software", and the line that separates them becomes increasingly blurred.

Worldwide the demand for IT personnel far outstrips supply. In the US, this causes the delay of development schedules, projects to go over budget, and hamper expansion plans. Vacancies affect more than 10% of IT jobs in an organization, turnover represents 10%, and in the Silicon Valley turnover represents 20%. Current estimates indicate that the shortage of IT personnel will last ten to fifteen years. It is estimated that this will have an effect of negative 5% growth in GDP over the next 5 years. This translates into a loss of 200 billion dollars, almost one thousand dollars for every citizen.

In the US, the number of degrees awarded in this area fell from 42,000 in 1986 to 24,000 in 1997. Additionally, industry leaders have indicated that the degrees and the quality of the professionals do not adequately address their needs. University programs have been slow to react to changes in the marketplace, and their degree programs are based on outmoded technologies. Stated briefly, recent graduates have been trained in technologies that are no longer used. As a reaction to this, many companies collaborate with universities to update their curricula, or they create their own universities. In order to retain their employees, industries have placed a priority on Continuing and Advance Education Courses.

This lack of professionals translates into a dead weight for the economy. There are 450,000 potential job openings for IT workers, and universities are producing 1/6th of what is needed. The question to be asked then is: – where will industry turn to find the talent that is needed?

The globalization and integration of the world's markets will lead industries to search for this talent in other parts of the world, particularly in Latin America. According to trends and studies conducted by American industries, the next decade points to Latin America. The Latin American markets are subject to this process of globalization, and in order to

ensure more suitable development, these markets must be restructured. Various governments, educational institutions, research facilities, and industrial firms have great interest in establishing efforts of cooperation in technical fields. The identification of areas of common interest is also crucial for the investment in appropriate resources. In the next ten years the population of Latin America will have a workforce of 120 million, another 120 million will be in schools, and the amount of people in poverty will be 140 million. Clearly, hands-on education, research, and technology transfer in state-of-the-art technology and science is critical for the success of Latin America.

In order to address these challenges, the US has launched three initiatives to increase academic and R&D resources. These are: vBNS, Internet 2, and Next Generation Internet (NGI). These projects, proposed by Vice-President Al Gore and known as Global Information Infrastructure (GII), are instruments created within the US's independent vision, and unique to that country's development and needs. This is precisely what the Latin-American region needs in order to develop and avoid an unnecessary technological dependence.

Like capital and labor, information is considered a vital factor to production. In the decade of 1980, the information sector amounted from 30-50% of GDP and employment in the developed countries of OECD. This sector will increase to 60% among the European Union countries. In the telecommunications context, this is considered a strategic investment to maintain and develop a competitive advantage at national, regional, and hemispheric levels. Countries and industries that do not have access to modern communications systems will not be able to participate effectively in the global economy, and will not fully develop economically or socially. This is a critical reality to those countries in the region that aspire to become developed [4].

An idea on the importance and necessity of IT for the development of a country and a region can be obtained by observing the following indicators [5]:

**Teledensity (telephone lines per 100 inhabitants):**

Industrialized countries	> 48 %
Countries of medium development	~ 10 %
Countries of lesser development	~ 1.5 %
World average	11.5 %

**Informatics Gap (PC's per 100 inhabitants)**

Industrialized countries	> 18 %
Countries of medium development	~ 2.3 %
Countries of lesser development	~ 0.01 %

**Participation in the IT Market:**

U.S.A.	34.7 %
Europe	29.3 %
Japan	14.6 %
Rest of the World	21.4 %

IV. WHO INVESTS IN SCIENCE AND TECHNOLOGY?

In the group of industrialized nations known as the Group of 7, industries are responsible for 50-70% of S&T. Resources originate from both the industrial and government sectors, yet most of them are spent in the industrial sector. In the US, the government mainly sponsors basic R&D, while both industries and the government sponsor applied R&D. Universities are responsible for a large portion of this basic R&D, and industries finance approximately 7% of their needs [2-3].

**Ratio of R&D to GDP (1994 Figures)**

U.S.A.	2.0 %
Germany	2.4 %
France	2.0 %
Japan	2.7 %
U.K.	1.9 %
Italy	1.7 %
Canada	1.5 %
Brazil	1.2 %
Cuba	1.5 %
Russia	0.5 %
Latin American average	0.5 %

V. IBERO-AMERICAN SCIENCE AND TECHNOLOGY EDUCATION CONSORTIUM: ISTECS

In the summer of 1990 personnel from the University of New Mexico visited countries in Latin America to identify and evaluate opportunities for successful collaboration in an international effort in science and technology education. Meetings were held with officials with various governments, educational institutions, research facilities, and industrial firms to gauge interest in establishing efforts of cooperation in technical fields. The meetings resulted in the identification of areas of common interest for employing hands-on education, research, and technology transfer in state-of-the-art technology and science. As a result of these visits, an organizational meeting was held in December of 1990, at the University of New Mexico, involving personnel from universities, industries, governments, and foundations throughout Ibero-America. These discussions, which resulted in the creation of the Ibero-American Science and Technology Education Consortium (ISTEC), identified a number of obstacles that need to be addressed:

- Lack of current information for planning and developing technology
- Lack of expertise in the use of information
- Lack of international cooperation in developing the critical mass needed for projects and joint efforts
- Lack of interaction among universities, industries, and governments

The above difficulties are aggravated by another problem, which is the lack of awareness of the simultaneous existence and interaction of the above obstacles. It is imperative that efforts be made to address these issues concurrently in order to further the scientific and technological development of Ibero-America. It was a consensus among the participants in the meeting that traditional mechanisms for cooperation

are not sufficient, and new, more effective mechanisms are needed. As a result of the meeting, ISTECE was created, and universities, industries, and other organizations become members by signing a Memorandum of Understanding (MOU). The MOU establishes a General Assembly to which all members belong that sets policy and direction, an Executive Committee, which is made up of nine members of the General Assembly that carries out the policies and promotes the Consortium, and an Executive Office that handles the day-to-day operations.

The organizations that constitute ISTECE have agreed upon the following Mission Statement: ISTECE is a non-profit organization comprised of educational, research, and industrial institutions throughout the Americas and the Iberian Peninsula. The Consortium has been established to foster scientific, engineering, and technology education, joint international research and development efforts among its members, and to provide a cost-effective vehicle for the application and transfer of technology.

The objectives of the Consortium are to conceive, plan, and carry out activities of higher education, research and development, and technology transfer, for the purpose of facilitating scientific and technical progress of the Ibero-American countries. ISTECE participants encourage the free flow and access of information in the pursuit of technical excellence. The mechanism developed by ISTECE to work on its objectives by involving personnel and resources from diverse geographical locations is the Initiative, which is an organized effort to create activities to address a specific area of concern. The Initiative concept provides an effective answer to the challenges present in Ibero-America. The Initiatives are member-driven, flexible, and run concurrently. Within initiatives, projects are identified, planned, and implemented. The distributed structure from which the projects stem avoids duplication of efforts and inherently responds to the needs of the ISTECE membership. Projects are designed with both short- and long-term goals, as well as consideration of social impact. They are dynamic and expandable, and coordination is encouraged in order to maximize the utilization of available resources. Currently, there are four Initiatives underway: Library Linkages, Advanced Continuing Education, Research and Development Laboratories, and Los Libertadores.

**Library Linkages Initiative:** One of the basic tenets of science and technology is access to up-to-date information. The Library Linkages Initiative seeks to modernize document delivery as component of education, and research, as well as policy design. This initiative also seeks to broaden electronic availability of research materials, to upgrade the information system skills of library staff, and to sharpen the savvy and independence of the electronic library user. The ISTECE Cooperative Interlibrary Loan project has facilitated installation of Internet based document transmission software, trained users to electronically research science and engineering databases, and coordinated electronic request and transmission of documents among libraries of ISTECE. To date, projects within the Library Linkages Initiative have trained in excess of 5,000 people, transferred over 150,000 pages of documents, created regional inter-library loan systems, established

an on-line journal for Information Technology, established databases for local library collections, and developed software for document transmission as well as a search engine for retrieval of on-line journal information. For instance in Brazil, ISTECE has a working network of 18 Brazilian universities for real-time information exchange. This is the largest collaborative effort in Digital Libraries via Internet in the entire region. This effort provides 86% of all documents delivered to the universities. Based on this experience, the model is being utilized in Argentina, Colombia, Mexico, and Spain.

**Advanced Continuing Education Initiative:** The key to the development of any nation is the availability of highly qualified human resources. The lack of education in Latin American will increase the inequalities and the level of poverty of its population and will induce a negative impact in the productivity and development. Presently, the principle areas needed are Information Technology and Telecommunications. This initiative seeks to upgrade the available skills and increase the number of qualified individuals in applicable areas. Projects conducted within the auspices of this initiative involve curriculum adaptation, design and enhancement, professional development, on-site training, web based distance learning, as well as non-traditional faculty, staff, and student exchanges, including "sandwich" graduate programs. Regional partnerships are evolving to meet these goals. ISTECE is a member of the Asociación de Televisión Educativa Iberoamericana (an association of over 300 institutions throughout the Americas, Spain, and Portugal), and to date five courses have been delivered via the ATEI system, which involves satellite transmission of coursework to participating institutions throughout Ibero-America. Innovative technology has been used to incorporate course feedback using the Internet. With funding from the Organization of American States (OAS), ISTECE has identified and created new R&D capabilities in image processing, and enhanced existing human resources in the area. At the present time, ISTECE is developing a web-based network for training throughout the region that will make state-of-the-art technology available to a variety of personnel, foster horizontal collaboration, and produce material for the improvement of education, research, and development in the region. Of particular interest is the development of materials that incorporate the latest technology in the education process, both in the way of state-of-the-art textbooks and laboratory materials, and also in the way of developments systems.

**Research and Development Laboratories:** The costs of introducing computers in education are difficult to accomplish for most countries in Latin America. The costs involved in creating computer lab facilities have been estimated at US\$50,000 in Brazil, not including the upgrading costs [7]. This initiative has been created to provide a vehicle for performing research and development in a variety of informatics and telecommunications related areas. The laboratory facilities are also designed to be utilized in teaching situations, and are being used to enhance interaction between industries and universities. Thus, this initiative improves the ability of technology to be applied to the resolution of problems in a variety of areas. At the present time, over a 125 processor

laboratories have been established throughout the region and provide a common platform for sharing knowledge, exchange of information, and enhancement of curricula materials for undergraduate and graduate education. These processors include micro-controllers for effective control of a variety of systems, microprocessors for applications that are based on computations, and digital signal processing systems for applications that manipulate the characteristics of signals or images. These laboratories are distributed throughout 24 countries. Over twelve telecommunication-based facilities have also been installed in the region, and instrumentation equipment has also been made available to a number of institutions. At the present time, installation is proceeding on a major aspect of this system, which is a network of communication servers. The machines involved in this activity will provide access to a variety of different types of information. For participating educational institutions, access is provided to state-of-the-art software, tools, and techniques. For companies and other organizations that require it, access is provided to talent and facilities located throughout the region. And for all participants, access is provided to technology indicators that can measure the success of educational programs and identify the areas in which growth is needed. In addition, this process has helped to create an innovative and creative vehicle of collaboration with industry, and for promoting R&D efforts. With Motorola, for example, ISTE C has deployed technologies for microprocessors, micro-controllers, DSP, and signed a licensing agreement to work with the M-CORE technology in education and R&D for Systems-on-a-Chip. Key in this development has been Motorola Inc., Nortel Networks, Sun Microsystems, and Fluke Corporation.

**Los Libertadores:** This initiative is a “common thread” effort that links together all of ISTE C’s goals and objectives. It seeks to create a flexible network of telecommunication services (a hemispheric backbone for academic and R&D purposes), computing facilities, and teaching stations, known as “Centers of Excellence”. Each country or region identifies needs that must be met, and then designs a Center of Excellence to address those needs. Each Center of Excellence brings together people from the private sector, the public sector, and the educational system to work together to find solutions to the problems of interest. Since those problems invariably have multiple facets, the solutions must involve multiple disciplines and the diverse contributions available from each sector. It is important that the Center be adapted to the needs of the country, identifying those areas that can be most beneficial for all the participants and finding effective methods of collaboration. Thus, the Center may not be a central building, but rather a network of capabilities distributed throughout an area. To date, legislation has been passed in two countries to establish the legal framework for creation of Centers, and ISTE C is actively working with several governments, international funding agencies, and professional organizations to highlight the importance and critical nature of this effort in the development of the nations in Ibero-America. Progress is being made toward the creation of other Centers in the region, and as those Centers are developed they will be linked with the existing Centers to form a power-

ful resource for addressing problems of the region. For example, ISTE C and two Brazilian universities, the University of So Paulo (USP) and the State University of Campinas (UNICAMP) are assuming a leadership position in microelectronics education and research and development in the hemisphere. These universities are in the process of establishing an advanced semiconductor processing capability, on a par with the most advanced educational installations in the world. The two universities plan to build a new facility in which they will consolidate all their sub-micron capable equipment. The equipment set will be completed through donations from private sector. In addition, we have developed cooperation strategies with the Organization of American States (OAS), the Inter-American Development Bank (IADB), United Nations Education, Science and Culture Organization (UNESCO), United Nations Development Program (UNDP), United Nations Economic and Social Council (ECOSOC.) The common goal is to develop human capital, emphasizing the involvement of both public and private institutions that implement training, research, and academic exchanges in science and technology within the region.

## VI. CONCLUSION

Presently, ISTE C tries to support, project, and regionalize a hemispheric policy to address the challenges of the XXI century. In this effort we invite governments, politicians, the business community, academia, universities, technical assistance institutions, and international organizations to approve and implement policies that will extend the benefits of Information Technologies and Telecommunications.

Before the challenges presented to us by the XXI century, ISTE C beckons all to begin, united and convinced, a new integration, without exclusions, equitable, scientific and technological, so that we can face the challenges of the future. Together with the corrections from the present, we can constitute another historic age for our region and the entire world.

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