

5-1-2005

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Recommended Citation

Abdallah, Chaouki T.; R. Jordan; and H. L. Pollard. "Technology education challenges and solutions in Latin America." *IEEE Transactions on Education* 44, 2 (2005): 203-204. http://digitalrepository.unm.edu/ece_fsp/8

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Technology Education Challenges and Solutions 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&T), a term that encompasses the fields of Electrical and Computer Engineering, and Computer Science. Increasingly, IT&T is an effective indicator of the difference between developed and developing nations. The competitiveness of a nation is directly related to its incorporation of IT&T which requires a substantial restructuring of the forms and procedures in attempting to generate a base for development of science and technology. To achieve this, it is important to revise the education of human technical and scientific resources. This paper summarizes the experience of the Ibero-American Science and Technology Education (ISTEC) consortium in IT education in Latin America.

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

I. INTRODUCTION

IT&T has shortened time and distances, facilitating the exchange of products, ideas and services. No country can ignore the benefits and opportunities to transform society with the tools based on IT&T. This must take place with total participation from all parts of society and in an equitable fashion. Increasingly, IT&T is also becoming an effective indicator of the difference between developed and developing nations. For nations to compete successfully, it is imperative that they have at their disposal elements of this technology. The degree of success will be directly proportional to strategic investments in science, technology, information systems and human resources. Specifically, countries in Ibero-America that do not adapt to the new technological paradigm will face insurmountable difficulties keeping pace economically with the rest of the world, and will be marginalized from the process of globalization.

It is clear that for a country to be competitive at an international level it must:

- Utilize state-of-the-art technology
- Create and enhance curricula

- Increase its capacity for Research and Development (R&D)
- Promote national and international R&D projects
- Enhance or create new infrastructures in Information Technologies
- Have the capacity to access information in real time (without time differences)
- Develop Continuing Training programs

Specifically, IT&T is critical in the following areas:

- Academic resources: 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.
- 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.

Finally, the procedures for searching, processing, and distributing information in a minimal amount of time will be key in the future. As we evolve 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. 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.

This paper presents the experiences of ISTECS, a consortium dedicated to bringing the fruits of IT to the Ibero-American region. It reviews the status of technology in Latin America and makes the case for a regional effort similar to that of ISTECS. It then presents a particular ISTECS initiative (the LibLink initiative) as a particular example of a successful targeted program.

II. TRENDS AND NEEDS IN INFORMATION TECHNOLOGIES FOR LATIN AMERICA AND THE WORLD

In the US, 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 [RJ give reference]. The average car comes with 50 microcontrollers 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 tele-communications, bandwidth is doubled every 9 months [RJ give reference]. In Latin America, there are 10 million estimated Internet users, and its growth in 1997 was estimated at 250%. With similar projections for future growth, by the year 2000 the number of users will surpass 35 million. The fastest growing area on the Internet is Latin America. Like capital and labor, information is now 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].

On the positive side, telecommunications and computer equipment are constantly becoming less expensive and more powerful. This is one reason we can now tackle more complex problems, like climate simulation and modelling, and the effects of weather systems such as El Niño. We can process larger amounts of data such as those obtained by remote sensors, for the identification and proper administration of natural resources. The solutions to many of the problems faced by developed and developing nations require costly and specific resources that may not be universally accessible. In addition, the volume of information is currently doubling every 5 years, and it is estimated that by the beginning of the twenty first century [this information will double every 72 days.

Because of these reasons (and many others), the solutions to development problems require multidisciplinary work teams and collaborative technologies that allow both synchronous and asynchronous interaction. These solutions must be conceptualized as projects that take a minimum amount of time between the genesis of an idea and its actual implementation. IT&T provides such solutions.

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

Moreover the situation is not getting any better as the number of IT degrees awarded in the US 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. This lack of professionals translates into a dead weight for the economy. There are 450,000 potential job openings for IT&T 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? As a partial answer to this question, many companies are collaborating with universities to update their curricula, or choose to create their own universities and training centers. In order to retain their employees, industries have placed a priority on Continuing Education Courses. The answer however may lie somewhere else.

The globalization and interaction of the world's markets is leading 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 the emergence of Latin America. However, as the Latin American markets are subjected to a process of globalization, they must be restructured in order to ensure a sustainable development. As an example of addressing some of its own IT challenges described above, the US has launched three initiatives to increase academic and R&D resources in the area of IT. These are: vBNS, Internet 2, and Next Generation Internet (NGI). These projects, 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.

III. 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 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 %

Table 1: R&D to GDP Ratios in 1994.

An idea on the impact of IT&T on 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&T Market:

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

Table 2: IT Indicators

In the face of such obvious needs and benefits what can be done in order to bring Latin America along the IT revolution? The authors have answered this question in 1990 by creating ISTEAC.

IV. IBERO-AMERICAN SCIENCE AND TECHNOLOGY EDUCATION CONSORTIUM: ISTEAC

In the summer of 1990 personnel from the University of New Mexico visited countries in Latin America to identify and evaluate opportunities for collaboration in an international effort in science and technology education. Meetings were held with officials of various governments, educational institutions, research facilities, and industrial firms to gauge interest in cooperating in various technical fields. The meetings resulted in the identification of areas of common interest (IT), and for accessing hands-on education, research, and technology transfer. As a result of these visits, an organizational meeting was held in December, 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 ISTEAC, identified a number of immediate obstacles that need to be addressed before IT benefits can be realized:

- 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 exacerbated by a more subtle problem, which is the lack of awareness of the simultaneous existence and interaction of the above obstacles. In addition, it was deemed imperative that efforts be made to address these issues concurrently in order to successfully further the technological development of Ibero-America. It was a consensus among the participants in the meeting that traditional mechanisms for collaboration are not sufficient, and that new, more effective mechanisms are needed.

As a result of the meeting, ISTEAC was created, and universities, industries, and other organizations become members by signing a Memorandum of Understanding (MOU). The MOU establishes a General Assembly that sets policy and direction, an Executive Committee which carries out the policies and promotes the Consortium, and an Executive Office which handles the day-to-day operations.

The organizations that comprise ISTEAC have agreed upon the following Mission Statement: *ISTEAC is a non-profit organization comprised of educational, research, and industrial institutions throughout the Americas and the Iberian Peninsula.*

ISTEAC has thus 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 immediate objectives of the Consortium are then 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. ISTECS participants encourage the free flow and access of information in the pursuit of technical excellence. The mechanism proposed by ISTECS to work on its objectives, by involving personnel and resources from diverse geographical locations, is the *Initiative*. . Currently, there are four ISTECS Initiatives underway: Library Linkages, Advanced Continuing Education, Research and Development Laboratories, and Los Libertadores. The Initiative concept provides an effective answer to the challenges identified by the 1990 meeting's participants. 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 actively avoids duplication of efforts and inherently responds to membership needs. 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 to maximize the utilization of available resources. In the following, we summarize the four ISTECS initiatives designed to address the concerns of its members:

Library Linkages Initiative (LibLink): One of the basic tenets of science and technology is access to up-to-date information. The Library Linkages Initiative aims to modernize document delivery as a complement to education, research, and policy design, 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 ISTECS Cooperative Interlibrary Loan project has facilitated installation of Internet document transmission software, trained users to electronically research science and engineering data bases, and coordinated electronic request and transmission of documents among libraries of ISTECS.

To date, projects within the Library Linkages Initiative have trained in excess of 3,000 people, transferred over 100,000 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.

Advanced Continuing Education Initiative (ACE): A key to the development of any nation is the availability of highly qualified human resources. As stated earlier, the critical need areas are Information Technology and Telecommunications. This initiative seeks to upgrade the available skills and increase the number of qualified individuals within applicable areas. Projects conducted within the auspices of this initiative involve curriculum design and enhancement, professional development, on-site training, web based distance learning, and non-traditional faculty, staff, and student exchanges, including "sandwich" graduate programs.

ISTECS is an active 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. Innovative technology has been used to incorporate course feedback using the Internet. With funding from the Organization of American States, ISTECS has identified and created new R&D capabilities in image processing, and enhanced existing human resources in the area. At the present time, ISTECS 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.

Research and Development Laboratories (R&D): This initiative strives to provide a vehicle for performing hands-on 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. At the present time, over fifty processor laboratories have been established throughout the region and provide a common platform for sharing knowledge and exchange of information. 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. Key in this development has been the participations of the industrial partners such as Motorola Inc., Nortel Networks, and Fluke Corporation.

Los Libertadores: This initiative is the "common thread" linking together all of ISTECS 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 which 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.

Since the problems faced 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 and the region, 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 ISTECS 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 powerful resource for addressing problems of the region.

The next section discusses the details of the LibLink initiative and shows its evolution and impact.

V. LIBLINK INITIATIVE

The library initiative or LibLink is one of the most mature ISTECS initiatives and is comprised of many projects. The initiative is about 8 years old and was started to address the lack of current information at many of the ISTECS institutions libraries or even the lack of a proper library. The initial project was piloted amongst 3 universities and as it matured was rolled out to all institutions. The chart in Figure 1 illustrates the growth of the document delivery project for the years 1997-1999. Note that the document delivery model

Document delivery is a benefit provided to any ISTECS member as part of their membership and requires very little additional investment at their end (a Scanner, a PC, a printer and a licensed software). As soon as a document-delivery site is launched, users with access to that site are able to browse different library catalogues online and fill out a web form requesting a particular document from a particular library on the system. The document is then delivered electronically to the requesting site after taking care of all copyright issues by the delivering site.

Depending on the load and seasonality of the requests, a document is delivered within 48 hours on the average. Other projects within LibLink involve the training of Library personnel through workshops and the initiation of internal research projects on digital libraries.

The success of LibLink has brought with it new challenges: As the number of ISTECS members increase and their participation in LibLink becomes more mature, they demand more services and as such tax the infrastructure of the document-delivery project both in terms of resources and responsiveness. The challenge is currently to grow LibLink document delivery at our current rate of 200% a year while maintaining the quality of the product.

VI. CONCLUSION

In order to address some of the IT challenges in Latin America, ISTECS was formed in 1990. Presently, ISTECS tries to support, project, and regionalize a hemispheric policy to address the challenges of the XXI century. In this effort we have worked with and continue to 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. The participation of all these constituents has made the ISTECS model a success which can be translated to other developing regions of the world.

Before the challenges presented to us by the XXI century, ISTECS 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 the Latin American region and the entire world.

**ISTECS DOCUMENTS SUPPLIED
by UNM Library Linkages Project
July 1997 - Aug 1999**

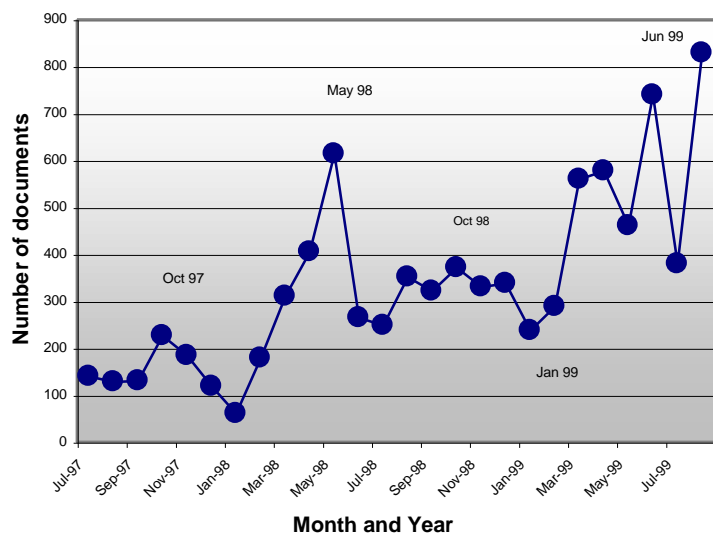


Figure 1: LibLink document delivery July 1997—August 1999

is but one aspect of the project which has also been copied by other library consortia such as the Brazilian Bibliotecas-LigDoc project.

VII. ACKNOWLEDGEMENTS

The existence and growth of the Ibero-American Science and Technology Education Consortium is due to the individual efforts of the dedicated personnel at member institutions. These people continue to invest time and energy in the activities of the Consortium, knowing that this investment will result in improved opportunities for all Ibero-America. Special mention should be made for Motorola, Nortel Networks, Fluke, IBM-Brazil, Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq - Brazil), Fundação de Amparo a Pesquisa do Estado de São Paulo (FAPESP - Brazil), Colciencias (Colombia), CICYT (Spain), and Xunta de Galicia (Spain). Finally, the authors are grateful to the State of New Mexico for supporting the activities of the University of New Mexico in its interaction with the Consortium.

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