Technology in Schools: Education, ICT and the Knowledge Society

by

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EXECUTIVE SUMMARY

Many countries around the world are investing in Information and Communication Technologies (ICT) to improve and update the education they provide their younger generations. Developed nations such as Canada, the United Kingdom and the United States are achieving students-per-computer ratios below 10:1, and their governments are deploying high bandwidth in schools. They are also consistently promoting research on ICT use inside the classrooms for many different educational, cultural and social settings. They are using their findings for fine-tuning policy decisions. Hardware and software industries continue their fast expansion and development, with new products for the educational system constantly emerging. As a consequence, many developing countries are facing a double challenge: First, they face a growing educational divide in terms of access to digital resources and services and of human capacity to take advantage of them; and second, when addressing the issues involved in defining ICT in education policy, decision-makers in these countries are experiencing increasingly complex scenarios.

For policy-makers in developing countries, the increasing variety of ICT applications in education, and the many associated claims, put an ever-increasing demand on more and better information before they are able to make decisions on investments. Fortunately for them, ICT in education are under constant research worldwide and many projects, in both developed and developing nations, can be visited and much can be learned from them. This document describes experiences and offers analyses from ICT in education initiatives in Latin American in general, and from the Chilean "Enlaces" (links) project in particular. However other projects worldwide have been reviewed as well, along with an ample literature review on the subject.

Although there is no breakthrough on improving learning achievements with ICT, many developed countries are experiencing good results on a minor scale and under particular conditions. The experience is showing that well-trained and motivated teachers can improve the learning *conditions* with ICT, and can acquire ICT skills together with their students, thus preparing them more properly for the emerging knowledge society. Classroom, school and system-wide information management processes may also be enhanced through ICT, freeing teachers from clerical tasks, making information flow more efficient and transparent inside the educational system, and helping policy-makers with more timely and accurate decision-relevant data. ICT are also an equity issue in many developing countries where low income and isolated rural schools may use them to dramatically enhance their learning tools and resources and connect students with other realities, peoples and educational projects around the world.

This document offers examples and insights on a number of issues that are relevant to policy- makers in developing countries. A particular effort has been made to demonstrate that introducing ICT into the schools, without a proper staff development plan and without a pedagogical perspective, is a low-return investment. Technology is still expensive and requires constant support at the school level for hardware and network repairs and software configurations, updates and management. Relevant digital educational content, both from the Internet and from CDs is an important consideration that needs careful attention, especially in terms of addressing learning needs, teaching practices and models that may become critical factors inside the classroom.

Implementing an ICT policy in education requires a long-term commitment from various levels of government; therefore, this report offers a few guidelines for program implementation in terms of management needs and program enhancement. A sound evaluation strategy of the ICT program, with achievement standards and performance indicators, will help in providing accountability. It will also be of

great value for the program's management team once it gets into its implementation stages. A special section is devoted to ICT for small rural schools, which are common in developing countries and which require, and deserve, special attention in terms of staff development, technical support and relevant content for their students. This is particularly important when local cultures are an issue. In the final section, a number of implementation priorities are analyzed, including the profile of the ICT management team, its alignment with other national educational priorities, and the importance of human capacity-building in terms of program scale, right from the beginning of the program. The paper ends with a resource base that can be used for further procurement of up-to-date information on ICT use in education.

The authors have been cautious to emphasize that there is no universal truth when it comes to applying ICT in education, and that there is no advice that can be directly applied without considering each country's reality, priorities and long-term budgetary prospects and commitment. In a sense, this document represents the authors' views and reflections, not just on "Enlaces" and other Latin American projects, but also, on the modifications they would make were they to redesign and implement an ICT program again.

I. INTRODUCTION

Defining an ICT policy is becoming increasingly difficult because of the many promises and differing alternatives that are presently available. Education has turned into a huge global market with aggressive players in place for countries willing to invest in e-learning, hardware, software, and networks. However, the growing evidence from large-scale programs that have lasted for years and have documented their successes [1] (and some of their failures) now offer ample opportunities for policy-makers to take advantage of these initiatives and thus avoid many mistakes, harbor more realistic expectations and eventually reduce costs on new program implementations.

Using as a reference point the Chilean experience with Information and Communication Technologies (ICT [1]), this document is structured to help in the definition of a policy framework for introducing or expanding an ICT Program in educational systems of developing countries. It is intended for policy-makers who may benefit from others' experiences, and its focus is on K-12 schools.

> The authors draw mainly from their own experiences with "**Enlaces**" (Links), the Chilean ICT program in education developed since 1990, but also from their observations and visits to other projects worldwide.
>
> *This document also includes the authors' reflections on the modifications they would make to Enlaces if they could redesign and implement it again.*

1. The Value of ICT in Education

Information and Communication Technologies (ICT) have been utilized by education ever since their inception, but they have been massively present in schools only since the early 1980s. Developed countries have applied them to K-12 education for a variety of reasons, most of which are still valid today, although in many cases they have remained unfulfilled expectations. Some of the reasoning found in the literature is as follows:

- A new society requires new skills: ICT increasingly pervade every aspect of life (work, learning, leisure, and health). Because ICT are the preeminent tools for information processing, new generations need to become competent in their use, should acquire the necessary skills, and therefore must have access to computers and networks during their school life. There is an equity issue in this argument related to the need to prioritize access to ICT resources to the more underserved population, which is being left behind on a digital divide [2].

- Productivity enhancement: Schools are information- and knowledge-handling institutions; therefore, ICT should be fundamental management tools on all levels of an educational system, from classrooms to ministries.

- A quest for quality learning: Schools should profoundly revise present teaching practices and resources to create more effective learning environments and improve life-long learning skills and habits in their students. ICT are versatile and powerful tools that can help in this purpose and should therefore be present in every classroom, library and teacher room. It must be said, however, that so far ICT have not provided any large-scale breakthrough in learning improvements. They are still promises with great potential.

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[1] This document focuses on digital interactive information handling technology such as computers, software, scanners, and printers and also on local and wide area networks, including Internet.

[2] See for example the documents of the World Summit on the Information Society in: http://www.wsisgeneva2003.org/home.html

> In terms of learning, it has been argued that a few subjects are being intrinsically changed because of ICT. For example learning *science* is increasingly related to having access to scientific databases, with information-sharing over the network, and with the use of digital devices for data processing. *Language* and *societal communications* are being modified because of the presence of Internet (i.e. chats, e-mail, forums and digital newspapers) and of handheld devices with communication capabilities.

Although several counter-arguments have emerged (i.e. lack of hard, replicable evidence of educational impact, unfulfilled expectations of revolutionary changes, need for long-term investment and high recurrent costs), we have seen an increased pressure for a more rapid infusion of ICT into education in recent years. Developing countries have become anxious about the widening gap between their reality and the aggressive ICT policies of countries such as the United States, Canada ("the most connected country in the world"[3]), and some of the northern European countries. The most recurrent argument for the new situation is as follows.

> *Developing countries are finding it increasingly difficult to compete with their present human resources in a global economy that regards information as an essential asset to design, produce and deliver goods for the changing consumer habits within a dynamic global market. ICT play a major role for dealing with information and its transformation into knowledge, which is a basic requirement for citizens to become effective participants in this new scenario* [2].

Consequently, there is a more urgent need to improve the quality and equity of education to bridge the gap between developed and developing nations, and ICT are perceived as necessary tools for this purpose.

The last ten years have produced a vast amount of research in the field of ICT in education with mixed results [1, 3-7]. Many projects have embarked on large-scale efforts using differing approaches, and technology itself has evolved at a rapid pace with many new promises for education every year. At the same time, the literature contains many unsubstantiated claims about the revolutionary potential of ICT to improve the quality of education. Some claims are now deferred to a near future when hardware will be presumably more affordable and software will become, at last, an effective learning tool.

Perhaps the most important lesson from past initiatives is that a technology-centered policy, i.e. one that focuses primarily on deploying machines, software and Internet connections, will not produce meaningful results or the expected impact on students learning. Although machines and networks are a fundamental component in any ICT policy, to achieve effective gains in student's learning, improved teaching practices and more efficient management at all levels (classroom, school, district and nation), the focus should reside on people and how to improve and develop their skills and practices with the help of ICT [8].

In order to have long lasting effects, to be effectively infused into the schools' culture, and to be considered relevant by teachers and school administrators, an ICT policy should preferably not be designed in isolation. Rather, it should be part of a more comprehensive effort towards improving the equity and quality of an educational system. Also, educational initiatives ought to be coordinated through all possible administrative and operational levels in order to effectively send coherent messages to teachers, parents and administrators.

2. ICT Roles in the Educational System

ICT can and should play a variety of roles inside a school. Some of the more important ones are pedagogical, cultural, social, professional and administrative. ICT, if sensibly deployed and with carefully selected software, can positively affect many aspects of school life, from a healthy questioning of present teaching practices to a gradual improvement of the quality, scope and depth of the learning environment, as well as to provide a remarkable opportunity for teachers' development.

[3] See http://www.connect.gc.ca/en/100-e.asp

a. Pedagogical Tool Role

An important role of ICT inside a school is that of providing a new framework that can foster a revision and an improvement of teaching and learning practices. Though many positive results have been reported on a small scale, there has been no breakthrough in learning improvements because of ICT on a large, replicable scale. Nevertheless, teachers and students can take advantage of the growing availability of educational resources as software packages and Web pages. Teachers will need curricula-related content and clear strategies and examples to effectively use these materials in the classroom. They will find that students can become highly motivated towards learning (and even toward regularly attending school) if technology makes up part of their classroom experience. Teachers can fruitfully use this positive attitude to explore new learning strategies in which students can be more actively involved in learning, as opposed to being simply passive information receivers.

Collaborative, project-based and self-paced learning are just a few alternatives amply documented and particularly appropriate to use when ICT are present [9]. Primary and secondary students with special talents (i.e. mathematics, music or literature) will find a vast amount of digital tools and resources as well as groups of similarly inclined youngsters all over the world with whom to share and develop their talents. On the other hand, students with special needs will also find resources and tools for remedial or self-paced learning. This can have a particularly high impact on more deprived and culturally isolated schools where primary students have fewer information resources and learning opportunities.

However, it is important to emphasize that it is not the presence of technology in itself (or of outstanding and guaranteed learning software, if such thing exists) that will stimulate significant changes inside a school. Without teacher involvement, most students in primary levels in particular, but also in higher levels may not take advantage of all the available potential on their own. Teachers need to become active participants for effective ICT educational use, such as providing guidance, help and usage rules for the students. Teachers are needed to organize the learning spaces and to guide toward the achievement of significant learning objectives.

In developing countries, students often do not acquire sufficient mathematical skills, a basic understanding of scientific concepts or an adequate reading comprehension level during their school years[4]. ICT provides tools and content to exercise these abilities, which will be needed to take advantage of the vast amount of content present in today's networks. Information processing skills to transform data (i.e. searching, selecting, synthesizing and communicating information) into knowledge is rapidly becoming a basic requirement for the emergent information society.

If ICT policies are closely related to the curriculum, teachers will more likely use them for learning practices in classrooms. Therefore, curriculum designers should consider the inclusion of ICT as transversal themes, i.e. in all curricular sectors, and in the curriculum-specification guidelines that will be used by teachers. It is not advisable to have ICT as separate, isolated technical subjects or sectors in the curriculum (e.g. programming, software tools and hardware configurations), because in this atmosphere, teachers will tend to regard ICT as special subjects and may not integrate them in their normal practice. Rather, ICT should be included as teaching and learning resources, along with examples of how to use them in classrooms, in all sectors, and in this way, turning them, explicitly, into a tool for all teachers in all grades and subject areas.

b. Cultural, Social, and Professional Roles

The cultural, social and professional roles of ICT are exercised primarily through an effective use of the vast amount of information sources and services available today via Internet and CD-based content for the entire educational community: students, teachers, administrators and parents. Also, nowadays new equipment (such as PDAs, science

[4] See for example TIMSS results in http://www.iea.nl/iea/hq/ and PISA results in http://www.oecd.org

devices and Tablet PCs) and low-cost portable keyboards[5] with text-handling capacities are helping teachers around the world with their professional routines.

A school connected to the Internet can foster communication at local (i.e. inside a community), national and international levels. Educational projects that connect students and teachers from different countries might amplify the quality of the conversational spaces, may expand students' horizons by allowing them to know and interact with people from other cultures and can stimulate group work and social interaction [9-11]. See, for example, projects such as WorldLinks [12], I*Earn [13], SchoolNet [14], Enlaces [15], Conexiones [16] and Think.Com [17].

WorldLinks and I*Earn both deserve particular attention because of their extensive experience with ICT in many developing countries around the world, their delivery of high-quality teacher training and their provision of multilingual educational resources.

For teachers, networks provide a medium to establish fluent links among peers from schools worldwide. Teachers can benefit greatly from sharing their experiences, problems and queries with colleagues in same situations. Of similar importance is the growing field of e-learning, with the availability of a large number of training courses for teachers delivered through the Internet, thus providing new means for professional development regardless of the teacher's workplace.

As discussed later in this document, bandwidth and communication quality can become major constraints. A low bandwidth and/or poor quality communication infrastructure can restrict network usability to text-only e-mails, limited to a few times a week. This is a far cry from the potential benefits of e-learning and from participating in professional groups and learning circles using high bandwidth connections.

This is particularly important for geographically and/or culturally isolated schools, which are common in rural and suburban areas. With up-to-date communications technology in place, students and teachers in these settings may experience a reduction in their cultural isolation and a significant improvement in their learning resources. Again, this will be highly dependent on the quality of the telecommunications infrastructure and its cost.

c. Administrative Roles

ICT have important roles to play in making school administration less burdensome and more effectively integrated to the official information flow about students, curricula, teachers, budgets and activities through the educational system information pipelines. They are also a good means for informing community members (parents, politicians, and researchers) about educational news and policies. See for example, http://www.mineduc.cl/ .

At the classroom level, teachers can more easily keep student's marks and their personal and academic records permanently up-to-date, as well as produce all required data for school administration and for parents, using preformatted documents. Most importantly, teachers can maintain their subject content (lesson plans, exercises, evaluation) in digital format, making it easy to update, to share with other teachers and to enhance with time. In fact, the many ways tools such as a computer, a handheld device or a portable keyboard (and a network) can help a teacher in administrative tasks is one of the more convincing arguments to make to inexperienced teachers so they will accept training eagerly.

This should be carefully considered during teacher-training planning because before pedagogical use in the classroom, many teachers may prefer to become familiarized first with the technology outside the classroom. This can often be facilitated greatly by starting out with software applications or simple devices such as portable keyboards or handhelds that can be of immediate use. It is relatively easy to learn how to use these machines to store text in a portable keyboard, to construct spreadsheets, or to make use of word processing to record students' marks and records.

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[5] Portable keyboards, also known as" Intelligent Keyboards", are low-cost portable devices with basic text handling and PC-to-keyboard connection capabilities. They are discussed later in this document.

At the school level, administrators will appreciate the use of spreadsheets, word processors, small databases and special accounting software to organize and store all relevant data. Internet can help link the school with the Ministry of Education offices to make the transfer of documents, new regulations and queries more efficient throughout the system. It can also help in improving the flow of information to the community through web sites and with regular well-designed information sheets.

At the educational system level, policy-makers may consider the introduction of ICT at all three levels (classroom, school, system) as a great opportunity to acquire and to distribute information through the system and from the general public to the classroom teacher. A coordinated effort can achieve economies of scale and compatibility of information processes and flows at all levels.

There are a number of software packages for all these levels of usage, which should be carefully evaluated by the teachers and the school administration to assess their completeness, their adaptability to the school's reality and the level of support offered by the software vendors.

3. Document Organization

This document elaborates on the key policy issues addressed by the Chilean ICT in Education Program (Enlaces) and other similar initiatives worldwide. These issues are summarized in the following text and expanded in succeeding chapters.

- Program Development and Administration. A very early and important decision in Enlaces was to define a team of professionals (the *Program's Management Team*) with technical and pedagogical background that could lead the development of the ICT Program. These professional needed to have an opportunity to gain experience and sustain the program's development over the long run. Also, the organization entrusted to develop the ICT in Education Program should be carefully defined as to draw a balance between keeping itself somewhat isolated from excessive state bureaucracy and at the same time maintaining an effective working relationship with the Ministry of Education as the major educational policy-making organization.

- Following the Enlaces experience, it is desirable for an ICT program to become an initiative with ample participation and with explicit roles for several constituencies, particularly teachers, school owners and administrators, the private sector, parents, universities and politicians. Finally, given the complexities and many problems that will have to be addressed, a gradual approach to the full development of the ICT Program is advisable.

- Staff Development. Teachers are key players in any educational innovation effort inside the classroom. Therefore, Enlaces focused on a teacher training and support strategy that presently lasts for two years (and several additional activities beyond the second year) in each school; this strategy carefully considers how to best develop teachers' ICT skills as well as their self-confidence in classroom uses of ICT. Depending upon their attitude towards technology, teachers might be grossly classified as innovators, resistant, or mainstream. Consequently, training strategies should address the special needs and attitudes about technology of all three groups. Achieving significant uses of technology inside the classroom is still a major challenge worldwide, and there is no reported breakthrough on this.

- Technology. Digital educational devices are becoming more affordable and more diverse every year, and, therefore, there are many more choices than computers and printers for schools at present (i.e. science and music devices, PDAs, intelligent keyboards). Also, there are many alternatives for the deployment and maintenance of hardware and networks, and each will produce a particular learning environment at a different cost. Special rooms -- technology labs -- that contain all the school's ICT may be less expensive and more controllable than a more decentralized approach with technology deployed all over the school. However, technology labs might have less impact on the school as a system, and might become less flexible for teachers who need an evolutionary approach for modifying his or her practice towards more

engaging learning environments with their students. Wireless technologies have radically improved the hardware deployment options and the cost figures in the last few years.

- Digital Content. Educational resources in digital format comprise software encapsulated in CDs and web-based educational content that is available today in many educational Portals and which offer services such as reviews, forums and courses through e-learning platforms. Providing relevant digital educational content to schools proved more complex than expected in Enlaces because teachers will accept the content only if several conditions are met, such as its adaptability to their current teaching practice and to the existing curriculum.

- Evaluation. Strategies for assessing the ICT program provide information for the program's accountability and serve as a management tool. This means that results can be used to modify the program's decisions and to fine-tune field actions. Additionally, communicating evaluation standards to the educational system helps to emphasize educational priorities for teachers and schools. Finally, the use of international standards and protocols can be useful for comparisons with similar initiatives from other countries.

- Rural Education. Rural schools pose different and more complex challenges than urban schools, but they also offer unique opportunities for fostering better learning by using ICT. Therefore, rural schools require and deserve special considerations and distinct strategies. Rural schools can also become a critical agent for the diffusion of ICT in their surrounding communities.

- Initial implementation priorities. This chapter discusses a few initial decisions that should be considered when starting an ICT in education program.

This document will refer to policy implementation propositions as part of a hypothetical "ICT Program," which might have a number of alternatives. However, they should be considered only as examples that need to be adapted to the particular reality of every country initiating a new program. For the sake of readability, the terms "ICT" and "technologies" will be used interchangeably throughout this text.

The following chapters expand on all aspects covered in this introduction. More references are provided together with a few examples from Chile and other countries.

II. PROGRAM DEVELOPMENT AND ADMINISTRATION

This chapter deals with some management issues that have been central to the development of Enlaces from its early pilot project to its full-scale nationwide ICT in education policy and programs.

1. Management Team and Institutional Framework

An early and transcendental decision in Enlaces was the identification of a small team of highly motivated professionals to initiate and lead the development of the ICT Program from the early definitional processes into its later stages, leading toward a larger provincial launch and then to the national scale. In our experience, it is advisable to assemble a team with solid educational and technical background and also one with strong leadership and political backing so as to remain relatively unhindered in the face of continuous political change.

An ICT policy requires stability so that the professional team in charge of its implementation can build its capacity, mature its expertise and to accompany the program from its very early stages. This team will be referred to as the **Management Team** in this document.

The Management Team should be composed of a mixture of expertise and backgrounds. Professionals such as educators, psychologists, project managers, engineers and graphic designers can play important roles in a core team for an ICT program. It is advisable to include academic experts in education, as well as experienced teachers who have used technology in their classrooms. A short description of the roles these professionals have played in Enlaces is offered next:

- Educators were in charge of defining the diffusion and training strategies inside each school category (i.e. urban and rural, primary and secondary). Experts in curriculum design, school administration and educational technology were hired, along with seasoned teachers, some with classroom experience using ICT.

- A mixture of innovative academicians with sound theoretical backgrounds in ICT, together with practitioners, provided a desirable combination of forward-thinking and realism. For example, in Chile it is common to find teachers dealing with 40 or 50 students in one classroom with no extra time to engage in training or without a real motivation to modify his or her teaching procedures because of the presence of ICT. The staff development policy had to take into account these kinds of situations.

- Educational reforms worldwide have often encountered a very tough and conservative reality when trying to change teaching and learning strategies. Therefore, innovation efforts need very careful planning as well as a thorough understanding of the educational reality to be addressed. It was essential for the core team of educators in Enlaces to invest in acquiring some knowledge in educational innovation [18-20]. But as will be described in another chapter, innovation inside the classrooms was much more difficult to achieve than expected by the Enlaces team.

- Educational psychologists contributed, along with educators in the team, to the strategic planning for ICT integration in schools and into the teachers' daily practice. One of their main tasks was to adjust the training strategy and to prepare teacher trainers to address teacher's beliefs and their level of self-confidence related to the uses of ICT in schools [21]. Also, they had to address a number of myths aroused by the fear of technology (i.e., teachers "being replaced" by machines, or teachers feeling intimidated or incapable of handling technology, etc.).

- Program managers were in charge of budget planning and control, procurement procedures, program evaluation processes, legal aspects and staff hiring. This group also included the necessary personnel to undertake the secretarial and janitorial work required by the managing team and the upkeep of the program's headquarters.

- Engineers were needed in three areas of expertise in Enlaces: (I) Hardware experts, capable of defining hardware configurations, maintenance procedures and services; (ii) telecommunication engineers for both local networks and Internet services; and (iii) software engineers, for supporting content development in both CDs and web-based platforms.

- Graphic designers with software and web production experience were helpful in defining the program's marketing strategy, the look and feel of CDs as well as Web-based material developed in-house, and the format of the program's documents and media-related communications.

Although there were specific responsibilities assigned to each professional group, the tasks of the ICT program required an integration of the expertise of all of them. For example, while designing the teacher training strategy, teachers defined the method and content; managers contributed with the logistic dimensions, and engineers analyzed the technical requirements imposed by the strategy. The Management team encouraged, from the very beginning of the program, a multidisciplinary teamwork and a culture of collaboration.

Also, (and only recently implemented in Enlaces) the Management Team was assisted by a high level External Advisory Board consisting of qualified people from business, academia and government as well as a few external, ideally international, experts without personal commitments with the ICT Program. This Board should be capable of providing feedback, constructive criticism and offer long-term direction. Enlaces was often accused by political and business opinion leaders of not taking them enough into account. A board -- together with a communication strategy -- can constitute a two-way channel to inform and listen to interested parties.

Because there is a requirement for human capacity-building in the long term, the Management Team should be allowed to transcend short-term decisions at the political level. Therefore, it is advisable to house this team in an institution that offers stability, independence and enough maneuverability to establish flexible links with government (integration with high-level educational policies, budget definitions, procurement standards and procedures), academia (research, evaluation, training), and the private sector (procurement, donations, community involvement).

Costa Rica decided to establish the Omar Dengo Foundation which is linked to the Ministry of Education [22] for its long-standing ICT initiative which began in 1987. Omar Dengo's management team adopted a profound constructivist approach backed by an MIT team led by Seymour Papert [23] and focusing on Logo and later on MicroWorlds as its main software tool for establishing learning environments in each school.

Chile developed its Enlaces program (since 1990) with strong links between the Ministry of Education and a group of public and private universities from all over the country. Most of the Enlaces core team has served during three presidential terms and seven Ministers of Education [24].

Both, Omar Dengo and Enlaces were able to prevail over time, gradually refining their work, and extending their reach.

2. Program Participants

As a long-term project, Enlaces has enjoyed ample and active participation of many segments of society, particularly the teachers, school owners and administrators, the private sector, parents, universities and politicians. A strong communication strategy was an important part of the ICT policy to help build long-lasting working alliances with all participants. A brief explanation of the role of each segment in the Chilean case is offered next.

Teachers have to be reassured that they and students are at the center of any educational initiative, and that technology such as computers, although powerful and multipurpose machines, will be only at the service of the teachers' professional skills and students' educational needs. A communication strategy was aimed at motivating teachers to participate in training activities as a professional need, and it was linked to a few benefits for their own

career development. They should also see their training as a pedagogical opportunity to improve and broaden their students' learning environment and thus regard themselves as key players in the modernization of the educational system and of society at large.

School administrators and school owners should perceive the introduction of ICT as a necessary modernization effort for their schools as well as an opportunity to attract new parents looking for more modern learning environments for their children[6]. School administrators can play an influential role in fostering teacher attitudes towards innovation and ICT use in classrooms. Too often, administrators are either passive or actively against ICT initiatives, mainly due to cost. They perceive technology as expensive devices that will consume scarce resources as well as distract teachers' time, without evident short-term returns.

It has been important to address these issues as part of the ICT policy, with realistic solutions and arguments in order to gain the administrator's approval and commitment. The importance of this effort cannot be over-emphasized; otherwise, after the initial excitement about the technology wears off, administrators may gradually build subtle barriers against new technology (i.e. locked technology rooms for safety reasons, withdrawal of incentives for teacher training, focusing on alternative projects, and reducing budgeting for supplies and hardware maintenance).

An important message to school administrators was that they should not simply promote the use of the technology by teachers and students; rather, they should regard themselves as key players, supporting actively and explicitly every initiative from teachers to improve learning with ICT. To carry out this policy, administrators need to know the costs and benefits, and the incentives for the schools. They should also be promptly informed of the results of evaluation studies, especially those of their own schools.

Private sector entrepreneurs and businesspersons can become active allies in many ways. This is partly due to their interest in improving the future labor force to become more competitive. Also, helping education can be a marketing strategy to improve a brand's image or to invest in students as consumers. Also, the private sector normally associates ICT with productivity enhancement and modernization. Two initiatives that seem effective in other countries are special tax deductions (i.e. for donating computers to schools) and a strong communications strategy to stimulate support to schools from the private sector.

Businesses are normally inclined to support schools in their surroundings (vocational schools in particular) and therefore small and medium-sized businesses should be considered as potential donors by a special communication campaign. Hardware and software donations, expert help, hardware maintenance, free Internet and hardware supplies, would all be welcome. National and international funding agencies and local authorities should also be targeted for help on all these areas of need.

> Enlaces received from *Telefónica CTC*, the largest telecommunications service provider, a 10-year free Internet donation (1998 – 2008) for more than 4,000 schools. It has been estimated that Telefónica's donation equals more than 1 US$ million a year. As a consequence of this effort, Telefónica is now installing high bandwidth Internet in a growing market of schools demanding more communication capabilities.
>
> Despite Chile's weak donation law, the Chilean private sector (mostly parents) and other school projects not related to Enlaces have contributed nearly 20% of the present hardware in primary schools (K-8), and more than 30% in secondary schools.

Parents should be clearly informed about the costs and benefits of introducing ICT in schools in order to invite them to support this initiative. Many schools in rural and economically deprived areas will need a comprehensive effort to sustain ICT programs over the long term. After initial installation, several recurrent expenses have to be met to allow for sustained pedagogical use of technology. Hardware supplies -- such as printing ink and paper, telephone lines for Internet connection, supervision when teachers are not on hand, maintenance and equipment replacement --

[6] The Chilean system has a subsidy scheme based on vouchers given to the schools according to the amount of students they have. Since parents can choose the schools for their children, it is important for the schools to make a marketing effort and provide a good educational service.

are just a few of the items essential in the long run. Parents and school administrators should clearly know about these needs to gain their assistance, either with their time or with small contributions of money.

Universities have played a distinctive role in Enlaces by providing human resources for training teachers and for performing technical support. In some, but unfortunately only a few cases, they have also engaged in research and related activities such as educational software evaluations and field experiments with learning methods using ICT. The reason: Chilean research policies do not properly stimulate the academia to perform field research in their own school systems.

> Enlaces has established a long-lasting relationship with close to 25 universities all over the country. Six of them are large universities that have a long-term contract (4-6 years) with the Ministry of Education (MoE) and are in charge of a large geographical area, altogether covering the whole country. These six universities subcontract other institutions to help in each specific region or province with teacher training and technical support. The local institutions also assist the regional branches of the MoE with the yearly process of selecting schools that should enter the Enlaces program and with checking the hardware and software installation during each procurement process. All these universities have proven to be strong allies to Enlaces, with a capacity to attend to the specificity of the schools inside their own geographical zone of influence (i.e. a province or a region). This relationship between the MoE and the universities started in 1990 at the beginning of Enlaces[7].

A powerful reason for integrating universities in an ICT education policy is the need to modernize the pre-service curriculum of teachers in order to integrate ICT as a transversal component at all levels. This was not properly addressed in the Enlaces policy, and it is only now recognized as a major challenge [25]. Starting from basic technical skills, young teachers should clearly understand the uses of ICT in their subject matter and have the capability to integrate them in schools immediately after graduating. As an investment, improving the pre-service teacher training curriculum might have the most profound effect over the long term, with each generation of new teachers well equipped to upgrade teaching practices. However, if a strong resistance is perceived from academics (which might be the expected case), an initial step might be to include ICT as a separate compulsory subject. However, in this case there is a risk that it might shift ICT to a technology-driven approach (i.e. programming and hardware configurations), rather than the desired curriculum-driven one.

Political leaders: The introduction of ICT in education, as part of a modernization effort in the Chilean school system has been perceived as a sensible and necessary initiative by the general public and, with few exceptions, has not provoked a negative reaction. However, policy-makers should also consider a permanent communication strategy focused on legislators, opinion leaders, politicians and high-ranking state officials to keep them informed about what is involved (goals, costs, time frame), to keep expectations at realistic levels, and to avoid budget cuts on vital programs.

3. Stepwise Program Development

This section argues in favor of a stepwise development of ICT in education policy. Enlaces has not implemented every proposition that follows; rather, what is stated next is mostly a reflection of what Enlaces should have done, upon considering its history.

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[7] Enlaces was conceived in 1990 at the Catholic University of Chile in Santiago as a research project under a contract with the MoE. In 1993 Enlaces' headquarters moved to the University of La Frontera (UFRO) in the southern city of Temuco to prove its design outside the capital city in the poorest Chilean region. The idea was that "*if Enlaces can work in and around Temuco, it can work anywhere in Chile*". As Enlaces started to grow, it became a national policy and UFRO, in coordination with the MoE, partnered with other regional universities to attend its expansion. In the year 2000, Enlaces' headquarters moved back to the MoE in Santiago but the university network was maintained.

Given the present international experience, a good starting point prior to defining a new ICT program or expanding a present ICT in Education Program, is that of investing time in learning about other programs' experience and also to read a selection of the available literature from previous initiatives and from academia. This will require some travel and time for reading scholarly and policy-definition papers, to attend conferences and seminars, in both the native language and English; and also, to select and become part of several networks of people working and doing research in the field. Appendix 4 contains a listing of some interesting projects to visit worldwide, along with other relevant links.

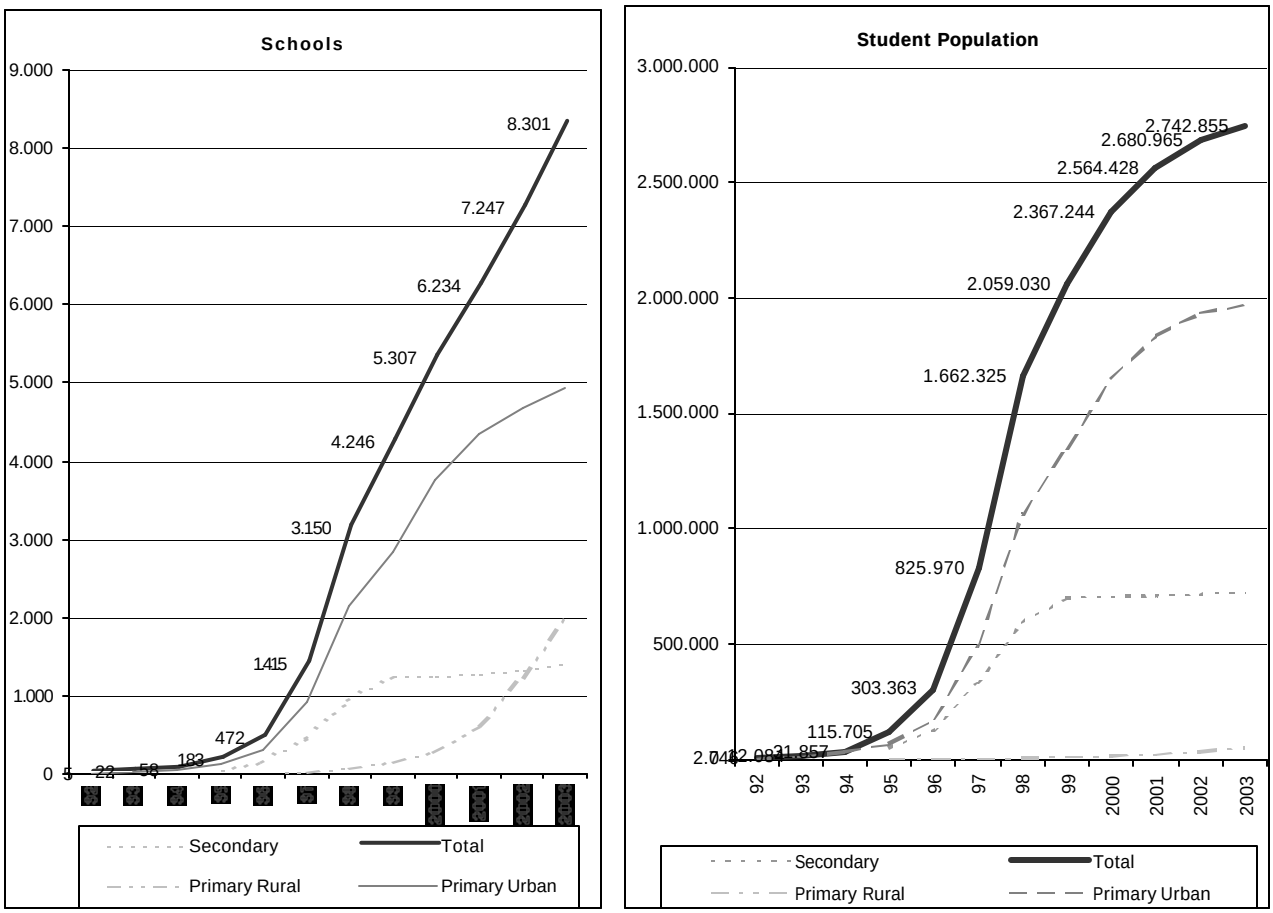
> A visit to ICT projects in Chile (Enlaces), Costa Rica (Fundación Omar Dengo), Uganda (WorldLinks[8]), Mexico (RedEscolar), USA (Challenge 2000, California) and Spain (PIE – Barcelona), can provide important insights and a deeper understanding about daily issues and problems and about the effectiveness of each proposed solution, than can be obtained by simply reading papers or attending conferences. Each of the aforementioned initiatives has particular ways of implementing ICT in their schools and they all work on different educational realities; hence, together they provide a comprehensive perspective of the available field experience.

Many times, it may not be advisable to start immediately an ICT Program on a regional or national scale, even if enough funds are available. There may be not enough capacity for training teachers, for hardware maintenance or for administering and monitoring the program's progress in all its many dimensions. An initial piloting stage can help in providing a core experience and in building up a management team for the long-term. From the very beginning, it might be preferable to define an institutional framework (at least a transitional one) for the multidisciplinary team that will lead the operation and growth of the ICT Program.

Enlaces started with only a dozen schools and grew to 100 in the following few years (1% of all schools). But that was in the early 1990s when very little experience in developed countries was at hand. More than ten years later and with many projects under development worldwide, a larger start-up figure can be determined by each country according to its particular situation. A program of 100 schools will prove radically different from one with 1,000 schools and even more so from one with 10,000 or more schools. The complexities of larger numbers will need an extremely well-experienced management team and a regional or nationwide network of people with the capacity to address a variety of problems. Enlaces expansion program is shown in the next graph:

[8] Se Uganda Country Report from WorldLinks in:
http://www.world-links.org/english/assets/WorldLinks-Uganda.pdf

Figure 1. Enlaces' expansion in terms of schools and students



These graphs show Enlaces' expansion in terms of schools and students. Although in the year 2003 Enlaces covered 80% of the schools (78% primary and 88% secondary schools), it represented 92% of the Chilean student population. This is because rural schools, most of which are still without Enlaces, have an average number of only 23 students.

The pilot stage should be planned in such a way as to provide the necessary field experience for the larger scale rather than as *an end* in itself. This stage should address a number of schools that represent the most typical school realities of a country. For example, consider urban and rural schools, small (i.e. fewer than 100 students) and large, primary and secondary, vocational and non-vocational, and other categories if needed, possibly those schools with large ethnic proportions of students, subsidized and/or privately owned schools, as well as a number of other possible key factors.

A few schools should be tagged as experimental so less proven approaches can be utilized. Though not yet proven, these approaches carry potentially good educational impact, such as particular learning strategies and teacher roles, or special configurations and characteristics of both hardware and software. Experimental schools should be considered during all program phases, small-scale and large-scale, and should be closely watched and critically analyzed. They can provide insights for future steps and allow for small-scale mistakes before the Management Team goes national with new propositions that might prove too radical and unacceptable by the educational establishment or that might simply not work as anticipated.

Experimental schools can also provide an escape valve and a firewall against the pressure of donations of software or hardware from important vendors claiming their highly educational value. Officials can always defer large donations until after a test period in these schools. Of course, these schools should know exactly the role they are

playing and, normally, it is not necessary to include the entire school but only a few voluntary teachers willing to cooperate for a limited time with a particular initiative.

Pilot programs should avoid the temptation of working only with innovative teachers that will, no doubt, provide a good showcase for funding agencies, but will not provide the necessary experience of working with mainstream, and even resistant teachers. This group may be exist in far larger numbers and may have very different training requirements than innovators.

Finally, pilot programs should look very actively for early exemplary uses of ICT inside the classroom during normal class hours and not only as extracurricular activities. It is well-known that it is easy to put ICT inside a school, but achieving meaningful learning results using ICT during normal class hours is a much more difficult and time consuming effort. A few early classroom cases may provide useful insights into those particular situations and serve as effective models for the rest of the teachers. They will also help the Management Team to better understand the actual problems that teachers are facing. These early cases should be closely documented and promoted. The message soon should be "Other teachers are doing it; it works; and it works well."

4. Management Tools for the Educational System

Educational systems are known as stable institutions, not prone to rapid changes and innovations. It is possible that a significant number of teachers and school administrators will resist the introduction of ICT in their schools. In this regard, a powerful modeling example is that of a Ministry of Education that introduces ICT to its management, gradually pressing all levels of administration -- central, regional, district and school -- to use technology for all their information processing needs, including information gathering and distribution.

At the most important level -- the school -- the pressure to provide and receive information to and from the central system digitally is a powerful message and a driving force towards change.

Centralized systems normally have a well-consolidated circuit of information flow to and fromall levels of the system. A change in a general rule or ordinance generally moves gradually through the circuit until it eventually reaches the classroom teacher or the parents if it is relevant to them. It is an administrator's responsibility at each level to decide when to move each piece of information and to whom. This reflects a power structure that imposes restrictions on the transparent and rapid flow of information. ICT can have a rapid and powerful impact on this structure by changing the rules of information flow. For example, all educational information can be placed for the teachers, administrators, parents and the community at large on a public web site. See for example, http://www.mineduc.cl.

5. Enlaces Program: present situation

The Enlaces program is presently reaching more than 93% of the subsidized school population. Close to 80% of all classroom teachers have been trained and more than 8,500 schools are part of the program which comprises almost all urban schools and a growing proportion of the rural schools. As a consequence, Enlaces is ending the phase of initial implementation and is moving gradually to address a number of more challenging questions beyond hardware deployment and initial teacher training. The present complexity of these challenges deserves a few reflections related to program management.

Enlaces headquarters are presently at the Ministry of Education which works closely with a number of institutions. There is a network of 25 universities all over the country, coordinated by the Ministry of Education, in charge of teacher training and technical support. To attend its major initiatives, Enlaces is now organized as follows:

1. The network of schools There are ICT laboratories in each school that need to be maintained and single subject teachers who need specialized training.

2. "Rural-Enlaces" (see related chapter) This program has specific challenges because of the isolation, small size and environmental conditions of rural schools. Supplying Internet connections here is also a different problem.

3. "Enlaces open to the community," This initiative started in the year 2001 and aims to attract parents to the schools by offering them basic ICT training. It has grown to become an important component of the national digital agenda. More than 1,000 schools now offer training plans to parents and community members.

4. "ICT driving license" and ICT skills certification This part of the national digital agenda seeks to improve Chilean ICT skills starting in secondary schools with special workshops for students, as well as coordinating other initiatives for adults.

Two institutions perform most research and development initiatives for Enlaces:

- Fundación Chile (http://www.fundacionchile.cl/) develops the educational portal and offers e-learning courses to teachers as well as offering other research initiatives related to school management.

- The Instituto de Informática Educativa (http://www.iie.ufro.cl/) at the University of La Frontera, previously the headquarters of Enlaces, is presently its major research partner and policy advisor institution. This institute is also in charge of the training and support in all schools in the four most southern regions down to the Antarctica, with a strong expertise in ICT for rural schools.

Besides these two institutions, there is a growing number of private and public organizations in Chile interested in ICT in education for specific purposes, mostly because of the new market opportunities offered by the relatively large number of schools with ICT. For example, their interests span from specific educational or school management software to specialized hardware, such as scientific devices or even new teacher training proposals. Because most of these institutions apply to the Ministry for help and support for their initiatives, a present challenge for Enlaces is to work effectively with them and connect them to the schools.

A complex side of this is that many entrepreneurs are looking for a "ministerial seal" for their products as a marketing bonus. Enlaces' response has been offering to field test each product in a few schools and disseminate the results. Most serious -- mainly large -- hardware and software vendors accept this option. Also, many small entrepreneurs or academic innovators cannot afford to invest in a field test on their own. For a ministerial program like Enlaces it is not possible to invest in private initiatives without a competitive and open bidding process to keep transparency and an egalitarian access to the few available funds. This situation imposes time-consuming administrative restrictions, which makes it increasingly difficult to take advantage of the many opportunities available at a national scale.

Another aspect of the complexity of Enlaces, related to the many processes performed nationwide that need to be coordinated and accurately reported to various decision-making levels, has been solved by implementing web-based information systems. There are presently many of them, all used at a national scale. A sample of them is as follows:

- One database contains general information about each school that enters the Enlaces program, together with a profile of the schools, teachers trained, etc. This database has been important to provide statistics to national authorities and to keep track of Enlaces quantitative progress. However, given the dynamics of the school system, in which each year new schools enter the system, and which has a growing population of students, it has become necessary to link this database with official ministerial databases to produce accurate and consistent statistics relative to the entire educational system.

- To support the installation process of new laboratories in schools that enter the Enlaces program, an information system records physical space, electricity, security conditions, etc. and reports to the central level to coordinate the installation of hardware by the selected dealers.

- Another system keeps track of the hardware warranty of each school laboratory to assist schools when hardware failures occur and dealers do not respond promptly.

- Internet monitoring systems register and quantify the quality and failures of the Internet connections to each school. They keep track of the quality of the service provided by the ISPs and analyze Internet availability in the schools under various categories: primary, secondary, north, south, etc.

Enlaces has also been pressed to move beyond K-12, attending pre-service teacher training in ICT, adult ICT literacy and e-learning in general. It also needs to take into account not only computers and peripherals but also other devices related to digital technology including for, example, digital TV.

To address its growing mission and increasing complexity, Enlaces is now working to become a formal consolidated national institution in the form of a Center for ICT in Education, in the hope of becoming more efficient in its decentralization efforts and in coordinating and fostering the growing number of private and public initiatives related to the use of ICT in education nationwide.

III. STAFF DEVELOPMENT

"Efforts to replace teachers with technology have uniformly failed. Inventions intended to take over teaching come and (mostly) go; what happens in classrooms looks pretty much the same. Why? Because technology enthusiasts continue to forget a basic fact: machines are tools, valuable only when a human intelligence organizes their use in a productive way. In the classroom, that human is the teacher, who controls the nature of the environment and what happens there. Good classroom tools extend the teacher's power to create a rich learning environment. If the teacher does not know what to make of the tool, or fears it, or misconstrues its uses, it will be used badly or not at all. If the teacher perceives the machine as a master, not as a servant, its potential will never be realized" From T.A. Callister [26].

Staff development should be at the core
of any policy for introducing ICT in education.

This chapter describes the main features considered in the design of the Chilean staff development policy for the Enlaces program and offers a few reflections on some of its strengths and weaknesses. In order to provide context, it starts by reviewing general issues related to the Chilean reality that influenced the Enlaces staff development policy. It follows by highlighting the view that teachers are the key players in any educational innovation and the importance of considering their skills as well as their beliefs during training. It then reflects on the school as a workplace. The chapter ends with a discussion about the Enlaces approach and its future directions. Appendix 2 offers an example of a concrete teacher-training program.

1. Context about Enlaces

This section starts with a brief summary of the Enlaces staff development policy and then explains some of the particularities of the Chilean case that might help to understand why some of the decisions were taken.

The Enlaces policy has consistently considered teachers as the central focus of its efforts [27, 28]. However, school administrators, ICT coordinators and teachers as teacher trainers have also been part of this effort. Students themselves have not been directly addressed by the policy, a situation presently being revised.

Each school that enters the Enlaces program is entitled to a two-year on-site training program for 20 teachers, followed by an annual program of seminars and a permanent offer of a variety of activities, including participation in international collaborative projects, professional learning circles, and educational competitions, many of which are promoted via the Educational Portal: http://www.educarchile.cl/.

The goals for the teacher-training program are defined by the Ministry of Education, and they encompass three domains: Pedagogical, Managerial, and Cultural. These domains are explained in Appendix 2. According to Enlaces internal evaluations, after two years of at least 100 hours of face-to-face training, teachers accomplish familiarity with ICT and use them regularly for personal, professional (e.g. engaging in professional circles, e-learning), managerial (e.g. student marks, parental reports) and off-classroom tasks (e.g. searching for educational content on the web, lesson planning). Only a minority of teachers will use ICT regularly in curricular activities inside the classroom.

The next step for Enlaces, and one that is being addressed as a priority through several initiatives, is to consider the present level of teachers' ICT skills as a basis to promote the use of this technology in each curricular subject. This is discussed in more detail at the end of this chapter.

The Enlaces teacher-training program is implemented through a network of universities all over the country in close coordination with the regional branches of the Ministry of Education, which are in charge of selecting the schools

that will enter the program each year. These universities hire trainers that are in most cases teachers that already have classroom experience with ICT. By the year 2000, Enlaces had around 1,000 trainers.

Besides regular teachers, a fundamental player in the present Enlaces policy is the "ICT Coordinator," a specially trained teacher, normally an early adopter and technology enthusiast. These professionals have a special role in infusing ICT inside schools, supporting teachers and keeping the hardware and software up-to-date and workable. Enlaces has recognized the importance of this cadre for the proper integration of ICT inside a school, and it has gradually increased its long-term support to them.

In terms of teacher training, the Chilean experience might be similar to that of many developing countries. Enlaces started in the early 1990s when no pre-service teacher training institution (mainly Faculties of Education) considered ICT for teaching and learning. After more than a decade of introducing ICT into the educational system, and with more than 90% of the student population having access to ICT in their schools, still very few Chilean Faculties of Education consider this to be an issue. The reasons are complex and manifold and are addressed by several studies, in particular the recent OECD Report [25] and others [29] which highlight the weak professional preparation of Chilean teachers. This situation has become a national priority and presently the Ministry of Education is aiming to reform pre-service teacher training.

As a consequence of the above situation, at the beginning of Enlaces the vast majority of teachers were not prepared to use ICT in schools, and few of them had had the opportunity or the means to learn on their own. On the other hand, given the scarcity of financial resources in many schools, it was also not realistic to expect schools to design or contract for professional development programs to train their teachers. Hence, to begin integrating ICT in schools in a reasonable time, the Ministry of Education decided to provide in-service professional training and support to teachers, through centrally funded programs and strategies.

Chile has been investing heavily in the last decade to promote the advantages of the "Information Society," and many public and private institutions are increasingly using ICT for their information and communication needs, including the Ministry of Education and its regional branches. For example, the Ministry maintains an official web site (http://www.mineduc.cl) with all its initiatives, standards, priorities and news for teachers, parents and school administrators. The educational authorities regularly promote the uses of ICT in education in their political and professional speeches. In addition, ICT is repeatedly in the news, in the popular media (i.e. TV shows) and at many levels of political discussion. As a consequence, Chilean teachers -- and all Chileans in fact -- are regularly exposed to this ICT wave in its many forms. It constitutes part of the cultural and social context in which teachers are immersed, a fact that is analyzed later on in this chapter.

2. Teachers as Key Innovators

This section offers a few ideas selected from international reports, from our own experiences with Enlaces, and from observations of similar projects in other developing countries.

a. The Teachers

There is ample evidence that teachers are vital players in any initiative aimed at improving teaching and learning processes [5, 30]. Moreover, ICTs at schools will have little impact if teachers are not actively involved in all phases of their integration to the curriculum [31]. In other words, a major obstacle to an adequate use of technology across all grade levels and in the curriculum, is the lack of a critical mass of teachers who feel comfortable in using the technology and can provide support and exemplary instances of good practice to those who are still not fluent with technology.

Some of the available evidence indicates that these programs must be long-standing. Studies of the Apple Classrooms of Tomorrow (ACOT) experimental schools project [31] as well as the OTA Report to the U.S. Congress on 21st Century Teachers [32], and Enlaces experience after ten years of teacher training, indicate that although innovators and early adopters will need only a few months to start using computers inside a classroom, mainstream teachers require much more time. Only after completing extended training for three or more years and

with steady access to computers will they feel sufficiently comfortable with computers to start incorporating their use in their teaching.

> A survey conducted in 26 countries [3] revealed that "Teachers lack of knowledge/skills" and "Difficulty to integrate it into instruction" were listed as the second and third most important obstacles, affecting the realization of computer-related goals in schools. (The most important was "Insufficient number of computers").

b. Teacher's Skills, Beliefs and Attitudes

Field researchers have learned that teachers work under a given social and cultural context that is a key influence in the way they perceive and use ICT for their personal and professional practices [21, 33, 34].

> One notable measure of the social and cultural pressure on Chilean teachers to use ICT is that 64% of them own a PC and 41% of them have an Internet connection at home [9].

In addition to the social and cultural context, teachers' perception of ICT in education is also influenced by their own experience and opportunities to use ICT for personal or professional reasons [33]. In our experience, it seems necessary that teachers understand and discuss the stages involved in their own process of becoming proficient in the variety of uses of these technologies.

Besides technical skills, training in Enlaces also considers a number of other factors that might affect teachers' decision to use ICT in the classroom. These factors can be grouped into the following two levels of barriers [21]:

- The "first order barriers" comprise a number of aspects that are extrinsic to teachers: access to technology, time for practice, technical support, resources and content, and training. Even if all these barriers were removed, most teachers would not automatically use technology.

- The "second order barriers" are intrinsic to teachers: attitudes, beliefs, practices and resistance. Teacher beliefs mediate their planning and classroom practices, in particular the belief about their level of ability to use ICT in classrooms. Self-efficacy, the belief about one's capability to perform actions at a given level, is based on the level of skill possessed and on judgments about what can be done with current skills.

"Without skill, performance is not possible, without self-efficacy performance may not be attempted" [21]

A broad but useful generalization about teachers' attitudes towards ICT is that of considering three basic categories of teachers: innovators, resistant and mainstream. Many discussions inside Enlaces use these categories when reviewing training results and considering possible modifications.

Innovators will rapidly recognize the potential of ICT in education, will be willing to explore its uses with their students and in their professional duties (i.e. management) in the early stages of the training process. They will also be willing to become responsible for administrative and technical tasks related to the equipment (i.e. running the technology lab). Innovators are normally the ones who volunteer for the first training courses and participate in the pilot stages of the ICT program. The schools' ICT coordinator will normally be a volunteer from this group.

Working only with innovators at the beginning of an ICT Program can be very deceiving for policy- makers because this group's active commitment is not necessarily shared by the rest of the teachers in all schools. Enlaces learned during its evolution, which included an increasing number of mainstream teachers, that progress with them is much more difficult to achieve. Policy-makers should be aware that although innovators can play a great role in having a

[9] Source: survey conducted by the Ministry of Education in 2002.

"working demo" running at early stages, the expectancies created by them may not be fulfilled in the next up scaling level, when less committed teachers become involved in the program.

Many good teachers are resistant to ICT with good and strong reasons that must be taken into account. Although many of them may never get actively involved in using computers in a lab (but may use a screen projector in their classroom), they will undoubtedly provide a healthy and necessary tension that will impose on policy-makers the need to use rigorous arguments in favor of ICT in schools. Also, these teachers can play a critical role against wholesale promises of improvements in education due to the introduction of computers and the Internet. Some of them may become active in resisting change, and because ICT programs are bound to have failures sooner or later at many levels (i.e., poor hardware maintenance, incompetent teacher trainers, etc.), and more so at larger scales, these failures will provide good ammunition for these teachers.

Some of these teachers' arguments against using ICT in education are that these technologies represent a threat to their professional status because they will diminish their role (i.e. stories about software that might substitute for them), will degrade their relationship with students and will take over initiative and control within the classroom to the detriment of teachers. Other teachers are simply not willing to make changes in their teaching praxis because they perceive it adequate as it is; still others are simply afraid of using computers and similar technologies such as TV recorders, cameras and screen projectors ("technophobes"). There is also the case of many schools with large classes (e.g. more than 40 children per room) without enough computers, poor Internet bandwidth, unreliable networks, inadequate software and other problems directly related with the technology that constitute a barrier for the teachers.

However, a teacher might carry a resistant attitude mainly because of a low level of confidence in his or her abilities. Enlaces encouraged its trainers to design exercises and tasks that provide early success (no matter how small) to increase confidence. Success stories from other teachers might not be helpful to one with a low confidence level. Rather, simple administrative applications and off-classroom uses might be a good way to start with them. For example, keeping student's marks in a spreadsheet or sending e-mail to friends and relatives are easy-to-learn exercises that provide immediate reward that may strengthen self-confidence.

Mainstream teachers are late adopters of technology and are arguably the largest group and therefore the most important in the long run. Normally, if innovators provide them with good working examples and they see a clear path for their own familiarization with the technology, as well as some incentives for their professional development, they will be more willing to give it a try.

Mainstream teachers with some confidence and with some level of skills can greatly benefit from a set of exemplary practices (in CD Rom or TV format), supplemented by lecture guides with an explicit and carefully designed instructions for ICT use in the classroom on each subject field. Our experience indicates that lecture guides can more effectively appeal to teachers by closely resembling their reality and experience: culturally similar students, similar schools and resources, and same or closely related subject matters.

The most challenging aspect for teachers in Enlaces (and apparently in many other countries, both developed and developing) has been the integration of technology within the curricula. In the Chilean case, because it provides a broad definition of their jobs, the national curriculum that teachers often consider to be their "navigational map" and all what is included in it, receives an explicit, pervasive life-long adherence. It has therefore been useful to integrate pedagogical uses of ICT into the formal, long-term curriculum. This has served as a powerful message to teachers, meaning that ICT are not only there to stay, but that it is their responsibility to use them effectively.

Besides the intrinsic complexity of hardware and software, teachers' pedagogical beliefs and their perceived confidence in using ICT in the classroom are critical aspects that must be considered in a staff development policy [21, 35], particularly for mainstream and resistant teachers.

"Skill instruction should always be embedded within meaningful educational projects or relevant tasks" [21].

> "The focus of teacher training should be on helping teachers use technology to teach more effectively, not on computer operation" [6]

Typically, Chilean schools include all three types of teachers, with a range of skill levels and self-confidence. Training should recognize and take into account this diversity to fine-tune the training program to each particular situation.

Finally, a variety of incentives is offered by Enlaces to all teachers, including certified recognition linked to career development and salary increases. The possibility of acquiring devices such an affordable (partly subsidized) kit comprising a home computer, printer, software and Internet access has been also tried, and it has helped the ICT policy by improving teacher acceptance and leading to a faster build-up of their basic user skills.

c. The ICT Coordinator

The ICT Coordinator is a teacher with special ICT training who has a central role in the school's long-term use of the technology. After Enlaces has finished training teachers at a school, these professionals will be essential in promoting the school's autonomy with regard to ICT decisions, priorities and investments. They also maintain a permanent link with other Enlaces initiatives in order for schools to participate. Some of the functions of the ICT Coordinator include the following:

- Technology: To practice basic preventive maintenance of equipment (cleaning, inventory checks); hardware, network and software configuration. School interface with local or national hardware and software providers. Selecting and purchasing hardware and operating system upgrades. Administrative and educational software; maintaining virus protection and Internet content filters, according to teachers' needs.

- Pedagogy: To coordinate computer lab and software uses according to teachers' needs. Assisting teacher-training processes, facilitating and preparing resources and supplies and also performing training. Helping to identify new uses of ICT inside the school and assisting teachers in implementing them.

- Administrative. To deal with school priorities and investments and negotiating the ICT budget with the school administrators.

In the Enlaces experience, coordinators readily took care of the hardware and basic support to teachers for general purpose uses: word processors, spreadsheets and presentation software. However, support for ICT use on subject-specific content teaching is more complex, and it requires a deeper involvement from the subject teacher. Coordinators can help in looking up web sites or searching for subject-related software in the market. However, pedagogical decisions about how and when to use a particular software or web site for learning purposes are more suitably in the hands of the subject teachers and the curriculum experts in each school.

One major problem in Chile has been the negotiation with school managers to pay for the ICT Coordinators' time. Schools with low budgets and a computer room often first try a teacher volunteer system, which in our experience almost always fades away with time because of the high demands on teachers' time. Usually, only after a number of negotiations and with evidence of equipment failure and low usability rates, will school administrators start spending on an ICT Coordinator. To reinforce the importance of having an ICT Coordinator in each school, Enlaces has linked future investments such as lab upgrades (paid by the state) to the provision of paid coordination time (paid by the school). This is a plan that has proven successful in large schools, but needs constant monitoring in small and medium-sized schools.

d. Teacher Trainers

At the beginning of Enlaces, there were no ICT trainers on hand ready to start training teachers according to established plans. The first generation of trainers, during the pilot phase, was selected at the pre-service levels in the universities as well as from those schools with some previous exposure to ICT.

After one year of program development, a second generation of trainers was selected from the teachers that already had direct classroom experience with ICT, normally innovators but later also mainstream teachers. Enlaces

experience indicates that peers are more effective trainers than university teachers or technicians from outside the school system. A teacher with a similar training experience as the trainees can be very convincing by using more realistic examples and by being more in tune with classroom culture.

Besides their role in training and guiding teachers towards pedagogical uses of ICT, trainers are permanently in close contact with both teachers and program managers; therefore they also perform a few very important complementary roles:

- Trainers become the ambassadors of the program at the school, conveying information from program headquarters to each teacher in the school. In this respect, trainers should be well-prepared to address a variety of questions in the school, from the technical to the pedagogical.

- Trainers provide feedback information to program management in many fashions. They can gather useful data about the schools' training progress and difficulties. This can help to refine staff development activities in each geographical zone.

- Trainers can help organize an annual fair for all schools from a community or province. These fairs are organized in Enlaces with teachers and students that have been involved with ICT. They have a number of goals. These include showing to parents, educational authorities and the community how the schools have progressed with ICT and demonstrating to other teachers what can be achieved with ICT in classrooms.

Enlaces' program managers implement a permanent coordination and information strategy for trainers. Some of the activities produced for trainers are the following:

- Maintaining a special teacher-trainer's web site with an up-to-date record from each, with news from the program, training documents, chat rooms and help desk. This site is the basis for gradually building up a community of trainers organized around subject matter and/or workplace (i.e. rural, vocational, religious school, etc.).

- Sending regular, personalized messages to trainers, with news about the program in general and about the program in the specific geographical school-zone of their responsibility.

- Providing trainers with copies of educational software and manuals to be distributed to the schools in their geographical school-zone.

- Organizing at least twice a year face-to-face meetings of teacher-trainers, including educational authorities, so trainers can share their achievements, discuss their problems, anticipate future challenges, and request and coordinate their support.

It is often the case that teachers use ICT in classrooms in inadequate forms, basically "doing the same thing, but this time with technology." The opportunities to adapt more engaging and meaningful learning approaches are precisely what teachers should develop in classrooms [4, 7, 36]. Therefore, a necessary (but still rather idealistic) requirement for teacher-trainers is that they know well the potential of ICT for fostering new learning environments and use appropriate state-of- the-art methodologies and software, such as project-based learning, learning by doing, and simulation software.

Chilean teachers are accustomed to face-to-face training and prefer this method especially during the initial warm-up sessions when more anxiety is present. However, the training program moves gradually towards more intense uses of distance-learning tools making use of the technology. Starting with e-mail communications among peers and trainers for discussions and problem solving, the group is encouraged to move into a total distance-learning environment using Internet for sustained training. Through Internet, teachers are stimulated to participate in communities of learners from other schools (and even other countries) that share similar realities. Unfortunately, few teachers -- mostly innovators -- will pursue these initiatives after the training period, a situation which is under debate because of the constant energy required to get mainstream teachers to participate.

Many institutions (mostly universities but increasingly businesses as well) are offering web-based courses to train people for a variety of jobs. The web also contains courses intended for primary and secondary students, gradually increasing in number though still mostly in English. This trend is gaining momentum and in the near future, there will be probably a whole curriculum that students will be able to follow at their own pace and convenience, with mature content in many languages.

Schank [4, 37] argues extensively about the benefits of e-learning and the opportunity to greatly improve students' learning by designing realistic simulations that can offer engaging learning-by-doing environments, for two reasons:

- They can provide a cost-effective and efficient means to train teachers on ICT in a nationwide program.
- They may positively enhance present classroom situations in which students are not motivated towards learning.

e. The School as a Work and Training Place

Each school has unique features: The way it is organized, the decision-making process and its own educational priorities. Similarly, each teacher has a particular teaching style, her way of dealing with students and relating to other teachers, her way of using the available resources and of planning each class. Therefore, each school offers a different kind and degree of acceptance of innovations such as the use of ICT in the curriculum.

The school is a good place for teachers to learn how to integrate ICT in their praxis and to explore new ways of teaching; it is their workplace and an environment they share with students. Therefore, their own classroom might be the best place for training sessions, simulating a real setting with other teachers playing student roles or practicing with actual students.

A distinct aspect of the initial Enlaces' ICT integration strategy acknowledges that no school was included in the program by default; it was a result of an active application process. This application included an explicit statement from the teachers, the principal, the administrators and the school owners (school districts, or private, subsidized owners) about why they wanted ICT tools to be put in their school, what they planned to do with them during the first year, and an explicit commitment to attend the training and to carry on with their projects, as planned.

As a result of the rapid expansion of Enlaces in every region, the application process had to be replaced by a less time-consuming decision process performed by each of the regional MoE branches in charge of selecting the schools that would enter the Enlaces program in their respective region. Nevertheless, each school still signs a contract that establishes its commitment to maintain and use the technology and train the teachers.

This active application process was of crucial importance for preventing many potential shortcomings during the first few years of a school's participation in the program. First, it helped make explicit to all parties involved exactly what receiving ICT really entailed. Second, by having to state why they wanted to have ICT, teachers usually ended up writing a project that helped give meaning to an otherwise cold insertion of alien equipment in the school. Also, the very fact that the ICT program was granted as a result of an application may have boosted teachers' motivation and provided them with a sense of ownership. Thus, they were more committed to the program and placed it higher in their priorities.

Of similar importance was the explicit commitment established between the MoE and school administrators. The latter had to provide the budgetary means for maintaining the hardware, upgrading and buying new software, keeping a stock of printing supplies, paying for the Internet connection and teacher training time. This commitment is often not fully appreciated by these administrators, and it can be easily overlooked in the face of the excitement caused by the prospect of bringing in such interesting technological novelties; hence, the importance of making it explicit in writing and securing the commitment from the start.

A fundamental requirement for a successful staff development strategy is that teachers have time for hands-on practice with ICT during normal working hours. *"Time for Practice"* has been considered by Enlaces' teachers as one of the top problems for their effective familiarization with technology.

The introduction of ICT imposes some changes in the managing practices of schools. Different activities must be scheduled; additional bills must be paid, etc. It is therefore important that the management (leadership) of the school becomes involved in the training program, ideally, on equal terms as everyone else. This has positive impact in the near future and in the long-term future. First, by gaining familiarity with the use of ICT tools, managers will be more able to understand the needs and concerns of teachers. Second, it will allow the leadership to represent in more precise and realistic terms the school's achievements and its needs to other critical agents from the community, be they parents, educational authorities, or fellow educators. Finally, it will help them to better decide on matters of planning, budgeting and investing for the future development of the school.

During the early stages of ICT integration into learning practices, the roles played by school principals and administrators, in terms of developing a positive climate that motivates teachers towards using ICT has been of great importance for Enlaces.

f. Educational Exhibitions

Each year, many counties[10] in Chile organize a one-day educational exhibition with some of their schools that participate in the Enlaces Program. During the exhibition, students and their teachers proudly show their work and progress with ICT to their community. It is a colorful event and an opportunity for teachers to look at the work and experiences of their peers, make contacts and get feedback. For this reason, these exhibitions are actively promoted by Enlaces. Teacher trainers take the opportunity to use the information exhibited at the exhibitions to reflect with teachers about the role and potential of ICT in education.

Figure 2. Rural participants demonstrate their work in a regional exhibition

[10] Chile is geographically divided into thirteen regions, each one has at least one province and each province has several counties.

The best experiences in each county are selected by the regional educational authorities for a regional exhibition that constitutes an important incentive for teachers and students. Students respond positively because of the visibility of their work and the feedback received from regional and national authorities. For Enlaces' managers, it is an opportunity to understand the experiences that teachers consider most relevant and successful in order to promote replication in other schools.

In the year 2003, a total of 66 of these exhibitions with nearly 1,000 participating schools were organized. The organization is conducted by the school authorities together with the regional branches of the Ministry of Education and with the network of associated universities.

g. Addressing Students

There has been no explicit strategy in Enlaces to address students in a direct way. This situation is presently being revised for a number of reasons. First, many students show a very positive attitude towards ICT, and their enthusiasm may be geared towards activities related to their personal motivations (e.g. sports, games, science, and hobbies). The aim is to achieve a more intense and more relevant use of available ICT resources in schools and to make these institutions more attractive to youngsters. There has also been a gradual build-up of pressure by the students who already have computers in their homes to use ICT in schools in more diverse and useful ways.

Second, students with good ICT skills can assist their teachers and school administrators in many ways to make better use of the available technology. In this way they also enhance their ICT skills by assisting other students who need help with the technology, by keeping the ICT lab in good order and by helping the ICT coordinator with software and hardware maintenance.

One initiative implemented in the year 2004, is that some secondary students (and also teachers) are being offered special training workshops in order to achieve an "ICT Driving License" certification, following the European model and standards[11]. It is expected that following this training students, particularly in vocational schools, will improve their employment chances. A first pilot stage whose aim is to certify 2,000 secondary students is already in place.

3. A discussion of the Enlaces Approach and Future Steps

This section offers a reflection of the Enlaces staff development policy and elaborates on some alternatives for future directions. The main challenge for Enlaces now is to achieve a more thorough integration of ICT into classroom activities on a large scale. This challenge may involve changing more than teachers' abilities and skills to use ICT. It may also require changes in teachers' pedagogical culture and, at some level, changes in their beliefs about ICT. This seems to be a worldwide challenge, and even developed countries have not found a proper solution to this issue [38]. Therefore, some of the ideas and opinions expressed are debatable, not substantiated through formal research and may not correlate with other realities. But the hope is that these ideas will provide "food for thought" and will stress the point that achieving learning impacts on a large scale with ICT is a very complex and still unresolved issue.

It is important to realize that as of 2004, a majority of Chilean classroom teachers have PCs and Internet at home, and more than 80% have successfully completed two-year training in ICT with Enlaces. These teachers have achieved familiarity with the basic uses of technology -- in particular with Internet, word processing, spreadsheet and presentation software. They have also had a chance to learn and use some special purpose software in their teaching. A basic understanding of some ethical and legal aspects of ICT (e.g. intellectual property rights, pornography, spam and viruses) was also discussed during training sessions. In summary, the present level of Enlaces teachers' familiarity with ICT provides a good basis for a next step in single-subject teaching.

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[11] See the European Computer Driving Licence Foundation Ltd. (ECDL-F) website in: http://www.ecdl.com/main/index.php

One major and debatable approach to ICT is its presentation to teachers during training sessions, and in most political discourses, as a *tool of change*. This, presupposes a) that changing teaching practice is always necessary and b) changes ought to be radical and fast because the information society now requires citizens to be proficient with ICT. As a consequence, teachers perceive a strong professional pressure to radically change their classroom practices when using ICT. However, as many researchers have pointed out, change in the teaching profession is complex and lengthy [3, 6, 18-21, 33, 38-40].

In the early stages of Enlaces, teachers' attitudes toward computers and to the proposed activities using them were carefully observed. Because ICT were presented as a "change agent," it was expected that some teachers would try to modify their practices and that some would become anxious or even resistant when asked to innovate in their daily routines.

To promote change, to address anxiety and resistance, and also because of technical and economic reasons (see chapter on technology), Enlaces allocated computers in a special ICT lab and did not introduce computers into the classroom (except in rural schools for space reasons). Most schools also received computers for teachers in the teachers' room. These decisions had a major impact on the way teachers have used the technology for learning purposes. However, after many years of experience with ICT, some schools are gradually steering towards a mixed model of technology deployment and are demanding differentiated training strategies for teachers to more effectively address their single-subject area demands.

From an international perspective, teachers are mostly adapting ICT to their teaching practices, and according to Cuban [38], less than 5% of teachers *actually change their classroom practices* because of computers. This is a major finding coming from U.S. schools with far more resources and incentives, a longer period of time using them, and possibly more pressure toward teachers to modify their practices than in Chile and possibly also in other developing countries.

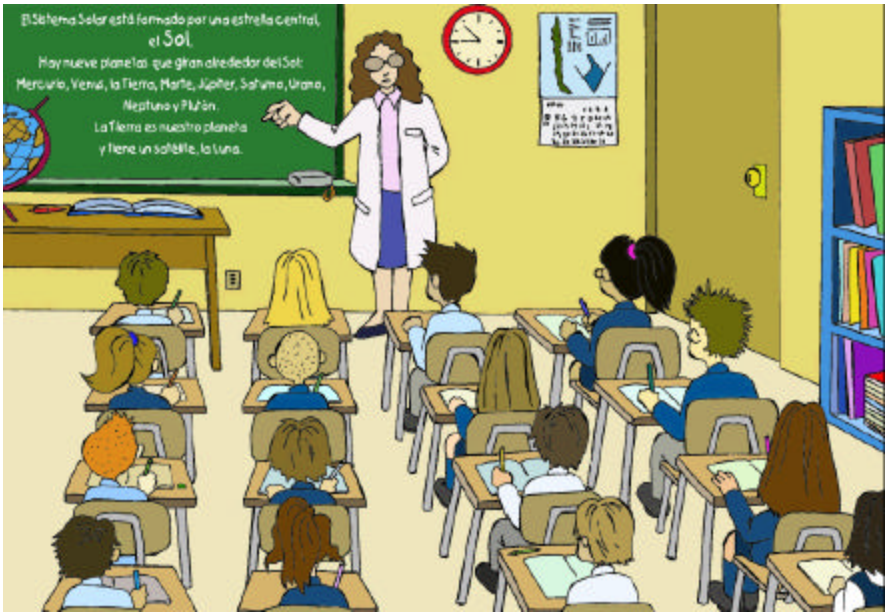
> *As Pasteur noted long ago, "In the fields of observation, chance favours only the prepared mind." So do ICT favor the prepared organization. No miracles derive from the mere presence of ICT in a school; they do not, except in unusual circumstances, act as catalysts for widespread improvements. Instead, ICT can be powerful levers for change when new directions are carefully planned, staff and support systems prepared, and resources for implementation and maintenance provided. Unlike other levers available to schools, however, ICT have the power to facilitate vast changes in instruction, in home, community, and school relations, and in school management. They should not be viewed as simple tools, to be considered only after changes are planned, but as more powerful allies that can help schools aspire to and reach the highest goals of education. Furthermore, once reform with ICT is implemented, a climate for innovation may remain wherein ICT can act as catalysts for further changes.* [41].

Given the present "ground floor" familiarity with ICT by most Chilean teachers, Enlaces is designing ways for moving from a standard and generalist approach in technology deployment and staff development to one more diverse. This approach would promote the use of ICT in several curricular subject areas in the classroom and in the computer lab. This is addressed by considering single-subject teachers' needs and cultures, the international experience with ICT in several subject areas, and also the national priorities. These are basically the competence requirements in reading, writing, arithmetic, science and vocational subject areas. The implementation of this strategy considers the available capacity at each school represented by the teachers and the ICT Coordinator who might take further training into his or her hands. These coordinators would be preferably supported by the subject-knowledge experts at universities that have, for example, language and science departments. In what follows, a few of the alternatives presently under discussion in Enlaces are offered.

Training for the classroom as well as for the computer lab

To illustrate the present debate aiming to achieve a more substantial use of ICT for learning purposes, a discussion of classroom uses and lab uses of ICT is offered next. This issue is also addressed from a technical point of view in the chapter on technology. Instead of photographs, we have decided to use drawings in this section to better illustrate our ideas around this topic.

Figure 3. A typical Chilean classroom with traditional resources



This is the preferred and most common teaching scenario in Chile (and Latin America) and the one for which teachers have been prepared. The teacher has full control over the resources, learning sequence, activities, discipline and task distribution. The teacher addresses the whole class, but combines this with work with individual students. Blackboard, textbooks, pencil and paper are the main resources, sometimes also overhead projectors.

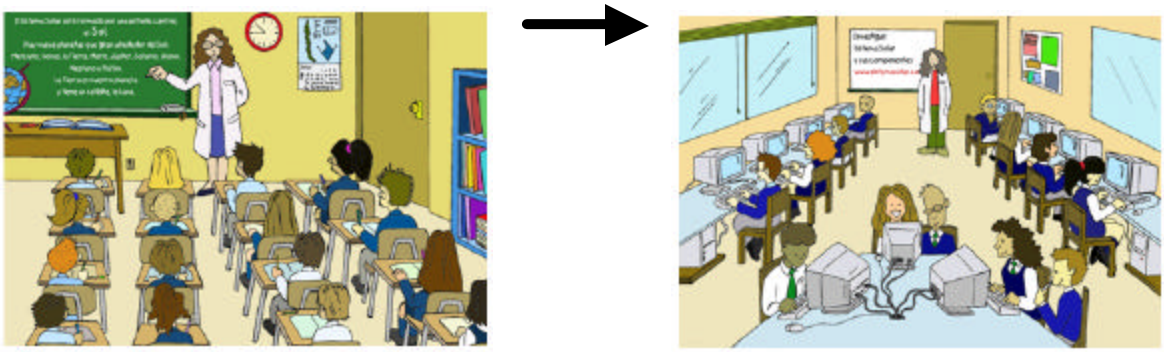
Figure 4. The computer lab

The computer lab is an intimidating scenario for some teachers. In many instances, it is more difficult for them to exercise control over the resources, the discipline, the learning sequence and the student activities. They see the software -- and sometimes the ICT Coordinator -- as mostly in control. The teacher has a different and new role: a guide, which requires new skills and often more planning -- and even contingency plans in case of hardware failure. The teacher normally has to stick to the lab an entire whole hour because of time and space coordination. However, he or she might prefer to use the technology for only a fraction of the time and only to illustrate some points or

provide some examples from the Internet and then return to the normal classroom setting. However, our evidence shows that students tend to enjoy this scenario, and if the software has been properly selected, the learning experience can be positive. With computers, most students are easier to engage and motivate.

In summary, this is a scenario that means a profound professional, pedagogical and organizational jump.

Figure 5. A professional, pedagogical and organizational jump for teachers



However, computer labs have an important role for whole classroom uses of technology and as spaces for autonomous learning with ICT by students alone or in groups, for remedial activities and as expansions of the school library. Therefore, Enlaces is actively investing in reinforcing the computer lab and its uses, but it is also promoting the use of some of the technology inside the classrooms.

This new approach might have an important impact on the teachers' attitudes towards technology as will be illustrated next. It also has a number of advantages in terms of teacher training because it gradually allows for immediate application during the first training sessions and hence for rapid feedback and experience-sharing among trainees and trainers.

> An international case study of innovative pedagogical practices using ICT (SITES M2) found that "in the large majority of cases, it was not innovative technologies that were used. The dominant technologies used in these classes were commonly available ones, such as productivity tools, e-mail, and the web" [42]).

The mixed evolutionary scenario

A proper dose of ICT inside the classroom might prove to be a safe and a gradual way for teachers to enrich their classes because it is not as radical as moving to the computer lab and because it offers a step-by-step move. With it, teachers can more readily move from their present practice to a more diverse use of learning resources, taking advantage from the available digital technology, but only when needed and not imposed "because its there." Eventually, if teachers perceive an explicit gain, this gradual approach might help them move toward a more active student-centered pedagogy using ICT.

A fundamental difference between classroom and computer lab deployment of technology is that in the classroom teachers may stick with whole-class learning activities -- the approach preferred in Chile -- as much as needed or desired. Technology may become seamless in the classroom, as can be seen from the reported experience with interactive whiteboards [43, 44]. Training is easy but software resources and activities for the whole class should be carefully selected and present during training.

In this scenario, the only technology available inside the classroom to begin with would be a computer, a screen projector or an interactive whiteboard and a printer. An Internet connection is also desirable. Presentation software and an Internet browser can comprise the starter software kit, both easy to learn for basic activities and without complex user or student interaction demands. Both hardware and software elements might be gradually expanded with more computers for small group work and with more specialized software for single-subject learning. In this

basic scenario, it is the teacher and the students' learning needs, i.e. the subject area requirements, that decide when and how to use the technology and the time it is needed for.

A few examples using an interactive whiteboard (or simply a screen projector) might exemplify the steps to be taken by trainers and teachers during both training sessions and classroom use. A fundamental condition for success seems to be that teachers find these changes to be meaningful [18]:

1) As a first introductory step for more resistant teachers, the only role of the technology is to be present in the classroom, without interfering with the normal lesson plans. The interactive whiteboard can be used as any normal blackboard, and hence the teacher might keep things completely unchanged. If it becomes uncomfortable, the whiteboard can be left as a second board besides the regular one, to be used only occasionally.

   Training at this step requires only some effort by the teacher to learn how to set up the interactive whiteboard and to get used to writing and erasing on it. These basic procedures can be learned in less than an hour.

Figure 6. ICT inside the classroom

2) As a second step, teachers may use gradually more advanced functions of the interactive whiteboard such as storing digitally different boards, showing pictures and movies and activating software. It can also be used as a large screen for web browsing. Some of these functions can also be performed using a regular screen projector, which is the preferred choice when teachers already have experience with overhead projectors. Screen projectors are also less expensive than interactive whiteboards.

   Training may proceed to aim for increased efficiency through the use of a variety of more engaging and more adequate learning resources without significantly disrupting the whole-class methods and always trying to convey meaning to the teachers. It can afterward move to propose and discuss new teaching and learning styles. Technology is introduced gradually, learning more functionalities of the interactive whiteboard and working with teachers' plans, with digital single-subject content and eventually with single-subject and sub-subject software. Teachers may learn to use the technology in steps:

   - As a multimedia, content provider -- a database of resources. This requires little training (a few hours) but demands some ready-made content for each single-subject teacher. Presentation software and/or a web browser are enough to start with. Students may also use the technology for their presentations (see figure 4).

- As a new learning tool, using whole-class web-based content and subject specific software (e.g. in mathematics, music composition, science, and geography), a new trend that is rapidly expanding in UK and other countries [43]. Training requires time to initially familiarize the teacher with the software but the investment can have a high pay-off. At this step, trainers should help teachers find materials in the Internet and join discussion forums.

- As a communication tool for the discussion and implementation of collaborative learning projects (e.g. connected via e-mail with computer-pals for language, science or history projects).

Research shows increased student interaction and improved motivation with interactive whiteboards [43], but for the Chilean reality they are still expensive compared with screen projectors, and there is still not enough evidence of their impact on learning in developing countries' realities.

In addition, besides computers, a variety of devices -- information appliances -- might be used when needed. In particular, wireless classrooms allow for a flexible, more pedagogical distribution of people for group or individual work inside the classroom. Intelligent keyboards are simple and effective for text-based tasks (see chapter on technology).

Figure 7. A wireless classroom with a mixed set of technology

In summary, there are many choices for teachers today, each one of them with different training requirements. ICT inside the classroom for whole-class activities might become a more acceptable evolutionary pathway with lower training requirements than laboratory use for integrating ICT in single-subject learning. On the other hand, it is important for the ICT policy to realize that schools, after completing a familiarization period, will start demanding training more in tune with their staffs´ demands and culture and congruent with their single-subject area requirements. This may mean a gradual transition from a supply driven to a demand driven staff development policy.

IV. TECHNOLOGY

The Enlaces experience with technology responds to a particular reality. Therefore, much of the discussion and analysis is not applicable everywhere. However, the authors made a special effort to look at similar realities in other developing countries in the hope of offering useful guidelines for policy-makers in other contexts. This chapter contains a general discussion of the issues involved in deciding how much technology (hardware and networks) to purchase, where to install it inside a school for the use of students, teachers and administrators, and how to keep it in good working condition.

1. Technology Acquisition

Undoubtedly, the most visible and media attractive side of an ICT Program is children using computers in a classroom. However there is much more to an ICT Program than deploying computers in the school system (and also, more to ICT than computers).

The strong communicative power of this image, as compared to the lower visibility of training sessions with teachers, has often been one of the causes that technology is regarded as an end in itself, and for political decision-makers to spend disproportionately more money on hardware than on teacher training. Hardware is certainly a fundamental necessity in an ICT program, but its effectiveness, and hence its return on investment, is probably proportional to the quality and effectiveness of the teacher-training program.

> The decision of how much technology to purchase for each school and where to put it follows no fixed or standard set of rules applicable in every case.
>
> It is often the case that budgetary restrictions impose a single solution for every school, i.e. a fixed number of computers (typically 6 to 20) and a few printers clustered in a special room. This solution is often far from optimal, and several other factors should be taken into account (see also [45, 46]). A budget driven by considerations that look only one year ahead might prove to be unwise after teachers become more confident with technology, possibly after one or two years of training.

Buying technology for schools can be a centralized or a decentralized process or a mixture of both.

a) Centralized acquisitions. One benefit of making all technology acquisitions at a higher-than-school level is that the larger the number of devices, and therefore the amount of money involved, the more possible it is to obtain lower prices, better support services and often, less expensive software licenses. However, although this approach is often preferred because of the cost reduction, a one-size-fits-all solution will rarely be optimal for any one school. Enlaces is presently working on three alternatives:

- New state-of-the-art hardware acquisitions through an international competitive bidding process for schools that enter the Enlaces Program. This has been the normal procedure for Enlaces in the past 13 years. In the early years of Enlaces, costs per computer were typically 30% less than street price, and the Ministry was able to negotiate warranty and software licenses with important cost reductions. However, today, the cost reductions due to centralized acquisition should be carefully analyzed due to the highly competitive hardware market with reduced profit margins.

> Enlaces has bought nearly 55,000 computers with this process. In fact, Enlaces purchases every year a number of "ICT rooms," a package of goods and services provided to each school by dealers. The room includes computers, printers, warranty, after-sale service and a software bundle. Furniture, electric and data networks are also part of the package.
>
> To control and coordinate each step of this process, Enlaces contracts with independent technicians all over the country each year. These technicians confirm that the school has a suitable room available, check that all the equipment was installed successfully, and report all problems.

- Reconditioning of second-hand computers following the Canadian[12] and Colombian[13] models that have been highly successful. This is new to Enlaces, and it has just started through an independent foundation,[14] which is in charge of collecting, reconditioning and distributing second-hand computers donated by private and public institutions. A major drawback in the Chilean case is that institutions have few incentives for donations (i.e. tax deductions), as is the case in Canada and Colombia.

- Large-scale acquisition of a basic configuration of computers to rapidly improve the student/computer ratio. This alternative is very attractive if funds and political will are available because of the low prices that are possible to negotiate. The rationale behind the basic configuration is that schools do not need a state-of-the-art PC for all tasks, and a computer with a small hard disk (if any), a two-year old processor and a good network connection is perfectly suitable for many educational and administrative tasks. Linux-based configurations are becoming increasingly popular, and if quality and technical support issues are carefully considered, this alternative might help an ICT program to leap forward within a year's time.

Enlaces is presently working on a large acquisition (on the order of 40,000 computers) of a basic machine to rapidly bring the student/computer ratio down to 30:1 and to replace equipment that is older than 6 years. It is estimated that these computers can be acquired, loaded with an operating system and an educational software bundle, distributed, configured and connected to a network in each school, for less than US$350 per machine.

b) Decentralized acquisitions. In the long run, school administrators together with teachers and parents should be responsible for the decisions about what and how much technology to purchase for their school and proceed according to their specific needs. This will require them (i) to know precisely what technology is needed for their educational projects; (ii) to be well informed about the options and benefits of each piece of hardware and software available on the market; and (iii) to be capable of freely and directly negotiating with vendors to make the most out of their budget. For example, the Irish ICT in education initiative provides advice and support through its institutional portal (see: http://www.ncte.ie/ICTAdviceSupport/).

c) An intermediate approach between the full flexibility obtained when each school is buying on its own and the possible lower costs derived from the whole system's large scale buying strategy, is that of defining a set of characteristics that would fit 3-5 different school categories (i.e. school size, students per classroom, etc.) and purchasing a separate pre-defined configuration of hardware, software and services for each category.

In addition to the Enlaces hardware acquisitions, schools have received private donations of computers, either from parents or from private business. Also, many school owners have decided to invest in hardware, complementing what Enlaces has provided. This can become an important way of improving and sustaining the technology park of a school in the long run. A suitable donation law – not yet available in Chile – has proven highly important in other countries like Colombia.

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[12] The Canadian initiative is called "*Computers for* Schools (CFS)". Quote from CFS web site: "*…Since its inception, CFS has provided more than 300 000 computers to schools and libraries in all provinces and territories. CFS now delivers in excess of 60 000 additional computers each year. In addition to coordinating computer donors and recipients, CFS oversees more than 55 repair and refurbishing centres throughout Canada…*" See: http://cfs-ope.ic.gc.ca/Default.asp?lang=en

[13] The Colombian initiative is called "Computadores para Educar" (Computers for Educating). See: http://www.computadoresparaeducar.gov.co/index.html

[14] The Chilean Foundation is called "TodoChileEnter" and is presently expanding in order to recondition close to 5,000 computers / year.

Several other factors besides the number of devices should be considered when planning for technology implementation in schools. Among these, the most important ones are:

- Maintenance
- Recurrent costs
- Electrical power system
- Furniture
- Local area network.
- Security and access (i.e. for parents and other community members)
- Environmental conditions

> For the years 2001-2005, Enlaces designates approximately 55% of its budget for hardware and software purchase. This includes equipment for new schools as well replacing or upgrading equipment in schools that have been with the program for many years or that have insufficient hardware according to their current student population.

Policy-makers should be aware of the rapid obsolescence of hardware and of the pressure fromhardware vendors to replace equipment. Technology becomes obsolete only if it cannot be used properly for a given task. For example, for most word processing and spreadsheet applications, computers with technologies from the late 1990s are perfectly suited. In Enlaces' experience, it is necessary to plan for some upgrades and replacements after 3-5 years (depending on environmental conditions) in rural settings and 5-7 years in urban schools.

> Computers, PDAs, portable keyboards and many other devices may last for more than a decade assisting with many useful tasks in a school, such as word processing and basic information storing and retrieving services. For example, many of these uses will require a computer with less than a 1GHz processor and with basic graphic capabilities (even as backup servers).

It is also important to be aware that centrally performed hardware and software procurement procedures can take many months. This length of time is due to the many steps involved in a well-run procurement process: (a) The careful definition of the protocols (a rigorous design of the procurement forms and of the technical specifications may save time and avoid problems with vendors for whom the procurement, because of its relative large size, can be of strategic importance for their business); (b) The time allowed for the hardware and software vendors to analyze the procurement documents and to prepare their offers; (c) The time to revise and analyze each offer by the ICT policy implementation team (which probably should hire independent consultants for assistance and for reasons of transparency), and finally; (d) The time to deliver and deploy the goods in the schools.

> In Enlaces, procurement steps last for a whole year and hence, the initially specified hardware could possibly be outdated once installed in the schools. Also, procurement has a direct effect on all other plans and yearly goals. Therefore, the ICT policy implementation team is advised to learn about hardware and software procurements from other ICT projects.

2. Hardware for Students

There are basically three ICT deployment approaches that have been tried out in schools around the world, and all have advantages and some problems. One approach is the concentration of technology in specially networked rooms, known as "Technology Labs." Another is a decentralized system in which a number of devices are put inside each or most classrooms, the library and science labs. A third approach is a mixture of the previous two.

<u>The centralized Technology Lab</u> is the easier and less expensive plan to implement, but also less effective in terms of teacher involvement. It is less expensive because it is possible to define a limited number of standard room configurations, including computers, peripherals, local area networks, Internet connections, cabling, heating, safety, power, and furniture that can be replicated in many similar schools and therefore acquired with economies of scale. From a school perspective, concentrating all ICT resources in one special place for all possible uses (learning,

teacher training and community involvement) makes its administration and maintenance easier than if these resources were installed throughout the school. It is also a safer solution if security is of great concern.

If resources are available for an ICT Coordinator, that staff member can assist the teacher with the technical aspects during class hours. Hardware, networks and software are prone to failure and these breakdowns are intimidating to a teacher asked to work in a technology lab. However, if help is on hand, the teacher can concentrate on the pedagogical aspects and leave the rest to the ICT Coordinator.

Figure 8. Children on their own in a Technology Lab

However, there are a number of drawbacks to this approach (see chapter on Staff Development). The most important is that a technology lab, which is separated from the "normal" classroom, will be more intimidating to those teachers who are less comfortable working with technology or who feel uneasy with the expected increase of social interaction. These factors are magnified if no technical help is available in the room. A technology lab may be perceived as a major challenge by these teachers. The available machinery, in large numbers and with a prominent presence, may seem beyond his or her control. A technology lab does require some modification of an individual's teaching strategy, as well as a good knowledge of the software to be used. It also puts students more on their own, with generally more social interaction. A technology lab also makes it clear to a teacher that its software is their teaching partner.

Technology labs are also sometimes in great demand for use by many classes and this can make it difficult and frustrating for teachers to plan activities that require only short sessions with computers.

> In Enlaces, another factor is that some school administrators restrict use of the technology lab for safety reasons, imposing restrictive rules, such as maintaining the room locked and assigning teachers with responsibility for any equipment failure or damage. This attitude has severely reduced use of the technology in some schools.

A teacher should be able to work with a whole classroom at once without the burden of separating the class in two groups, leaving one group unattended, either in the classroom, or in the technology lab. Therefore, the technology labs should be designed to allow for a ratio of two students per computer. A ratio of 3 or 4 student per computer with rotational use will also work well if the teacher includes sufficient group work in the day's plan. A higher ratio, i.e. 5 or more students per computer, will decrease the chances of each student being able to work with the computer and will not fit well with most teaching strategies. A 1:1 ratio might look ideal and could be the goal if money is available. However, it is more expensive and will not stimulate changes in teacher strategies that promote more group learning, peer tutoring and scaffolding as part of the learning process.

The technology lab plan might mix computers, portable keyboards and other devices (i.e. data loggers for science, digital microscopes, robotics devices and sensors, etc.) for student use, because for many tasks, students may need no more than a device with basic text processing capabilities or with some data storing functionality (i.e. for science

projects). The use of intelligent keyboards, together with computers, may alleviate a high demand for computers in a very cost-effective fashion.
When resources for digital equipment are too sparse to allow enough computers for a whole classroom -- in Chile some schools have more than 45 students per classroom -- it is still possible to work by separating the classroom in groups and putting parents or advanced students in charge of one of the groups. This does require more teacher time for planning, and it is often not possible to arrange for other people's involvement. This system may work well mainly for innovators willing to pay the costs. It may not work over the long run for most teachers who may perceive it as a too radical and time-consuming shift from their present teaching practices.

Different configurations are possible for a technology lab. The least expensive is to deploy computers along the walls. This makes electrical and data connections easier and safer. The teacher is able to look easily at each student's work to provide assistance. However, all students sitting facing the wall concentrating on a computer screen likely diminishes classroom interaction and makes difficult mixed uses in which students need to observe the teacher, read books and work with the computer at different times in the same class session. An alternative approach is that of semicircular rows of tables where students and teachers can easily work together in groups. Today, the availability of inexpensive wireless technology allows much more flexible deployment of educational resources inside a room.

The Technology-in-the-classroom approach has a number of benefits, and it is one of the more favored solutions at present (see chapter on Staff Development). The availability of the technology in the normal learning space has some important benefits because by its always being available, teachers can decide when to use it in more flexible ways, and can plan for its use in small, or large chunks of time, according to the educational needs and opportunities.

On the downside, it is normally not possible to have either enough devices inside a classroom for all the desired student groups or enough room space to allow for extra furniture; this is a frequent problem in Chilean classrooms. If the teacher desires to work with the whole class at once, a division by groups is often possible, but, normally, with large classes -- 40 to 50 students -- working in a technology lab with more machines might be preferable. Some teachers may feel uncomfortable with the presence of computers inside their classrooms, but this uneasiness is normally overcome with time. There will also be the need to periodically check the quality of the electrical network in the rooms and if Internet is available its quality levels.

Fostering the teaching skills and attitudes to allow for a learning environment in which some students work with computers, keyboards or similar devices, perhaps in groups of two to four, others attend directly to the teacher and some others work on their own at their table, is a complex and time-consuming goal. This is not the typical frontal one-to-many classroom that many teachers are used to work with (at least in Chile); rather it requires flexible approaches and a more interactive environment, where students are more actively cooperating to create more effective learning situations.

Figure 9. A teacher combining traditional and modern technology in her classroom

Many educational specialists favor constructivist methods to facilitate learning in these environments. Constructivist (and constructionist) methods seem to be particularly well-suited for mixed uses of diverse ICT devices. If not immediately used by teachers, they will at least help them in reflecting on their teaching methods and eventually to help move them towards more engaging learning environments.

The Mixed approach. Whatever decisions are made for the distribution of ICT inside a school in the early stages, a mixed decentralized approach should be seriously considered for the long run. ICT can play many roles effectively in a school, and in time, all professionals (teachers, administrators and librarians) will need and demand ICT for their work. Even if its advent is not consciously planned, ICT will be infused into schools over time, and, therefore it is most reasonable to plan for it in advance.

If budget is a strong constraint, this mixed approach can be adopted with a gradual implementation, i.e., starting with one technology lab and some technology in a few classrooms, the science labs, and the library and then gradually continue expanding to all classrooms, according to the number of students in the school, the available budget, and the priority needs and demands.

The distribution of equipment in many rooms throughout a school can pose security problems, such as hardware and software theft, tampering with files or misuse of information. If theft is a major concern, this approach can become very expensive in the long run. Also, if environmental conditions are poor inside the school (humidity, temperature, dust), then it might be preferable to proceed with a more centralized approach so these conditions can be controlled more effectively. These can be major drawbacks for this type of solution. Maintaining equipment and software that is distributed all over the school might also increase costs and organizational effort, especially if teachers have little enthusiasm or skills to attend to and solve technical problems.

The decentralized deployment of hardware will require additional training for all professionals involved. Supporting technical staff might also be required for maintenance and trouble-shooting tasks. This staff can be (and normally is in the Chilean case) a teacher that is specially trained to undertake this function.

3. Internet and Local Area Networks

Two types of networks should be considered. One is the local network that connects different pieces of equipment inside the school and another one is the connection of the school to the outside world. Both networks will be addressed.

Local area networks

A networked configuration inside the school -- an intranet -- can significantly improve the impact of ICT and diminish many security problems. Information and software, as well as peripheral equipment (i.e. scanners and printers) can be shared, administered and in the case of software and content, also protected, through the internal school network. Many administrative processes involving paperwork, decisions, memos, meetings, and schedules can be enhanced through the use of an intranet using appropriate software and security measures.

In the Enlaces experience, high-quality maintenance is key because once the school staff has been trained and becomes accustomed to its use in daily work, an unreliable network will become rapidly frustrating, and staff members will refuse to waste time and may well go back to their previous practices if problems are not remedied quickly.

> According to Enlaces' experience, unreliable technology is the biggest innovation killer in any work environment, and it will require a great deal of effort to convince people to give the technology another opportunity if their initial experiences were unsatisfactory.

If the initial network is small (i.e., with fewer than 10 devices) and security is not a big issue, any computer can provide the network management services, such as shared access to the printers and Internet connection. This is the

easier and less expensive solution for small networks and will require minimal maintenance effort, few cables (or none if wireless is utilized) and low network software investments.

For larger configurations, the intranet may be implemented using a dedicated computer as a central server, providing a client/server configuration. This approach will make communication operations, both internal and external, more efficient, will improve security by protecting sensitive data and personal information with special measures, will facilitate information management and backups by archiving and protecting all relevant information in one machine and will concentrate network as well as software maintenance efforts in a single, separate, safely guarded machine. Also, a client/server configuration is easily scalable allowing for a stepwise expansion of the network. However, this solution will require a well-trained technician who is resident or at least rapidly available for troubleshooting.

> Some school districts in developed countries are expanding the client/server approach with a centralized administration that provides servers for large groups of schools, in an effort to improve efficiency and achieve significant management and cost reductions. There is a tendency to have low cost terminals (eventually Linux based) inside the schools with a strong high bandwidth network connected to a central server.

Wireless networks

Wireless network technology is rapidly improving in terms of speed and reliability and is also becoming less expensive and simpler to install and to manage [47, 48]. It is increasingly used for mobile applications and local area networks inside offices, homes and public buildings. It has also the potential for low-cost broadband and last-mile connections.

> A useful discussion of the potential of wireless technology for developing countries, together with case studies and guidelines can be found in [47]. According to this publication, "*wireless Internet should be the most promising accelerator of technology adoption in developing nations.*"

For long distance, wireless point-to-point connections are presently developed around IEEE 802.16 standards, also known as WiMax. For local area networks, wireless Internet is also known as Wi-Fi (short for wireless fidelity). These networks use IEEE 802-11a, b or g standards, offering different speeds. Hardware such as laptops, peripherals and PDAs equipped with Wi-Fi are becoming commonplace. An increasing number of sites (i.e., airports, restaurants, universities, hotels and homes) are becoming a *hotspot*, an area with wireless Internet to which people can connect anywhere inside it.

> A school can easily become a hotspot, allowing for a flexible and dynamic distribution of hardware inside the whole school (and maybe also for the uses of mobile devices in the schoolyard).

Wireless networks use radio waves to connect communication devices, thus avoiding cables. They are physically more secure (fewer cables in a classroom) and offer the flexibility for a hardware deployment strategy that can follow pedagogical requirements instead of being limited by space constraints[15]. For example, a rack of laptops can be moved to a *hotspot* classroom for specific learning purpose where four or five computers may be distributed to students to search some Internet content and then stowed away.

In a wireless network it is simple to add, move or remove any device from the network anywhere inside the school. In some rooms (i.e. laboratories or libraries) it might be undesirable to drill through walls to lay cables when wireless will seamlessly reach all corners.

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[15] For technical and implementation issues, further references, advantages and disadvantages and of wireless networks in schools see BECTA (http://www.becta.org.uk/) Technical paper: "Wireless Local Area Networks (WLAN)".

New technologies such as electrical power lines to carry data may also significantly reduce network deployment by reducing cabling inside buildings. These technologies are changing the cost equation and should be assessed and considered when designing network configurations.

Internet

As previously mentioned, connecting the school to Internet has a number of benefits for the whole educational community (See also [46]). Communication can be established with either dial-up access using a phone line, broadband access such as DSL or cable or satellite dishes. These alternatives will be analyzed next.

Dial-up lines use a modem connected to a normal phone line, which is often the only alternative in many schools, particularly in non-urban or communities with limited communication capabilities. Modem technologies make it possible to share voice users and data communication without disruptions. When older, low-quality phone lines are in place, this alternative may not prove adequate for Internet content-browsing or for more than three to four users at the same time. However, it is enough for e-mail communication, and it can be a useful startup for a large number of educational projects for students, as well as for professional activities of teachers. Dial-up access is a less expensive (at least in the short-term) but also a less efficient solution, providing lower transmission bandwidth that makes communication inefficient when several users share access at the same time.

The use of dial-up lines is linked to the cost structure of dial-up services. Time-based rates usually have a cost structure that makes intensive Internet access expensive during school hours, which leads school administrators to discourage connections. If the phone service does not provide flat rates, it is recommended that school officials negotiate such a service at a district or national level for educational purposes. This is an issue that may need to be addressed at the highest political level and negotiated involving several government bodies because it may affect the current national telecommunication policy.

There are a number of technical solutions to solve communication problems when bandwidth is very narrow (i.e. lower than 56 kbps), communications costs are high or low-quality lines make transmissions unstable. For example:

- To download relevant content during the night (when telephone charges are usually lower), and storing it on a local computer for use the next day. E-mail based projects have worked this way for years in many countries where schools can connect only for a few minutes per week to transfer data.

- To select and store Internet content on CDs that simulate a restricted Internet session. To make this more cost-effective, the production of the CDs can be performed centrally, i.e., at the district or even national level, with carefully selected contents and then periodically distributed to each school.

Broadband is presently the driving force in Internet connections, at least in urban settings. There is no universally accepted definition of broadband, but it is generally agreed (in Chile) that it applies to faster than 256 kbps (Kilobits per second) always-on connections. In some developed countries, broadband is considered to be at least 2Mbps (Megabits per second)[16].

> In UK, the Department for Trade and Industry defines current generation broadband as a connection at speeds of 2 Mbps and above, and next generation broadband as a connection at 10Mbps and above. The DfES (Department for Education and Skills) hopes that by the year 2006 all schools can be connected at a minimum of 2 Mbps and secondary schools at 8 Mbps or higher.

Telecommunication companies in many countries are offering flat rates on dedicated line connections to Internet, which makes it far less expensive for intensive school use. Also, new technologies are rapidly increasing transmission bandwidth on present cable and phone lines.

[16] For more broadband information see OECD document "Broadband Driving Growth: Policy Responses" in http://www.oecd.org/dataoecd/18/3/16234106.pdf and BECTA Technical paper "Broadband" in http://www.becta.org.uk/corporate/display.cfm?section=22&id=2831

Chilean urban schools can rent broadband access at a flat-rate of approximately US$25/month. More than 1,000 schools had broadband access at the beginning of 2004 and another 3,000 are in the process of installation during 2004. Enlaces is partly subsidizing connection costs and is also actively negotiating prices with cable TV and telephone companies that are Internet providers.

Broadband access of more than 2Mbps allows a laboratory of 20-25 networked computers to use simultaneously web-based content without much disruption. With fewer computers, broadband allows for new uses such as video streaming (delivering a constant stream of video, as opposed to downloading the video first) or alternatively, downloading or using interactively web-based content, especially the ones with more dynamic multimedia capabilities (i.e. human body simulations with video and audio).

An increasing number of countries is evaluating the use of satellite connections for school systems. WorldLinks [12] is using it in Uganda. This issue is addressed again in the chapter on ICT for rural schools

4. Hardware for Teachers

Another strategic decision in Enlaces was that of providing different information handling devices for teachers in teacher rooms. Teachers who do not have these devices at home have reacted positively to having ICT in a space of their own. They appreciate enough privacy to work without pressure -- especially from their own students -- but also where they can interact with other teachers, learn and practice together.

A desirable configuration is an intranet for the school administration's network, but preferably safely separated from computers and networks for students' use.

Figure 10. Teachers will also benefit from group work

The teacher's network in Enlaces includes a variety of equipment that is autonomous from the rest of the school hardware, including at least one computer, a printer and a scanner. Teachers need excellent printing capability to produce class materials and documents for parents. Laser printers have proven more cost-effective for large amounts of copies. In retrospect, at least one backup printer should have been provided in case of failures. It is important not to leave teachers without a working solution for their needs at all times.

In addition to desktop computers, the provision of portable computers, PDAs and keyboards for teachers has been tried out in several projects. They can also be offered as a special "technology" kit with low prices or soft credits for teachers. See for example: http://www.becta.org.uk/technology/infosheets/html/portcomp.html

From BECTA Web site: *"In a sample of 1,000 teachers who took part in the 1998-99 DfEE Multimedia Portable Computers Scheme, 92.3% said their portable computer improved their efficiency, making it easier and quicker to prepare high-quality worksheets and reports. The ability to take a computer from home to school and back again was frequently mentioned as a big advantage. Unlike desktop machines, portables can be used wherever they are needed: at home, in the classroom or on field trips."*

5. Hardware for School Administration

School administrators will also need equipment (and training) for several reasons. First, ICT can have a notable positive impact on internal school administrative efficiency if complemented with a management improvement effort that can be performed stepwise as part of a medium-term plan (within a year or two). Second, once school administrators start using ICT for their work, it will become evident to them that it is a valuable asset for the school and therefore, investment on maintenance will be more readily accepted.

A third argument is that the use of ICT by the school administration will have a positive exemplary effect on those teachers who may have a more resistant attitude towards technology, providing them a good incentive to give ICT a try, at least for administrative tasks.

6. Special Hardware

There are many different digital devices that have special-purpose functions and can be useful in schools, together with traditional computers and common peripherals such as printers and scanners. These devices are evolving rapidly in both functionality and price; it is advisable to review up-to-date technical literature before buying them.

A few links to popular technical literature and reviews with the latest news from hardware and software industries are as follows:

- http://www.byte.com/
- http://www.pcworld.com/
- http://www.cnet.com/
- http://www.zdnet.com/

A brief overview of some of these devices are offered next.

Portable or Intelligent Keyboards

Portable keyboards, also known as *intelligent keyboards*, are special-purpose, low-cost portable devices whose main (and sometimes only) function is to serve as a basic word processor. The idea behind these devices is that teachers and students don't need the whole functionality and power of a computer for most of their writing tasks. They are stand-alone devices for writing and storing plain text, with the capability of later sending the text to a computer for formatting or e-mail.

Other advantages of these devices for a school are that they are relatively low-cost; they are easy to use (no training needed, just a brief demo); they are rugged; they need no maintenance; and they can be taken home or used to write reports during a field project. They are battery operated with a long battery life. An important feature is that they can be easily connected to a computer (some can do this through an infrared port) or a printer to transmit the stored text.

Schools may combine computers and keyboards in a laboratory or in the library for people who need basic word processing. The library can also lend these devices for field trips or homework.

Figure 11. A portable keyboard

More information on these devices can be found at:
http://www.alphasmart.com
http://www.edweek.org/ew/newstory.cfm?slug=20wordtech.h21

Handheld and Tablet Technologies

Handheld technologies, also known as Personal Digital Assistants (PDAs), are a rapidly expanding industry with many new products introduced every few months. These devices are basically palm-sized battery-operated computers with powerful processors inside and with a screen for the user-interface.

Among popular PDA manufacturers are Palm (http://www.palm.com/), Handspring (http://www.handspring.com/),Hewlett-Packard (http://www.hp.com/jornada), Sony (http://www.sonystyle.com/micros/clie/) and Compaq: (http://www.compaq.com/showroom/handhelds.html)

More information on handheld technologies in education can be found in:
http://www.handheld.hice-dev.org
http://educatorspalm.org/index.html
http://www.pdaed.com/vertical/home.xml

Tablet PCs are a relatively new technology and therefore still rather expensive, but prices are dropping steadily. They are basically very thin and light computers with pen-based capabilities (like PDAs), allowing users to write directly on the screen in their own handwriting -- or convert them to typed text for use in other applications. More information on Tablet PCs is available from all major computer and laptop producers.

Other Technologies

There are number of other digital devices that can be used in schools to enhance students' project activities. Some of these are:

Digital cameras: They are presently a relatively costly investment but then, digital pictures are free. A digital camera can connect to a computer to store, edit, print or project digital pictures. Their prices are gradually dropping, becoming affordable devices for schools. These cameras can be used as mobile scanners in outdoor school projects and field trips that may benefit from using images. Students' school newspapers, which are very popular educational projects, can also make good use of these devices.

UPS: These are necessary devices in environments prone to power failure, such as rural schools. UPSs work on batteries and keep hardware working for a few minutes in case of a power failure, so that users can save their work and close the operating system without information loss. UPSs are also useful to protect the hardware from an unstable power supply.

Screen projectors: These are useful devices for multimedia classroom presentations. These devices are connected to computers to project the screen image onto a large screen so that a whole class can view the presentation. Presentations may be prepared on the computer with easy-to-use software such as PowerPoint. See: (http://www.microsoft.com/office/powerpoint/).

Science devices. There is a large software and hardware industry producing digital devices for school science, including data loggers, robots, sensors, and calculators. See for example: Science devices: http://www.pasco.com/ , http://www.vernier.com/ ,
http://www.rogerfrost.com/ , http://education.ti.com/educationportal/
Educational robotics: http://www.parallax.com/ , http://www.rec.ri.cmu.edu/education/,
http://handyboard.com/cricket/

7. Maintenance

The need to plan and budget for hardware and software maintenance cannot be overemphasized. In Enlaces' experience, schools without a well-funded technical support program will perceive very soon (in weeks or at most in a few months) the mistake of not having considered this issue. Reconfiguring computers and printers, installing new software, preventing and eliminating viruses and network shutdowns are just a few examples of the daily routine of the technical support team.

Proper maintenance requires a technical staff with continuous training, special purpose tools (i.e., to reconfigure a network from a remote location using IP tools) and standardized procedures. See, for example, the following Internet services monitoring system in use by Enlaces: http://smsi.enlaces.cl/).

Schools will need good quality long-term technical support, but it is advisable to plan for a gradual independence by training teachers on technical subjects and by providing regional help desks.

A few levels of technical assistance are advisable. The school level, with one or more teachers specially trained to perform basic troubleshooting and preventive maintenance procedures; a district level, with better prepared and dedicated technicians that can perform regular preventive maintenance at a deeper level and solve more difficult hardware and software problems; and, finally, a regional or national level, that coordinates these activities, provides regular training courses, deals with global software licenses and negotiates with hardware vendors and service providers to achieve quality services and reduced prices for hardware and software, their warranties and ideally, even supplies like printer ink-jet cartridges and toner, paper and other supplies.

> Enlaces installed in 2003 a free phone-based help desk for schools, whose purpose is to assist school technicians and ICT Coordinators in trouble-shooting hardware and software. Questions from users are registered and processed to determine assistance and training needs in different school categories (i.e. urban or rural, primary and secondary schools, etc.)

V. DIGITAL EDUCATIONAL CONTENT

This chapter offers a discussion of the Enlaces experience with software and Internet content. Decisions in Enlaces traditionally have been influenced by international experience, and the digital content issue is no exception. Nowadays, there is a large amount of documented experience and position papers about this subject, but the field is still in rapid evolution and without definitive answers for specific learning scenarios.

1. Questions about Digital Learning Content

One of the main preoccupations of Enlaces' managers has been that of providing to the schools a rich and diverse set of choices regarding digital content. Hundreds of software titles for all areas of the curriculum have been distributed to schools, and the Ministry of Education has invested heavily in a comprehensive educational portal. After more than a decade of monitoring teachers' decisions related to the use of digital content, the following issues have arisen in Enlaces:

1) Providing good software does not guarantee its use. This is a rather obvious observation, but the fact is that software titles with a sound "technical" evaluation (although few have field tests) from ICT experts, or which are highly ranked by software vendors, are not necessarily those preferred by teachers. In the Chilean experience, it has been often the case that teachers prefer rather simple software (in terms of multimedia bells and whistles), but close to their subject teaching requirements, their teaching methods and their level of self-confidence with ICT.

2) Digital content is barely used if it is not related to the curriculum. Most teachers will give software and web-based content a try if they perceive it is material directly related to the curriculum, and preferably if it is "officially" approved as such. To this end, the national curriculum includes many software and web references for each subject matter and age level.

3) Teachers do not have much time, and many of them do not have the motivation to navigate on the Internet in search for meaningful educational content. They prefer to look for advice. To meet this need, Enlaces has joined another institution ("Fundación Chile" http://www.fundacionchile.cl/) to develop an educational portal (http://www.educarchile.cl/). There, teachers, students, parents and researchers can gain access and appreciate examples of lesson plans, curricular content, teaching and learning aids, on-line advice, research papers and participate in discussion forums related to all levels of education. Many teachers value simple and straightforward material they can access in one click and that is ready to be used in the next lesson, without needing to invent new activities, reflect on the purpose, or figure out relevance to the curriculum.

4) Using digital content during training sessions with peers who have already used it in the classroom is a more convincing strategy for teachers than theoretical discussions about the benefits of a particular type of content.

Even adhering to the lessons from these experiences is no guarantee whatsoever that teachers will use software for learning purposes. More importantly, the fact that teachers actually integrate digital content in their lectures -- and that students indeed make use of it -- provides no guarantee that learning will improve. This is presently one of the controversial issues in Enlaces and in some other projects around the world. In other words, the most pressing issue relates to the suitability of digital content as a device to improve learning. Unfortunately, there are still few success stories reported in developing countries with sound classroom evaluations that demonstrate significant learning improvements [8].

To address this issue, and taking into account findings from recent research in developed countries, one present avenue of exploration by Enlaces is to consider digital content related to each single subject (and sub-subjects), learning requirements, and to the subjects' teacher cultures [33]. The purpose is to identify the role and impact that a

particular piece of software might have in a given context and to identify the means by which it can best be integrated by teachers into their lessons.

The debate has shifted from a generalist approach to an ever more detailed dimension. For example, in Enlaces the debate in the early 1990s started at the classroom level (i.e. "Internet inside the classroom"). It then moved to the subject and the context (i.e. "Internet inside the classroom for learning physics in urban schools with teachers who have no formal training in science and students that are, on average, underachievers").

Today the focus is on teachers' practices and the effectiveness of digital content to improve learning of a specific concept in a specific context (i.e. "How much can applet xyz help students understand the concept of mechanical energy conservation in secondary physics in a classroom with 45 students? What does a teacher need to know to make use of this content? What technical support will be needed and for how long? How should she evaluate the learning experience?).

The specificity of the debate is in tune with the "learning objects" approach, which is a novel and interesting proposal that might alleviate some of the troubles with present digital content. Learning objects are defined by the National Learning Infrastructure Initiative as "modular digital resources, uniquely identified and meta-tagged that can be used to support learning." http://www.educause.edu/nlii/keythemes/LearningObjects.asp.

A brief characterization made of learning objects by the University of Wisconsin at Milwaukee (http://www.uwm.edu/Dept/CIE/AOP/LO_what.html) is:

- Traditional digital content comes in a several hour chunk. Learning objects are much smaller units of learning, typically ranging from 2 to 15 minutes.
- Are self-contained: each learning object can be utilized independently
- Are reusable: a single learning object may be used in multiple contexts for multiple purposes
- Can be aggregated: learning objects can be grouped into larger collections of content, including traditional course structures
- Are tagged with metadata: every learning object has descriptive information allowing it to be easily found during a search.

Examples and resource bases of learning objects also can be found in the Milwaukee site. For more information on learning objects see *Learning Object Metadata Working Group of* the IEEE LTSC http://ltsc.ieee.org/wg12/index.html

The debate is also having important consequences to the Enlaces digital content acquisition policy, which has been mainly designed and operated from the central headquarters. This has advantages and disadvantages as will be explained later, but it must be noted that Chile is a highly centralized country (unlike Argentina or Mexico), a situation that explains many of the decisions made by Enlaces' managers.

First, well informed and seasoned teachers seem to be better suited than the Ministry to decide on the best pedagogical resources to meet their classroom needs. They choose the most suitable ones according to their perception of their subject's requirements, their own ICT skills, and, very importantly, their own methodological preferences. For these reasons, teachers ought to be the foremost decision-makers on this issue. Second, teachers become well-informed and capable of selecting digital resources only after some training and personal experience with the available software at the school. Third, to assist teachers and school administrators in content selection, it is necessary to provide well-packaged information about the educational content market together with peer reviews and field research.

It is generally regarded in Enlaces that this new scenario of fine-tuning its content distribution policy is mainly possible due to the previous efforts made by the Ministry in providing a base level of content, portal and teacher training. The new alternatives consider both centralized and decentralized content acquisition possibilities.

Another major administrative challenge in the Chilean case is to implement a decentralized content acquisition process, transferring money to schools in a system that has subsidized schools, half of them public and the rest privately-owned and which are not accustomed to purchase technology. The necessary legal engineering and control measures have proven to be major roadblocks. The complexity is even greater considering that the decentralization

process is being gradually implemented, starting first with only those more "mature" schools (mainly large schools with more than two years of ICT teacher training).

It will probably always be convenient for a developing country to negotiate at the highest distributor or manufacturer levels those pieces of software licenses that will be useful in all schools, such as productivity software licenses and encyclopedias. Also, many educational software titles will be useful and convenient for all primary schools and others for all secondary schools (i.e. encyclopedias, atlases, drawing software, etc.). Therefore, the acquisition of common software for these schools might also be more cost-effective if performed centrally. The Chilean Ministry of Education has been active in dealing with software vendors, achieving substantial discounts and even large-scale donations in return for publicity and market expansion.

2. Digital Content for Teachers

Enlaces decided that teachers should have at the schools least one copy of all the software provided for the students, together with their manuals if they were also purchased. The reason for doing this was the policy decision that all teachers should have readily available (in schools, as well as, at home) at least the following pieces of software: word processor, spreadsheet, drawer or painter, a presentation manager and those titles related to their teaching subject matter. If Internet is available, then a navigator and e-mail software is also provided.

Due to Enlaces' former centralized software acquisition policy, most schools in the Enlaces program have the same software packages and teacher training standardized on a comprehensive set of productivity and communication tools. An alternative that has been tried in Enlaces is to offer primary schools an integrated, education-oriented productivity software package, whereas secondary schools received a more professional labor-oriented product. However, many schools reported that teachers and students complained that they had to learn how to use the software a second time when moving from primary to secondary education. Standardization facilitates the interchange of documents among teachers. It avoids complex format conversions, and makes the training more cost effective by having the trainers all use the same training package (examples and contents). Cost is further controlled by producing, updating and distributing software centrally on a large scale. Standardization has also made easier the negotiation of software licenses for all teachers, allowing for future upgrades at lower prices.

In another realm, even though the Web's great strength is its abundant availability of the most diverse content material and its ability to deliver content on demand at low cost, high-quality *free* content remains difficult to find. Most teachers become easily confused when attempting to sort out the differences between open source software, freeware, shareware, public domain software, and open content licenses.

A report by Cushman [49] explores the possibilities for significant expansion of digital content for teaching -- particularly free content. It describes how this might occur, as well as current impediments to expansion.

> Enlaces managers and technicians constantly analyze developments and news in open software initiatives and Linux-based platforms for school environments. It is an expanding market, which may have a positive impact on license costs and hardware requirements, but might also require larger investments in training and technical support if an immature version of Linux is selected. Previous versions of Linux were mostly oriented to technical staff at universities, and the software suffered from installation and configuration problems requiring highly trained personnel. This situation has rapidly improved in the last few years, making Linux a reasonable alternative for schools.
>
> See for example: http://www.edulinux.cl/ (Spanish) for an introduction to open source and Linux, as well as for further links.
>
> Linux is also increasingly used as an operating system capable of handling old machines as terminals in a client-server configuration, thus expanding the life span of computers in schools and other institutions.

3. Software and Internet Content

Software for learning and for school administration is a fast-growing industry with a large variety of different titles and approaches to the same subjects. Hence, it is difficult for school administration to select the appropriate set of software titles to suit every educational strategy. However, there are some hints that can be helpful as a starting point.

It is easy to distinguish between software for administrative uses and software for learning purposes. However, software normally designed as "productivity software" also has a place in classrooms, especially in secondary and vocational schools. Teachers in Enlaces receive many hours of training on the uses of software for administrative tasks, and, according to our observations, they use them daily for this purpose. Because of this, Enlaces is helping teachers to find and design classroom applications of this software, in the hope that they might feel more confident in using them with their students.

> In an international case study of innovative pedagogical practices using ICT (SITES M2), it was found that "in the large majority of cases, it was not innovative technologies that were used. The dominant technologies used in these classes were commonly available ones, such as productivity tools, e-mail, and the web" [42].

Fortunately, this is the case, and there is ample evidence that productivity software has many classroom applications. For example, spreadsheets may be used for graphic presentations, solving equations and numerical analysis.

There are many sites dealing with word processors and spreadsheets as learning tools in different subjects. For examples and recommendations in many different subjects, you may search documents in:

- Eduteka: http://www.eduteka.org/ (Spanish)
- EducarChile: http://www.educarchile.cl/ (Spanish)
- The Becta data base in http://www.eduteka.org/ (English)
- The Irish ICTE site: http://www.ncte.ie/ (English)
- ISTE: http://www.iste.org/resources/curriculum/k-12/index.cfm (English)
- The NCTE site: http://www.ncte.ie/ (English)

a. Software for Administration

There are several software tools that offer an integrated solution for school management. These software packages provide most of the functionality needed by the typical school, including data consistency checking, backup procedures, report generation and even network capabilities. However, they incorporate a particular conception of how a school should be administered, and no matter how flexible they are, there will always be a number of cases in every school that will not be accommodated by the software. This integrated software needs fine-tuning by trained support staff. Therefore it is advisable to evaluate only those packages for which there is a competent local support agent capable of tuning the software to the school's needs. This individual also needs to be capable of solving the main problems that will arise during the shakedown period, which, given the annual cycles of a school, will last for at least a year.

A second approach is that of using commercial packages such as spreadsheets, text processors and databases. These software products are general purpose and adaptable to any particular configuration of need. They are used in all sectors of society (industry, services, ministries and home) and are therefore well-known, mature products. Their flexibility and generality has the downside that they will have to be adapted to a school, normally using predefined or preprogrammed forms.

b. Digital Content for Learning

Teachers face many difficulties when selecting appropriate digital content for a particular educational goal at the classroom level. Part of the complexity is due to the many titles available, with different pedagogical strategies and design features (interactivity, ease of use, on-line help and language choice). There are many sources of review information for teachers (mostly in English). The most helpful seem to be those reviews written by teachers working in similar contexts because the most difficult issue is that of determining if a given software title will help a teacher achieve the desired result in his/her classroom. Reviews are also a handy source for gaining knowledge about more general features of a particular piece of software: its robustness, whether it is both educational and entertaining for students, whether it is well designed, and if it is worth its price. These are all important criteria when it comes to the actual decision of buying.

Because of the need to acquire proficiency and to gain and share experience during the first years of teacher training, a carefully selected set of about a dozen pieces of educational software, for both primary and secondary education, might be preferable to a larger number of titles. For this purpose, software titles that can be used through many grades and that already have strong communities of users, classroom examples and other resources are already available in many languages. Some of these are productivity software that can also be effectively used as learning tools. An example of this would be the use of spreadsheets to teach mathematics, and the use of word processors to teach creative writing.

As teachers become more confident with technology, they will demand additional software titles to work with more specific concepts and content material in their classrooms.

The use of software in the classroom should be made as easy as possible for teachers, particularly at the initial stages when self-confidence in the use of technology is at a low level. For example, it is advisable to accompany software with classroom notes, including specific and meaningful examples of use, lesson tips, and orientation about how to organize student work. Evaluation procedures should be included. Also, it is necessary to provide teachers with enough copies of the software licenses and the learning aids (manuals and guidelines) to work with the entire classroom at the same time. Even though many times teachers might assign only a few students to the computers, copies of the materials should be available for the whole classroom.

If Internet is available, it will be useful to help teachers participate in discussion lists with other teachers from similar realities (i.e. same county). Using these lists, teachers will be able to ask for help, discuss their classroom ideas and learn, reassuringly, that many other teachers share their fears and have similar questions. Although all these seem to be natural uses of Internet, the Enlaces experience showed that teaches are rather resistant to participate in these type of lists, and there is a need for additional effort to engage them in these activities.

The software industry is continuously providing new titles and upgrading existing ones. Therefore, teachers need permanent advice for classroom applications, which can be provided in part by the ICT Coordinator in the school (a specially trained teacher – see Appendix 2) or by special web sites, some of which are listed in the Appendices. A few examples follow:

- The Becta (http://besd.becta.org.uk/ software database is searchable by subject, key word or by grade and contains information such as title, publisher, price, summary, format, etc. for each software. Its TEEM site contains teacher evaluations, case studies and information provided by the publishers. Its information is in English.

- Similarly, the software database in http://www.educarchile.cl/ is also searchable in different ways; each content has a comprehensive record with information for the teacher. Its information is in Spanish.

There are several organizations (universities, parent associations, magazines) interested in educational software evaluation, but using different judgment criteria. Some of these criteria and organizations can be found in [50] and in the BECTA site.

Teachers might more readily use software (or at least start using software) that already has a community of practitioners with whom they can interact, share ideas and solve problems.

Examples of software with a community of educational users are:

Primary Education

MicroWorlds (http://www.micromundos.com/) is extensively used in Costa Rica and in many schools in the United States, Brazil and other countries. It can be used in literacy, arts and in all grades for mathematics and science projects. Teachers use it in almost all subjects. It is available in Spanish, English and other languages.

KidPix (http://www.kidpix.com/) offers creative painting and story animation for primary schools. It can be used in arts and early literacy. It is available in Spanish, English and other languages.

Secondary Education

Cabri Geometre has a large community of users and associated research in both primary and secondary education. A long list of Cabri sites in different languages and countries can be found at http://www.cabri.net/

Appendix 4 contains a short list of some of these software and their related web sites as well as sites that hold databases with software descriptions.

Teachers already more experienced with software can try to develop, together with their students, their own titles, mostly for their own uses. It is frequent to see in schools homemade CDs produced by a class using a variety of software tools for programming. New web generation tools are constantly reaching the market, offering simple-to-use software platforms.

Comprehensive programming environments: Director, DreamWeaver and Authorware from Macromedia: http://www.macromedia.com/ .

Graphics design and sound edition software: Photoshop or Illustrator fromAdobe: http://www.adobe.com/

c. Internet Content

Even if Internet is not available on a large scale at the beginning of the ICT Program, it is advisable to include the provision of relevant web-based content into its design. Internet has by now a vast amount of resources in most languages but only part of it is relevant for education in general and even less for activities related to a particular curriculum. Also, where indigenous cultures are present, it might be relevant to produce content that is specially tailored for students from these cultures.

Given the necessity to provide Internet content that would be relevant to teachers and students, many countries have embarked in the construction of Internet "Educational Portals" to address this need. See for example:

- Argentina: http://www.educ.ar/educar/index.jsp
- Chile: http://www.educarchile.cl/
- European Schoolnet: http://www.eun.org/
- Ireland: http://www.scoilnet.ie/

Given the costs and complexities in implementing a national educational portal, and the advantage of sharing a common language, a few South American countries are working to establish an alliance to share content and software platforms among their portals. This may help them to focalize on producing content that is either not available or that has a special meaning to their curriculum (i.e. culturally relevant content).

If Internet is not available, or access to it is of low quality in the schools, it is always possible to select a supply of relevant educational content from national and international web sites and put it on CDs, which can then be reproduced and distributed to the schools. In this way, a restricted educational Internet can be easily simulated for the students and teachers. This CD-based Internet production can have a number of additional possibilities:

- It might include a special interface that helps students browse and use the content.
- Each piece of content can be briefly documented for teacher convenience.
- Schools or a central facility can copy the CDs for all students and teachers.
- The management team can acquire Internet content that needs special authorization for its use.
- The CD can be carefully analyzed to avoid content that might be undesirable for small children in primary schools.
- A special set of CDs can be produced for primary schools and another for secondary schools.

Teachers may also find that some content in educational CDs produced in other countries is relevant for their students. In this case, the production of a specially tailored new CD may be far less expensive or even reduced to the cost of the copying and of the distribution of the original CD.

Figure 12. Enlaces 2001 CD contains two disks full of evaluated educational software

VI. EVALUATION

Through the Enlaces experience, the authors learned that evaluation is an important but complex issue when designing and implementing a national program for introducing ICT in education. Probably because of such complexity, many programs defer evaluation until sometime in the future or include it as a separate, understated and non-central task. But, if evaluation is not an integral part of each major decision, it will be difficult to reach sound and reliable conclusions about the effectiveness of the program and to decide whether or not there is need for adjustments and change. Achieving a clear definition of what should be evaluated during the design of the program brings about an additional important gain because it imposes a precise and measurable definition of goals and helps detect unrealistic expectations. It also proved to be important for political reasons because it will readily secure the program at an eventual (and rightful) call for accountability. Therefore, it can be said that a sound evaluation strategy that defines fundamental standards of achievement and performance indicators in advance, will be of great value for the program's management team once it gets into its implementation stages.

> The aim of the initial evaluation of Enlaces (1993-95) was to answer questions regarding the impact of ICT on students, teachers and parents. This considered a wide range of variables for each subject, such as: students' self-concept, creativity, reading comprehension and cognitive development; teachers' self-concept, teaching styles and perception of working conditions; and parents' perception of the school. Results of this evaluation showed that students increased their reading and comprehension capacity as well as their creativity and concentration ability. Results also indicated that ICT produced a high level of motivation among students, a more horizontal social organization within the classroom and an increase in self-esteem. For the teachers, evaluations showed that a high number of them believed that the relation with the staff members was better and that they had better resources for teaching. However, parents did not show significant changes.
>
> These generally positive results of the early stages of Enlaces provided good support to the project's management team and were important for Enlaces prestige among policy-makers and academics. In this sense, they served as a catalyst that triggered the decision for the national expansion of Enlaces. On the other hand, results did not have such an impact on the redefinition of Enlaces national expansion strategy, probably because of the general positive trend that they showed. Nevertheless, some aspects, such as cost-related issues, were discussed and considered in the plan.

Evaluation is mainly about stating whether the program did, or is doing, what it was planned it would do, and to what extent. Therefore data needs to be collected, ideally, before, during and after the program implementation. In order to ensure this, for Enlaces, evaluation became an integral and distinguishable part of the culture of the management team.

While designing the evaluation studies and procedures for Enlaces, the team kept in mind that the purpose of evaluation was, and still is, fourfold: First it makes the program accountable. Second, it serves as a management tool, that is, its results can be used to modify the program's decisions and to fine-tune field actions. Third, communicating evaluation standards constitutes a message to the educational system, stating implicitly or explicitly what is important to achieve; in this sense, it can help underline the educational priorities for teachers and schools. And fourth, it turns itself into a political issue that will affect, either by its results or its mere existence, the decisions of politicians, particularly in relation to budget allocation and, eventually, to the composition of the management team.

> A clearly stated set of goals and standards for the ICT program will help in defining it in all its aspects, both in the short and in the long run.

Broadly speaking, two types of evaluation were considered in Enlaces[17]: that of the products from the program and that of the impact of the program. Each of these served different aims of the management team. Although in what follows product evaluation is presented first, ICT Programs tend to overlook impact evaluation, which should have the higher priority.

1. Product Evaluation

Product evaluation is aimed at determining the degree to which specific goals of the program (partial or end goals) are accomplished. The evaluation procedures, therefore, will depend on the nature of the goals to be assessed.

Other complementary processes are the ones related to the monitoring requirements of the program, which are different from the evaluation processes. The former are intended to get a picture on how things are being done, the latter are aimed at knowing the results of these actions. This is to say if goals were met or not with relative independence as to how they were achieved. In some cases there is a diffuse border between monitoring and evaluation. From now on, we will focus on describing what should be evaluated, rather than specifying whether it corresponds to a monitoring process or an evaluation. *In any case, Enlaces experience showed that* ***both*** *were very important!*

In order to be able to analyze if the process of implementation fits the expectations, it is required that each action has a well-defined goal to achieve (a product), expressed in measurable parameters (indicators). Although, this could seem a straightforward task, Enlaces experience showed that it demands a major effort; therefore, it needs to be explicitly included in the action plan.

The following table summarizes the main actions identified in Enlaces. The corresponding Indicators and their specific expression in terms of examples, or formulas for their calculation, can be found in Appendix 4.

Table 1. Main actions and their definition for product evaluation

Action	Definition
Teacher Training	Realization of the task (to train) and the quality of the training (defined through its goals and standards).
Technical Support	Realization of the task and quality of the service provided
Hardware Provision	Quality of the hardware, its distribution, the installation process and the warranty service provided by the company. Another aspect, which can also be evaluated, is actual use of the hardware provided.
Software Provision	Quality of the software, of its distribution and usefulness.
Internet Provision	Services such as web hosting, Internet access, and others such as e-mail, chat, video conferencing, etc. Generally, these services are provided by external agencies (communications companies) so it is advisable to define clear standards and monitoring procedures.
General	It is important to evaluate the perception of the quality of each service provided. This can help to redefine the standards for each service, if necessary.

In order to effectively carry out the product evaluation process, Enlaces collects data in various ways; among these, some of the most important ones are:

- Surveys: In order to gain a more accurate perception of the quality of the services the program is providing (training, technical support), as well as of the quality and appropriateness of the infrastructure that has been

[17] There is also process evaluation, but this type of evaluation is normally associated with assessing the activities that are part of the actions of the program.

installed, the management team should consider conducting a survey, every two years, in a representative sample of schools. It is important to integrate the views of school management, teachers, and the technology coordinator.

- Tests: An interactive test may be used to evaluate the ICT skills that teachers acquired as a result from the training process.

- Automatic Logs files and Feedback forms. For some of the processes (i.e. Internet provision), the program could consider the use of software for monitoring the use of Internet. Also, web- based forms can be filled in directly by the technology coordinator at each school when, for example, computers are installed or new software arrives at the school.

> Some of the information systems developed by Enlaces to monitor implementation are:
> - Internet quality monitoring system (http://smsi.enlaces.cl/).
> - System for controlling the quality of the guarantee provided by computer suppliers (http://www.redenlaces.cl/sss).
> - Digital signature system to approve the technical and pedagogical support provided by universities to the schools (http://operaciones.redenlaces.cl).
>
> These systems are constantly used by Enlaces' technical staff to detect possible failures in the services the schools receive from the suppliers or from the universities. The aim is to have reliable and timely information to correct the more important and frequent problems.

- Case Studies: To monitor the application of resources, it is advisable to select a sample of schools for classroom observations. This will provide useful information about the results from the combined actions of the program (i.e. teacher training, technical support, usability of software provided, etc.).

2. Impact Evaluation

Evaluating the program's impact is aimed at stating the changes that the program produced in, for example, student learning achievements, acquisition of new competencies or other variables that are important for the educational system. Given the complexity of this topic, this section draws more on literature in order to enrich the Enlaces experience.

With respect to educational systems, many educational authorities around the world are looking at the same type of issues related to the impact of ICT in education. Moreover, many international agencies [51-53] have carried out similar assessment initiatives, aimed at finding out, if and how, ICT impacts educational achievements. Despite the present debate on the actual effectiveness of ICT as an aid to improve student learning achievement [54-57], it must be realized that there is widespread interest and a definite need to find evidence of the impact of ICT on student attainment. In many ways, governments are nowadays more cautious towards investing in ICT for education and are asking for measurement of returns on the investment made.

Several studies have tried to find a positive correlation between high levels of students' attainment and good practices with ICT [18]. Qualitative studies try to define and identify the conditions of good practices using ICT [52, 53]. Quantitative studies try to show a correlation between the use of ICT and higher achievement [58]. Some other studies combine both methods.

One good example of a long-term study is SITES [52]. This is a study in three modules. Module 1, conducted during 1997-1999, was a survey of school principals and technology coordinators from samples of schools in 26 countries. Its focus was on the extent to which schools had adopted and implemented pedagogical practices that are considered important to education in the information society (see report in [59]). Module 2, conducted during 1999-2003, was a

[18] However, due to their mixed results, very few of them have been published.

series of qualitative studies which identified and described innovative pedagogical practices that used technology (see report in [60]). Module 2 builds on M1, in that it looks into the classroom to examine in more detail the emerging pedagogical practices reported by principals in Module 1, and test the validity of some indicators. It also examines the contextual factors that influence these practices. Scheduled for 2004-2006, Module 3 will be an assessment of teachers and students, focusing on the impact of ICT on the skills and competencies they will need for the information society.

In the year 2000, Enlaces decided to participate in Module 2 of SITES in search of answers that could help to characterize innovative uses of ICT in Chilean schools and to understand their characteristics. In this framework, seven case studies of exemplary uses of ICT were performed. The main results of the study in Chile [61] showed that these innovative uses of ICT did not provide evidence of impact on students' learning achievement as defined in the national curriculum and measured by the national students' assessment tests. However, they did show that students participating in these projects could learn other content, had the opportunity to develop abilities defined as cross-curricular and practiced ICT related skills. The analysis of the teaching and learning activities implemented highlighted some deficiencies in the way that teachers implement new teaching strategies, indicating the need for further and more specific training. It also showed that innovative teaching practices can have an impact on students' conception of the world, social relations beyond the school and that they can change parents' conception of the school. Finally, results highlighted the special importance of the way in which teachers plan the use of ICT, in so far as their scaffolding role is transferred to the activity guides they prepare before the lesson takes place.

Regarding the results of these type of studies, only recently is there some evidence of a positive correlation between the level of ICT resources in schools and the achievement of better standards [58].

Keeping in mind these results, and based on Enlaces experience, it is advisable that an ICT implementation program in education draw the boundaries of its desired impact on students. With that purpose in mind, we present a brief discussion of the possible impacts in the areas that were mentioned previously (learning achievements, acquisition of ICT management skills and other variables).

Learning Achievements

Regarding learning achievements (as defined by their corresponding national/local curriculum), several studies have tried to identify patterns that might lead to specific areas of impact of ICT in students attainment [62-64]. Broadly speaking, results coincide in showing that, although there is evidence of impact in specific areas, computer-based technology is only one element in what must be a coordinated approach for improving curriculum, pedagogy, assessment, teacher development and other aspects of the schools' culture [62, 65]. Nevertheless, if a choice is to be made, based on the current research, the strongest evidence of gains in students' learning tends to focus on applications in science and mathematics [62].

What seems to be a consensus about ICT and learning achievements is that they enable key conditions for learning. One example of these conditions are presented in [62]:

- Real World Contexts
- Connections to outside world
- Visualization and analysis tools
- Scaffolds for problem solving
- Opportunities for feedback, reflection and revision

In this respect, the report of the OECD has pointed out that:

> *ICT use enriches the school curriculum in at least two fundamental ways. The first is as an enhancement across almost every subject and activity, through resource banks, simulations, learning sequences, collaborative activity and so forth. This in itself has the potential to transform the learning environment more than any innovation hitherto. The second, and yet more radical, is*

the pursuit of digital literacy in its own right, whereby the individual becomes empowered as a discriminating and autonomous learner. [66]

Based on the evidence just presented, it would be unwise to base the main argument for a national ICT in education policy on a direct impact of ICT on students' learning achievement. We would argue, however, that through changing the teaching and learning conditions and if used wisely, ICT have the potential to transform the teaching and learning process which, in turn, would lead to better learning achievements.

ICT management skills

With regards to ICT management skills, there are at least three different types of definitions: the ones aimed at defining skills oriented towards mastering the software, such as those defined by the European Computer Driving License [67]. The other types of definitions are oriented towards defining a set of competencies that students can develop while using software. Finally, the advanced ICT skills, such as programming, system design, etc. are taught mainly in vocational schools.

The following table exemplifies the skills and competencies underlying the first two types of definitions:

Table 2. Skills and Competencies

General categories of the European Computer Driving License[19]	Knowledge Management Competencies[20]
▪ Basic Concepts of Information Technology ▪ Using the Computer and Managing Files ▪ Word Processing ▪ Spreadsheets ▪ Database ▪ Presentation ▪ Information and Communication	▪ Knowledge construction ▪ Critical thinking: analyze, interpret data, and evaluate evidence ▪ Project and complex problem-solving ▪ Complete collaborative projects ▪ Effective presentations and discourse ▪ Find, assemble, re-structure knowledge ▪ Understand principles, including secondary effects

The skills described in the left-hand column are more likely to be included as a separate subject in the curriculum. The competencies described in the right-hand column are supposed to be acquired while developing activities that demand the use of ICT tools in different subjects of the curriculum.

In this respect, it should be noted that the general trend is now towards the adoption of ICT across all parts of the curriculum [66]. If a given country's curriculum does not include these competencies at some level, the decision to implement an ICT program in education could require a major call to integrate these competencies within the curriculum. However, such a discussion is beyond the scope of the present document.

Returning, briefly, to the idea of assessment, it must be said that international agencies have only recently started to design instruments to assess these competencies using ICT tools (i.e., see Module 3 of SITES [52]).

From the perspective of the design of an ICT Program, it should be considered that in developing countries, as in Chile, it is likely that a considerable percentage of the students will have access to this technology only at school. Therefore, one major impact of its introduction could be to enable students to learn to master the technology (digital literacy), apart from other educational impacts the ICT Program might have.

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[19] 67. ECDL, *European Computer Driving Licence*. 1997, European Computer Driving Licence Foundation.

[20] Adapted from the design of module 3 of SITES 52. IEA, *SITES Module 2: Case Studies of Innovative Pedagogical Practices Using Technology Second Information Technology in Education Study*. 2000, International Association for the Evaluation of Educational Achievement.

Other variables

Looking at other areas of impact, a good example of the set of potential variables to be considered for impact evidence was reported in [68]. In their review, they show the different theories of enhanced learning through the use of ICT developed in the last two decades.

Table 3. Theories of Enhanced Learning

Theory	Proponent	Date	In	Published
Extrinsic reinforcement	Loftus G.R. and Loftus E.F.	1983	Mind and Play: The psychology of video games	Basic Books
Intrinsic rewards	Malone T.W.	1981	Toward a theory of intrinsically motivating instruction	Cognitive Science 4, 333-369
Challenge	Lepper M.R. et. al.	1993	Motivational techniques of expert human tutors in Lajoie S.P. and Derry S.J. (eds.) Computers as Cognitive Tools	Lawrence Erlbaum
User control	Wishart J.	1990	Cognitive factors related to user involvement with computers and their effects upon learning	Computers and Education, 15 (1-3), 145-150
Increased self-esteem	Cox M.	1997	The effects of Information Technology on Students' Motivation	NCET and Kings College
Vocational relevance	Cox M.	1997	The effects of Information Technology on Students' Motivation	NCET and Kings College
Higher order thinking	Papert S.	1980	Mindstorms	Harvester press
Social construction	Crook C.	1991	Computers and the collaborative experience of learning	Routledge
Zone of Proximal Development	Somekh E. and Davis N. (eds.)	1997	Using IT effectively in Teaching and Learning	Routledge

The variables listed in the above table have shown to be positively affected through the sustained use of ICT. The issue here is that, in general terms, these variables are not part of the curriculum, or if they are, they are not assessed by the national tests. This is another reason why impact of ICT at a national level is difficult to demonstrate, although it may exist.

Finally, there is an additional set of arguments that draw on the association of ICT with the process of 'educational innovation' [69, 70], either acting as a Trojan Horse [71], as a catalyst [72] or, more recently, as a lever -- a tool that must be applied purposefully to a task to be of value [41]. ICT both underline a *need* for curriculum change and afford the *means* whereby the desired change could be achieved [66]. In this sense, there is the underlying assumption that ICT will help educational reform processes and that this could also be considered as an impact or a substantive "side-effect." In fact, Enlaces is perceived by school principals and ICT coordinators as an aid to implement new teaching strategies that are promoted by the educational reform [73].

Summarizing, at a policy level, promises about achieving an impact on student attainment involve a high risk and may not be sustainable. Hence, the conception of ICT as "tools for improving the teaching and learning processes" should be kept in mind. The argument for developing ICT competencies is probably the strongest one. In developing countries, the provision of computers in schools may be the difference for many students between having or not having access to ICT. This may be the strongest argument and the basis for further improvements; it denotes a matter of equity.

3. Recommendations for Evaluation Design

The scenario described in the previous section raises questions and uncertainties about the role of ICT in education, but the analysis might lead a reasonable person to conclude that, at least for matters of equity, ICT should be part of any educational reform process. Therefore, and probably because of these uncertainties, evaluation of its impact on students should be an integral part of the program and some aspects to be considered are the following:

- Design longitudinal studies. Generally the uptake of ICT in schools is a long process. It takes years for teachers to fully appropriate the technology (see for example [31] and even longer to be able to effectively integrate ICT into their teaching routines. Therefore studies should look at the impact on students over a period of years.

- Use external sources of information. Many countries have their own national assessment procedures. Results of these assessments could be analyzed to see if there is an impact that could be attributed to ICT. For example, the study by Becta [58] used the results of the national students assessment tests as an external source, and then it defined an indicator that characterized different levels of resources that a school may have. The correlation between higher achievement and better resources was found to be significantly positive, implying that students who attend schools with better ICT resources will attain higher levels of achievement.

- Look for differentiated impact. Especially in developing countries, there will be socio-economic differences among the student population, including for example, accessibility to ICT. So, it is possible that the ICT resources at school are, in fact, the only ones that some students may use. It can be expected, therefore, that the impact on those students include different variables and different degrees, compared to students who have ICT at home. So, there should be a core set of variables to look at within the system as a whole, but also different sets of variables depending on the context of each type of school (location, ethnicity, socio-economic level, etc.).

- ICT impact can be difficult to isolate from the impact due to other external interventions, such as curricular reforms. It is therefore advisable to consider an array of different types of evaluations (case studies, surveys and others) that could help draw a fuller and more reliable picture of the possible effects, and aimed at isolating the causes that could explain the observed effects.

- Use international standards. To be able to compare the evolution of the implementation of the ICT program over the years, it is advisable to use international indicators. One interesting set of indicators was used in the SITES M1 study [59]. In this study, data was collected regarding four areas: Infrastructure (hardware, software, Internet); Pedagogical Practices (curriculum implementation); Professional Development; and general issues about ICT in the school (attitudes, technical support, barriers, aims). If the methodology used in SITES M1 is replicated in a country that starts implementing an ICT program, it would be possible to compare its results and indicators with those from other countries. More recently, UNESCO proposed a set of Indicators of ICT use in education [74]. The aim in this case is to follow international trends.

- Generate a base line. Related to the previous point, it is important to know what is happening today in the educational system: its current practices and achievements. Thus, results can be checked out every two years and see the possible areas of impact of the program as well as the progress that was made. Some of the indicators to be used in a base-line assessment are:

  - Number of students/teachers per device (mostly computers, portable keyboards and PDAs available for students/teachers in the school)
  - Percentage of schools that have computers/Internet connection
  - Number of devices per school (sorted by their technical characteristics)
  - Number of students/teachers using the Internet per school
  - Number of pieces of educational software available for key subjects (mathematics, language and science) per school
  - Investment in hardware and in software per school
  - Percentage of teachers trained in the use of ICT per school

4. Evaluation Team

In general terms, and for transparency and objectivity reasons, it is recommended that evaluations be contracted to external institutions (national or international) that are prestigious and experienced. In Enlaces, the management team has an internal professional who perform the following duties.

- Develops the terms of reference for the bidding of the evaluation program
- Coordinates the bid (call, clarifications, evaluation and adjudication)
- Acts as an institutional counterpart for the institution during the implementation of the evaluation
- Verifies and approves the final report
- Elaborates and implements a dissemination plan of the results

The participation of an external advisory group of professionals is also recommended insofar as the design, implementation, analysis and dissemination of the evaluations need to have a strong theoretical and political support.

VII. RURAL SCHOOLS: A SPECIAL CASE

ICT for rural schools have been gradually becoming a political issue in developing countries. The situation is seen as matter of equity with regard to access to opportunities for improving people's quality of life.[21] This is generally expressed as the ability to participate in use of available content and services on Internet worldwide [75, 76]. In the Chilean case, ICT for rural schools have been considered a special case, which included a distinctive approach to staff development, different digital content and technology deployment and greater emphasis on community involvement.

This chapter addresses the Chilean rural reality and the ICT policy developed for its schools ("Rural-Enlaces") as a special case [77]. It also offers a few hints that might help when designing an ICT policy to serve rural schools.

> Chile has approximately 130,000 rural students in 3,600 schools with an average of 36 students and 2.3 teachers per school[22]. More than 900 schools have less than 15 students each and there are more than 2,100 schools with just 1 teacher.

1. Implementation Constraints in Rural Environments

Rural schools normally make up a larger proportion of the schools in developing countries and have a number of characteristics that impose additional challenges to the integration of ICT, as compared with schools located in urban areas.

First, their geographical isolation and precarious infrastructure (single room schools; absence of or low-quality electric and telephonic services; inadequate environmental conditions for hardware, etc.) make teacher training more expensive and menace hardware's lifespan. These have been some of the main sources of difficulties for Enlaces.

Second, most rural schools are located in areas with low population density, and therefore, they are very small schools, with different grades sharing the same classroom. This pedagogically complex situation poses a number of challenges, but interestingly, it also offers new opportunities for outstanding learning situations using ICT, arguably more so than in urban schools.

Third, the particular cultural reality of rural areas involves a special kind of relationship between the school and the local community, which normally lacks technological resources, and suffers from social and professional isolation. Each of these three challenges represents a different dimension in the Chilean ICT implementation policy for rural schools.

[21] See also: http://www.wsisgeneva2003.org/

[22] Source: Chilean Ministry of Education. Programa Educación Básica Rural. 2002.

Figure 13. A small Chilean rural school with many grades in one classroom

The geographical isolation and infrastructure issues have been solved through close cooperation with other rural development initiatives from the public and private sector. For example, Rural-Enlaces decided to move right behind initiatives that provided electricity to rural communities, either through conventional means (public network or local generators) or innovative solutions (wind power or photo-electric sources). This was a debatable decision because some ICT uses can be introduced without public electricity (i.e. using portable computers or handheld devices), but nevertheless, the rapid expansion of rural electricity in Chile allowed Rural-Enlaces to consider the provision of electricity as a basic requirement for a school to participate.

Communication infrastructure is usually a more complex issue than electricity. Many rural areas may have electricity, but lack telephone lines or mobile phone coverage, which makes it difficult, or economically unfeasible, to use conventional Internet access solutions such as those provided in urban areas. Additionally, in those rural areas that do have regular communication services, they are probably much more expensive than equivalent services in urban areas. Even though it is technically possible to provide Internet access to rural schools regardless of their geographical location, there are still considerable costs for a small-scale implementation (i.e. for one, or a few dozens of schools). A larger scale design (i.e. a district, or the whole country), may make the costs per school more affordable, but it will certainly require a high-level political decision to secure a public investment of that magnitude. In such cases, it would be desirable that the provision of Internet access to rural communities involved not just schools, but other public services (such as health) and private users, as well.

> In 1995, the Chilean government established a Universal Access Fund providing public telephone systems to isolated rural areas through a competitive "bidding for subsidies" program. In 7 years, the Fund provided public telephones to approximately 6,000 rural localities containing about 2.2 million inhabitants. Excluded population dropped from 15% to 1%. Total investment was $161 million, 86% funded by private companies. This mean there was $7 of private investment for each $1 of subsidy. The main success factors were reliance on market forces; minimal regulation; simplicity and speed; competence and leadership.

Geographical isolation directly relates to higher costs in transportation services (i.e. bringing personnel together for training, delivery and maintenance of equipment, etc). Since many rural schools don't have nearby public transportation, access is a major constraint for the provision of in-service teacher training. In addition to transportation costs, difficulty of access during certain periods of the year (i.e. rainy or snowy season), or particularly remote locations (i.e. schools in distant islands), required Rural-Enlaces to design a teacher training and

support strategy offered during concentrated periods of the year. Also, most of these schools are far away from the normal coverage by hardware maintenance services, a situation that requires teachers to learn some basic hardware and software trouble-shooting.

The small-school-size factor has several implications. Small schools require a higher per-student investment rate than urban schools, even if the provision of equipment is in smaller quantities. Questions related to whether it is worth putting computers in schools with only 10 or 20 students have been addressed from the political and ethical point of view of improving equity of opportunity as well as from an economic analysis of investment per student.

Another implication of small size schools is pedagogical. One of the main challenges for teachers in many rural schools is to teach with several grade levels in the same classroom. Small mixed class schools offer an interesting opportunity for organizing the classroom in collaborative work groups of similar learning levels. In rural schools, it seems to be particularly suitable to have ICT as learning resources available for small-group work inside the classroom (a *learning corner*). Hardware inside the classroom is also a reasonable design for many of these schools that may not have spare rooms; in many cases the whole school consists of a single room. Hence, one computer per classroom might be not only a good pedagogical decision in terms of curricular integration of the resources, but it might also be economically feasible for small schools (which may not be the case in large schools). For reasons that will become clear later, Rural-Enlaces decided on a minimum of two computers per school.

Small schools usually involve the challenge of fewer teachers (in many cases, just one teacher per school) who might have a non-professional initial formation and also lack a professional support network. In these cases, Rural-Enlaces took advantage of existing support networks, particularly when facing a highly demanding cultural challenge like the one represented by the introduction of modern information and communication technologies. Teacher training was solved partly by fostering the formation of teacher self-support networks among neighboring schools (i.e. grouping teachers in training workshops).

In a more cultural dimension, it is important to realize that ICT access produces a major breakthrough not just for the school, but for the whole community as well. Often rural schools are the last to acquire technological (or any other) innovations. Therefore, the community (students, teachers, parents) may feel they are being left behind during major societal changes. Parents may resent that their children don't have the same opportunities that urban children have so they normally appreciate the introduction of ICT into their schools. In Rural-Enlaces' experience, usually the whole community celebrates the inauguration of the ICT environment in a rural school as a special event in their lives. Teachers feel they are professionally upgraded, making their conditions closer to those of their urban colleagues. Students, who may never hope to have ICT at home, will be more motivated to attend school, looking forward to have a chance to explore and "play" with new machines. Parents will value the school as a more modern and empowering environment for their children.

However, rural teachers are used to working under severe conditions, with scarce resources and therefore, out from necessity they are used to solving school problems in creative ways. Another difference between urban and rural teachers in Chile is that the latter tend to have more time for professional development. These factors can become powerful forces for change in a rural learning environment. Teacher training in Rural-Enlaces took these factors into consideration when it came to the choice of software, the nature of content information, as well as to the learning practices that are most appropriate and relevant to everyday reality. The need to tone down unrealistic and excessively high expectancies associated with the use of ICT is also considered in this context.

Communities that have a strong cultural identity (i.e. ethnic groups) might feel that technology should be resisted as a cultural invasion from dominant groups. This is a potential risk that has to be recognized and dealt with carefully, but it is also the case that these groups may come to value technology as a powerful means to better represent and preserve their own cultural identity.

2. ICT Policy for Rural Schools: Rural-Enlaces

a. Teacher Development Strategy

Taking into account the mixture of opportunities (i.e. small schools) and difficulties (i.e. costly access) of rural education, teacher training in Rural-Enlaces has a particular flavor that differs from non-rural settings.

In order to achieve a better integration of ICT to the teaching practice, a strong emphasis has been put on the process through which this integration occurs. This process is not merely a product of intensive training that tries to develop general capacities, but is also a slow process of cultural appropriation. Particularly in rural schools, technology and the way it is used are distant from teachers' current cultural practices. The integration of technology is a progressive process, which might require initial external support to help teachers to actually participate in practices that integrate technology for pedagogical objectives. This approach to teacher training can be seen as a "scaffolding" process in which an external facilitator works with the teacher within her or his "zone of proximal development" [78, 79].

In the Chilean approach to Rural Education, the teacher-training dimension is called *Acompañamiento* (accompaniment), and it is based on the following premises [80, 81]:

- The integration of technology into cultural practices where it is not currently present is a progressive process that requires time (at least 2 school years).
- The appropriation of technology by teachers will be facilitated by an external supporter (or *facilitator*) who will demonstrate its use in the classroom with students. The teacher is not replaced by the facilitator, since she or he remains as the main protagonist and participant in the teaching role.
- The facilitator participates regularly in the classroom (once a month), and is expected to shift the role from a more central one in the beginning to a more peripheral one as the process evolves.

It is important that teachers see this direct intervention into the teaching practice as a professional development opportunity. For this purpose, it is suggested to link the participation of the facilitator in classroom sessions with other reflective opportunities in which the teacher and the facilitator can jointly design future actions (taking into account the particular school context) and also reflect on actions that have already occurred.

In the Chilean case, an important step had already taken by the Ministry of Education [82], that of promoting a monthly meeting at which rural teachers from nearby schools meet to jointly design and reflect on their pedagogical practices with the support of a facilitator. These meetings are part of a more encompassing entity called the "Microcentro" (microcenter), which consists of a reunion of schoolteachers from a specific neighboring area, and which constitutes what they call a "community of practice" [83].

The microcenter -- and its monthly meetings -- was in existence long before the ICT initiative for rural schools in Chile, so it turned out to be an ideal opportunity to incorporate joint design and reflection about the manner in which to introduce technology into rural classrooms. The facilitator that visits ICT school classrooms also participates in the monthly meetings of the microcenter, working along with teachers in the design of classroom activities that they would like use, before the next school visit the following month.

If rural school teachers don't have an already established space for group reflection and design, it is recommended that such an location be established as part of an in-service ICT professional development strategy.

The integration of ICT in the pedagogical practice is a central avenue of the teacher development approach of Rural-Enlaces, but it cannot be implemented if teachers do not have basic skills related to the use of technology. Therefore, another dimension of professional development has to be constructed for the development of these skills.

In urban schools, it is possible to develop these basic ICT skills through the use of weekly in-school workshops, in which a group of teachers participates in ICT sessions after school hours. But in rural schools, this model would be extremely expensive due to the low number of teachers per school. An alternative to weekly sessions is the

development of ICT skills during intensive workshops in which a number of schoolteachers meets together for a certain number of days to participate in ICT basic skills training. These workshops should enable teachers to gain computer literacy on the use of the operating system, on the basic functionality of applications like word processors and spreadsheets, and on the exploration and the design of learning activities based on the educational software the school should receive along with the hardware.

In summary, the Enlaces-Rural staff development approach for rural schools combines three tracks:

In-service Support. This activity is aimed at fostering the progressive appropriation of technology for pedagogical uses, with direct support from a facilitator who works with the teacher and students during regular visits to the school for an extended period of time. A gradual introduction of specially selected educational software (with local meaning; see later) and the development of basic ICT skills (keyboard and peripherals, file system, basic functions of the operating system, etc.) are developed.

Reflection Meetings. These are three-hour working sessions with a group of teachers from nearby schools who receive in-classroom support from the same facilitator. These meetings take place at the "microcenter" at least three times a year.

ICT Workshops. Intensive workshops in which a group of teachers from a microcenter receives focused instruction in the use of ICT. There are 4 workshops distributed throughout the year, each one concentrated in 3-day periods. This approach is more cost-effective than weekly sessions, and it allows for time for teachers to practice at their schools in-between workshops.

b. Local Support Organization

A major risk observed during the implementation of Rural-Enlaces' professional development strategy has been the loss of efficiency in the long chain that goes from the original design down to the final implementation of the strategy on a massive scale. In the above-mentioned strategy, a high degree of responsibility for the final implementation rests on the facilitator who plays a key role in the success of the program.

Facilitators are selected, if possible, from seasoned professionals with a deep understanding of general primary and rural education, a proficient use of technology, an ample knowledge and experience about exemplary use of technology for pedagogical purposes, and who are also knowledgeable of adult education principles. In the Chilean case, most of the professionals selected required a support program for themselves. This helped them to initially develop required skills and knowledge, educated them about the program's strategy, and offered them continuous support while they worked on other teachers' professional development and ICT implementation.

To provide this support on a national scale, Rural-Enlaces built regional partnerships with teams in charge of local management of the ICT initiative for rural schools. These teams have a specific focus on the particularities of local rural education; they coordinate with other agents that participate in the rural educational process (such as state supervisors, indigenous leaders, and school district authorities); they contribute to the design of national policies through constant feedback; they deal with local implementation logistics (i.e. transportation and workshop organizations); and particularly, they offer permanent support to facilitators.

c. Pedagogical Approach to ICT Integration in Rural Schools

The Rural-Enlaces strategy involves direct participation of ICT facilitators inside the classroom. This involvement raised a key debate relative to the responsibilities of ICT policy-makers in relation to professional and methodological autonomy of teachers in their pedagogical practices.

One position in this debate is to provide teachers with the tools and alternatives, and let them make the final decision according to the school's particular teaching approach. Another position is that no intervention is successful if it does not include the final objective of educational practice -- student learning -- therefore, the program's role is not

simply to provide a tool kit but to ensure its direct involvement in a pedagogical approach that ensures the tool is being appropriately used.

Figure 14. Chilean rural classroom with two computers

One step forward in this debate is to get deeply involved into the focus of student learning, but to assume that there is a shared responsibility with other initiatives beyond the ICT program. This implies that technology is not put inside rural classrooms simply to provide a general improvement in teaching practices, but to particularly improve learning in curricular areas such as early literacy and mathematics. To take this challenge seriously has meant for Rural-Enlaces that the pedagogical role of ICT cannot be seen merely as a technological challenge, but must be considered as a major disciplinary challenge that involves a more general, national orientation (curriculum), the teachers own backgrounds and their current practices and the available resources.

Our approach has been to put ICT at the service of rural education initiatives with a direct focus on improving student learning. This means there is full integration with other rural and national educational initiatives transmitting coherent messages to teachers. This coherence is due, in our case, to the fact that there is a national policy for approaching rural education within a clear pedagogical framework.

> In the Chilean case the pedagogical framework [84] is part of the Rural Education Program for Primary Schools.

Understanding the pedagogical approaches to rural education makes it possible to see technology as a means to support such approaches. For example, if the rural education policy promotes a new way of organizing teaching so that teachers can more effectively distribute their time working among groups of students with similar learning levels, then it is possible to conceive technology as a support to such organization, allowing the rotation of group activities around the "technology corner."

d. Digital Educational Content for Rural Schools

Rural schools are immersed in a cultural context that is often different in many ways from the one in nearby cities. For example, it is often the case that rural children are interested in topics or have developed skills with a strong local connotation, such as agricultural- or fishing-related activities, notions and games. In the Chilean case, many rural schools have indigenous students and teachers, belonging to different cultures with their own mother tongues -- Mapudungun, Aymara or Rapa Nui -- and with their own oral traditions and cultural forms.

Rural schools can certainly take advantage of the vast amount of digital content on CDs and on the web. However, there is hardly any digital content on the market that properly addresses the special needs of these children and

teachers. This is a situation that may not change in the near future because of their relatively small population and generally low buying capacity.

In Chile, it is also the case that rural students have below-average learning achievements according to the national tests performed yearly[23]. They have a higher than average drop-out rate, less learning material and fewer diverse sources of information compared to urban students. There is also a need to improve motivation towards learning. With the objective to partly alleviate this situation and to motivate children to use technology with meaningful content, Rural-Enlaces decided to provide rural schools with custom-made content on CDs. These have proven to be highly relevant and useful to them.

One of the older and more relevant software programs developed by Enlaces was the development of *La Plaza* [85]. It is still used in a few rural schools as introductory software for first-time users. La Plaza is basically a user-friendly application that allows easy access to computers, either for exploring educational software, taking advantage of electronic mail facilities (to participate in regional, national and international educational projects), or simply for sending and receiving information of personal interest by means of the network. The software was used as a "Trojan Horse" for a friendly and non-intimidating first encounter with ICT technology. It has been particularly successful in helping to reduce teacher anxiety towards a technology they perceived as difficult, meant only for experts, and that they believed required long hours of technical training to start using it effectively. With *La Plaza*, teachers can avoid the burden of first having to learn the operating system and can start familiarizing themselves with computers and e-mail in just a few hours. As ICT evolved, this software was replaced in urban schools with the use of Web-based interfaces.

Figure 15. La Plaza, a user friendly interface

As it is suggested by its name, this application consists of a graphic metaphor of a town's main square. Through icons of buildings that are a familiar sight in most Chilean cities and towns, the software provides four different work environments: a Post Office, a Kiosk, a Cultural Centre and a Museum.

Figure 16. Post Office, Kiosk and Cultural Center

[23] See http://www.mineduc.cl/ for further details about the SIMCE tests.

The *Post Office* is a friendly e-mail system, specially designed for students and teachers. It is an informal mechanism to establish first contact, and then to form a workgroup around a discussion topic of common interest in the Cultural Centre. This is a bulletin board system for developing collaborative projects and also a place to establish communication among teachers with common concerns, and for them to exchange experiences, written work and opinions. *The Kiosk* offers a window to dynamic information containing electronic newspapers and digital storybooks for students and teachers. *The Museum* is a database from which one can access information, experiences, demonstrations and uses of educational software along with the software itself.

One of the content-relevant CDs developed by Enlaces is called "Jaqaru, let's play to learn Aymara." Its purpose is to assist bilingual learning in schools from northern Chile attended by Aymara children.

Figure 17. The Jaqaru CD and an example of a screen with content

Another CD is "Pre-Hispanic indigenous peoples in Chile. Its content presents eleven of the most important indigenous peoples that were living in Chile around the sixteenth century. It is designed for history and social science, language, arts and mathematics in primary rural schools.

Figure 18. The Pre-Hispanic People CD and one content page

Some of the software for rural schools and most of the teacher-training materials (documents and websites) for Rural-Enlaces follow a particular instructional design with the aid of rural and educational specialists. One problem with this approach is the materials' high production costs for a relatively small student population. One important cost has been the difficulty in building up a team of people who can design instructional content for each of the rural special cases. For example, in southern Chile, there are many factions and subcultures of the Mapuche people, each very sensitive about content related to their culture, a situation that imposes another level of complexity and additional development costs.

Despite the difficulties, what has been of particular significance in rural schools has been the opportunity to start with the technology inside the classroom from the first day. This situation has led Rural-Enlaces to design a set of precise and extensive activities and examples for both teachers and students to allow them to work with the technology right after the first teacher training session.

e. Technological Implementation

As has already been mentioned, a key decision for small schools in Rural-Enlaces has been the deployment of hardware inside the regular classroom. We have assumed that computers inside the classroom would not be used on a one-computer-per-student arrangement but as a learning corner, shared by groups of students.

In our experience, we have found that one computer per school even in small schools (i.e. 10 students) is not adequate because it leaves the school highly vulnerable to total loss of ICT resources in case of any kind of failure. Therefore, we decided to have a minimum of two computers per school, no matter how small the school was.

Installation of electrical and local data networks has been part of the equipment acquisition. Special care has been taken in cases of instabilities in the electric power supply, which are frequent in some rural areas. Therefore, the equipment acquisition includes an uninterrupted power supply (UPS) with electrical stabilization.

Figure 19. ICT corner in rural schools

Environmental conditions and security are two major concerns in relation to equipment care. Rural areas are more vulnerable to high concentrations of dust in the air and high humidity, which are two variables that affect the lifetime of computer equipment. In terms of security, rural schools are usually located in places with no close neighbors and may stay unprotected for long periods during weekends and vacations. These conditions call for a special attention to the computer furniture, which should allow for equipment to be kept locked outside of class periods.

As a measure of protection against robberies, the purchase of equipment insurance has been highly recommended.

f. Internet Access

Internet access is still expensive in Chilean rural areas, and it is also one of the major technological challenges.

When technical and economical conditions allowed for it, Rural-Enlaces included Internet access as part of the ICT package. But when this was not possible, the program has been divided in two steps: The first step includes pedagogical use of ICT to support classroom activities. The second step includes the school's connection to the Internet.

When no Internet is available, a CD with packaged web sites carrying educational content material is provided. This CD is installed in the Local Area Network for access by all computers. This approach allows rural students to have access to valuable content that is usually found on the Internet (such as literature, music, science, museums), but carries restrictions on the access of communication services and content information (particularly the ones depending on on-line database access).

If schools have basic communication infrastructure (dial-up phone lines), then dial-up Internet access has been implemented. Still, rural telephone services have high costs, which -- particularly when there is a time-based fare -- makes Internet costs prohibitive for a limited school budget. In this case, a trade-off solution has been to provide only electronic mail service through connections that occur during low-fare hours and at the same time, to provide CD ROM-packaged web-based materials.

Technical solutions for full Internet access in rural areas are now available in the market. Radio-based wireless solutions have the attraction of a one-time installation cost and no further operating costs. These solutions work well for specific cases, but have the hidden cost of requiring specialized support in case of failures. Any large-scale solution incorporates these costs as well as the costs for the repairing and replacing communication equipment. This often makes it a good idea to agree to pay for these services with a monthly fee at the time of equipment purchase.

One problem with communication solutions for rural areas is that they often require a high investment in infrastructure, making the service extremely expensive for a small number of access points. A larger scale design might promote a more attractive market for rural services with lower costs per point.

For example, a satellite-based solution might make possible shared use with a monthly cost of several thousand dollars, which can be used to provide shared Internet access to thousands of schools. Each school might require local communication equipment (such as a VSAT) with an initial investment of about US$3,000 (costs are becoming rapidly more affordable). The complete solution might require a complex financial design, but technically and economically it is possible to provide Internet access to a large number of rural schools for a relatively low monthly fee (less than US$50). The financial design might include a combination of public subsidy for initial investment and a school payment for recurrent costs. Satellite solutions are developing rapidly and prices should continue dropping. Satellite solutions might well become a more effective and affordable solution in the next few years.

> The Mexican "RedEscolar" (http://www.redescolar.ilce.edu.mx/) has a long tradition in distance education through satellite TV, and is currently working on satellite-based solutions for providing Internet access to schools.
>
> The World Links organization (http://www.world-links.org/) has piloted several technologies for Internet access and is currently implementing a VSAT broadband Internet access experience with rural schools in Uganda.

Rural-Enlaces is continually experimenting with new technologies. A recent study with GSM/GPRS and CDMA wireless mobile technologies using cellular phones has given encouraging results in terms of geographical availability and quality of data transfer. However, communication costs would still need to be subsidized. According to our experience, most Chilean rural schools regard US$20/month as the highest possible communication cost they could afford.

Perhaps the most promising solution for rural areas at present is wireless technology with the emergence of new technologies for point-to-point connections (i.e. developed around IEEE 802.16 standards). See chapter on Technology and [47] for more details.

g. Technological Support

Technical support in case of failures is a major problem with computer equipment in rural areas. It is critical to consider the provision of technical support as part of the complete design of the ICT program in order to maintain the equipment.

A first concern is the provision of equipment warranty in case of failures. We considered an extended initial warranty combined with the provision of technical support to the schools after the warranty is expired.

> In the Chilean Enlaces program, equipment is bought with a two-year warranty, but other experiences – such as the Brazilian Proinfo Program (http://www.proinfo.gov.br/) – require a longer period.

In the Chilean case, the per-school cost of technological support averages US$2,500. It does depend on the size of the school: one, two or three classrooms. It includes a local area network and electrical installations in the classrooms, and an extended on-site warranty for 2 years. Hardware provision includes one computer, printer, and productivity software (office style) for each classroom One-classroom schools receive two computers. Additionally, every school receives a flatbed scanner.

Besides the period of warranty, a key aspect is response time. *Onsite* service means high costs in distant areas if the equipment provider does not have a well-distributed technical support network. Conversely, a *Carry-in* service might make it impossible for the schools to solve transportation costs and logistics.

Even with good on-site technical support from the equipment provider, it might be difficult to actually make the notification of failures if the school has no telephone or Internet service. In this case, it has been important to consider warranty management support by the institutions that provide the school's teacher training which do maintain a regular contact with the school.

Besides the equipment warranty and technical support, it is important to consider basic technical support for those problems that might not be covered by the warranty, such as operating system configurations or viruses. This type of technical support consists of regular school visits to check the technical situation, identifying problems that teachers might not be aware of, and emergency visits to solve problems detected by the school.

Because school visits for technical support might involve high transportation and labor costs, some elementary trouble-shooting skills have been included during teacher training to solve virus infections, basic hardware and operating system configuration problems, to teach back-up procedures and simple cable connections.

h. Community Involvement

The incorporation of ICT into the schools[24] can greatly benefit community involvement in school activities. On one hand, parents' support might be crucial to finance some of the recurrent costs (computer supplies, telephone charges, etc.), and on the other hand, the school may be the only possibility for parents themselves to gain access to technology and training. Hence, rural schools can become part of larger initiatives to offer technology access to rural communities.

In Chilean rural schools, it is often the case that parents are regularly invited to attend the schools and help in different ways. For example, if the sole teacher needs time for a meeting, a mother might voluntarily come in to attend the children. Parents are stimulated to use the technology, and in many cases it is the children who help the parents with computers and software. This situation has had a positive effect on the parent-child relationship and also on improving the attitude of parents toward helping their children's school.

[24] See also: http://www.worldbank.org/wbi/ictforeducation/html/

VIII. INITIAL IMPLEMENTATION PRIORITIES

The preceding chapters of this document contain a large number of issues, which, according to our experience, need to be considered when designing an ICT policy for education. As a closing section, we believe it relevant to suggest a few policy implementation priorities that may help in getting a new program started. However, decision-makers are typically faced with many conflicting challenges, with ICT-related issues competing with other pressing matters such as poverty alleviation or healthcare, and it is unlikely that all areas of ICT need can be addressed immediately. Therefore, it is strongly recommended that each country make its own decisions and set its own priorities based on its most important educational needs, its level of infra-structural development, and its medium- to long-range budgetary resources.

The first steps might well be the most sensitive with regard to sustainability and success because the whole ICT program direction might depend on the quality of these early decisions. Therefore, it is advisable to focus on the people and on the initial few critical decisions that will set the framework for what can be expected from the program in the long run.

1. Appointment of the Core Management Team and Initial Documents

The appointment of the core management team is the starting point of an ICT Program. However, at the beginning, and due to the importance of performing a careful selection of the management team's director, a special commission could be assigned the task of head-hunting and establishing an initial working relationship with the Ministry of Education to put together the national parameters of priorities, timings, focus and initial budget. This commission could also propose an initial institutional framework appropriate for the implementation of the ICT program.

The core management team should include at least the program's director, an educator with experience in using ICT in education, and an engineer with experience in hardware, software and telecommunications. A related decision is the appointment of a small advisory board with three to five experienced professionals from industry, government and academia that may help in providing a broad national perspective for the first decisions from the management team. A seasoned international expert, if budget permits, should also be included n this board from its inception.

The management team should spend three to five months visiting ongoing initiatives in other countries, to conduct interviews and meetings with different departments of the Ministry of Education and related institutions, to browse through the available literature, and to assess the country's distribution and quality of its electrical and telecommunications infrastructure.

As a result, the management team should produce a set of two documents: a Position Paper and an Implementation Plan.

The Implementation Plan should be addressed to national leaders, to institutions that might directly participate (i.e. foundations, ICT companies and universities) and to the management team itself. It should contain the broad strategic goals and guidelines for the ICT program at large, a discussion of the cost-benefit ratios of the available options, the country's strengths and weaknesses (i.e. electricity or Internet provision), and a general plan for the steps during the following 6-12 months, together with an initial estimate of the budget.

The Position Paper should be a well documented text addressed to a larger audience to inform it the ICT policy and to receive feedback and constructive criticism from different sources, such as academia, government, legislators, private sector and other relevant public and private institutions as well from national opinion leaders.

One of the goals at this stage is to develop a common strategic vision, a sense of shared purpose, and to devise a corporate image and an effective public communication strategy. It is critical for the future of the program to achieve a shared understanding in relation to strategic priorities.

2. Alignment of the ICT Policy with National Educational Priorities

The management team should not launch the design of the ICT Program as a project separate from the rest of the country's educational efforts. This is even more critical if an educational reform is underway. The management team should establish early, close working relationships with other educational teams at the national level (e.g. curriculum designers, teacher trainers, experts in rural education, etc.), in order to improve efficacy and avoid repetition, or worse, delivering inconsistent messages and content to teachers.

This alignment of the ICT management team with other educational teams should also provide information and feedback for the definition and evaluation of products and procedures relevant to the ICT policy, which should be in step with related efforts in other areas of education at the national level. Because of possible political effects, the evaluation goals should be revised and approved by the national educational authorities.

When possible, the alignment of the national curriculum and national assessment strategies with the ICT policy is advisable. To include ICT goals (i.e. ICT skills) as part of the curriculum and to assess them through use of the national tests will provide a strong visibility and credibility to the ICT program.

It is also important to establish a close relationship with key players in industry and politics. For example, in some countries the inclusion of the teachers' union could help in achieving higher teacher acceptance. If the telecommunications industry or service providers have a relevant role in the country, they should also be considered to discuss Internet access and educational tariffs.

3. Deciding To Start at Educational Level

The decision of where and at how many schools to launch an ICT program primarily depends on the educational priorities at the national level. It also depends on the availability of teacher training and technical support infrastructure (i.e. through a network of universities) and on the quality and reliability of the telecommunication infrastructure for Internet in the schools. If options are available, each one will call for a different approach and will have its own requirements. For example:

- Start with primary schools only. Most developing countries need to improve the quality of education in early reading, writing and arithmetic. For them, it makes sense to address these problems first. The particular software to be purchased, the curriculum-related digital content (Internet or CDs) to be produced, and the teacher-training program can all be specially tailored for these schools. This option is the least complex.

- Start with rural schools only. Rural schools have more complex demands for an ICT Program due to their relative isolation from urban areas where more assistance is at hand. They also, normally, have more pressing educational problems. A decision in this direction may take longer to implement, but in the medium and long run, it may produce faster and more profound educational and social impact.

- Start with secondary schools only. This will call for a software and teacher training strategy that considers more precisely each subject matter than is necessary in primary schools where a more generalist approach is possible. If preparing young people for the work market is a national priority, then, the ICT program could focus on the skills required (e.g. information handling skills), vocational teacher training, and proficiency in productivity software.

A mixture of some or all of the above options, though more complex, is also possible. However, such a program will need to assemble a more robust and experienced management team from the very beginning to address the different realities and their specific requirements (software, teachers, student's needs, etc.) and probably a longer pilot stage to acquire the necessary experience before scaling up.

4. Definition of the Pilot Stage and Staff Development Plan

The benefits of a pilot stage as the starting point for an ICT Program have been discussed extensively in this document. It serves to gain experience and to obtain information for the next broader steps. The size of the pilot phase ought to take into account the availability of capable ICT trainers, the budget allotted for such purpose, and the convenience to test trial responses from the most typical school categories (i.e., large and small, urban and rural, public and private).

At this stage, it will also be necessary to prepare plans for a teacher-training program that must be set up at a very early stage. This plan will call for a state-of-the-art teacher-learning model that includes a number of aspects that have been previously discussed. These include teacher's beliefs and attitudes towards innovation, learning methodologies, use of educational software, possible use of e-learning systems, production of exemplary practices, hardware and software trouble-shooting skills.

Presently, given the many exemplary ICT programs put in place by countries from different areas in the world, it is possible to find an already made in-service ICT staff development program that, with some reformulation, could fit a new program's requirements and without the costs it would take to start from scratch (See WorldLinks[25], Intel's Teach to The Future[26] and UNESCO[27] initiatives). The possibility of sharing resources and developing training programs with neighboring countries could also be considered as an eventual policy issue.

The teacher training plan may require production of curriculum-related learning activities, such as examples of "good practices" and some Internet content that may have to be ready before teacher training activities begin.

During this stage, the management team should also allocate time for the following tasks:

- To study and decide upon the configuration of hardware and software the schools will be provided with, and whether this configuration will vary according to school enrolment, class size, and level of education.

- To write the terms of reference and decide on the technical specifications for the first hardware and software procurement, which should be conducted via public bidding. When the budget comes through a loan or a grant from an international agency, this documentation has to be prepared several months in advance because it must be cleared not only by the country's administrative and budgetary technical staff, but also by those from the granting or loaning agency. Therefore, it is important to approach all other decisions that are incidental to procurements, during the first quarter of the year.

- To draft the terms of reference for an independent high-quality external Task Force for baseline and future evaluations. Without solid assessment and baseline data, it will become virtually impossible to monitor whether the ICT policies have had the desired outcome and whether further fine-tuning needs to be considered.

The definition of the number and type of schools to be included in the pilot stage, their geographical location, the number of teachers to be trained and similar decisions will produce the necessary information for the definition of the initial budget. It will also provide input for a possible expansion of the core management team and of the institutions that will have to be called in for help (e.g. universities in different regions).

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[25] WorldLinks is a World Bank Institute's initiative. See: http://www.worldbank.org/worldlinks/ .

[26] Intel's Teach to the Future initiative has trained more than a million teachers worldwide. See: http://www97.intel.com/education/teach/index.htm

[27] UNESCO (http://www.unesco.org) has a comprehensive "curriculum for schools and programme of teacher development" under its "Education and ICTs" theme.

These initial priorities should help with the main decisions during the first year of the ICT Program implementation. However, they should not be taken literally and each country ought to define its priorities according to its own reality and its broader educational policies. Also, at the beginning of the program, it will be important to avoid embarking on technology-driven solutions offered by hardware and software vendors in exchange for special pricing conditions.

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APPENDIX 2. ENLACES TEACHER TRAINING PROGRAM

The Enlaces teacher-training program is at the core of the Chilean policy in education. It has been revised many times by the Ministry of Education and by the network of participating universities that implement it. Independent consultants have evaluated its process and results, and clearly there is still ample room for improvements, particularly for more and better classroom uses of ICT.

> To review a comprehensive ICT teacher-training program, see in the UNESCO web site "A Curriculum for schools and Programme of Teacher Development" (http://www.unesco.org/).

This appendix offers a summarized version of the main elements of the Enlaces teacher-training program. Its goals are the attainment of improvements using ICT in the following three domains: **Pedagogical**, **Managerial**, and **Cultural**. A summary of activities and support materials for teacher training is provided at the end of the appendix.

1. The Pedagogical objective of the program deals with the fostering of innovation in teaching and learning practices inside the classroom. The specific objectives are as follows:

   a) Use ICT resources to enhance learning practices. Teachers should be capable of planning and performing a lesson, which includes:

      - Organizing the physical space, materials and activities to work with ICT, preferably with groups of students, during normal class hours.
      - Incorporating educational and productivity software as well as e-mail and web- based content in curriculum-related activities during normal class hours.

   b) Use ICT resources to prepare materials to enrich learning. Teachers should be capable of:

      - Using productivity software and network applications to plan and prepare class materials, student projects and exercises, work sheets, notes, presentations and other didactic materials.

2. At the managerial domain of the program, the objectives refer to the application of ICT tools and skills to modernize school management. Here, some of the basic elements are:

   a) Use of ICT basic application software to elaborate, maintain and administer school data. Teachers should be capable of:

      - Elaborating and using electronic databases containing student and parent records.
      - Elaborating electronic forms such as memos, official documents (students' marks and reports), lesson plans, etc.
      - Producing electronic promotional materials such as logos, leaflets, posters and web pages.

3. The objective of creating an ICT Culture implies developing the skills to understand and recognize different aspects related to ICT, including the maintenance, renewal and expansion of ICT resources at the school.

   a) Basic technological knowledge and autonomy. Teachers should be capable of:

      - Recognizing the primary purpose and functions of a computer, printer, scanner and screen projector.
      - Using satisfactorily the principal functions of an operating system and of the main productivity applications (word processors, spreadsheets, presentation software and a simple file or database handler).
      - Using the basic functionality of an Internet navigator and an e-mail software.

- Using Internet to communicate with peers and to find and use web links for their field subject.

b) Ethical and legal aspects. Teachers should be capable of:

- Understanding and identifying the main ethical and legal issues related to ICT, such as information privacy, software licenses, copyrights of Internet content, piracy, viruses, pornography, and hacking.

c) Maintenance and Coordination. At least one teacher per school should be capable of:

- Identifying technical problems and resolving whether they can be solved locally or external assistance is needed.
- Performing preventive hardware and software maintenance.
- Administering software and computer files.
- Selecting, purchasing and installing software.
- Configuring peripherals for both local and Internet network.
- Coordinating teachers' and students' (and parents') demands in order to achieve an efficient and fair use of ICT resources.

The content of the Enlaces training program responds to a number of directives provided by the Ministry of Education. Each university that delivers the training program can organize it under a given methodology. An example follows:

1. Training the trainers. Trainers are all important actors in the ICT policy. They are the ones that will assist teachers and move them into new teaching practices. An important effort was devoted to preparing a solid group of professionals with strong links to both academia and schools. They should combine state-of-the-art knowledge on educational innovation, learning, teaching, software, basic hardware troubleshooting, and classroom experience. Teachers appreciate trainers who "know their reality" and will be more inclined towards change if the examples presented are closely related to their reality.

   Therefore, it was important in our case to establish a community of teacher trainers, centrally coordinated, permanently nurtured and clearly positioned as a special task force with an exceptional role. Training of this group starts with general uses of ICT in education following with a gradual specialization in curricular subjects. E-learning over the Internet has been a useful work platform for this group.

Enlaces has gradually formed a group of nearly 1,000 trainers all over the country, each one closely related to a university for his (her) own training. A central database keeps a record of each trainer (professional profile, address, schools attended, etc.). A special web site offers news, documents, e-bulletin boards, conversation lists, etc. A central staff, which is independent from the Management Team, coordinates all actions among trainers, including seminars and courses.

2. Warming Up. This stage starts once the school has been notified that it will be incorporated into the ICT Program, and it ends once the teacher training sessions begin. It entails presenting the Program goals to the school staff, agreeing upon training days and hours, explaining responsibilities, and clearing doubts and answering questions.

   This stage is performed mostly in the school and it may take up about six hours in various meetings and presentations.

3. First year training. Its main goal is to familiarize teachers with the technology, and it is be performed in groups of no more than 20 teachers, including in all cases some administrative staff as well as the school principal.

   This training takes no less than 40 face-to-face hands-on sessions and it is performed at the school. The latter is important because it is the teacher's work place and many of their questions and examples can be addressed in a

realistic and familiar setting. This training is gradually complemented with an increasing number of remote interactions between teachers and facilitator if e-mail is available.

If teachers have no previous experience with ICT, training is started with administrative uses of computers before dealing with pedagogical issues. Administrative tasks can be performed immediately and have no student involvement (if apprehension about the latter were strongly present). With this approach, teachers should quickly perceive ICT as an ally and as support tools for their day-to-day duties.

If Internet access is at hand, teachers are encouraged to use it as an easy-to-explore reservoir of ready-to-use teaching material and to link with peers from other schools and even other countries. Teachers appreciate the possibility of sharing teaching experiences, especially if new methods are being tried.

Training makes use of printed manuals with clear examples and exercises to be performed by the teachers in-between sessions.

4. Second and third year training. Its goal is to provide a deeper understanding and experience of the pedagogical opportunities of ICT in the classroom and to share experiences with other teachers. It lasts for at least 30 to 40 face-to-face sessions if no Internet is available. But if reliable Internet access is available, face-to-face interaction is limited to 1 or 2 sessions per month, supplemented with intense use of e-mail and web based-content presentation and distance tutoring. Administrators are not required to participate at this stage, but they are invited and welcomed.

   Teachers are encouraged to discuss and analyze the changes they are introducing and perceiving when using ICT with students. These discussions sometimes involve (using the network) peers from other schools, and occasionally from other countries.

5. Training of Technology Coordinators. From the beginning, at least one of the teachers at each school is encouraged to engage in a deeper understanding of the pedagogical and administrative aspects of ICT. These teachers play an important role, and if possible, they are paid for their time to avoid voluntarism, which may diminish their dedication after initial enthusiasm is worn out. They will be referred here, in short, as "ICT Coordinators".

   The training of ICT Coordinators is performed in many flexible ways, including (I) a few short special sessions in-between normal teacher sessions, (ii) remotely using e-mail and special webs with pertinent content, (iii) booklets and self-teaching materials.

Support materials. Much of the training material is produced and updated by a central team of experts in the form of CD ROMs, web pages, leaflets and manuals. This centralized production provides important cost reduction. However, trainers are encouraged to complement this material with more pertinent content and examples according to the particular reality they face in each group of schools. Some of these materials are the following:

- Student book. Each teacher receives a "Student book" which contains all administrative information needed for the training course. It includes a summary of the activities to be performed, how to perform them, homework, and assessment. It also contains advice on how to organize their time to take advantage of each training session and also some adult learning strategies.

- Course Text. It contains a detail of all assignments of the course with their evaluations. Its purpose is to allow the teacher to study independently of the available technology (e.g. at home) and at his/her own pace. It also includes a few papers, a glossary of terms, software aids, web links and a number of hints on how to use these resources.

- Web site: each course has a web site with all the course content and assignments. It also contains demos, discussion forums (among students and with a tutor) and news.

- CD: in case of Internet failures or if not available (e.g. at home), this CD contains the Course Text, educational software demos, software utilities (e.g. anti-virus,), administrative examples (e.g. classroom plans, official document forms), clip art, additional papers and some of the web's content.

In our experience, motivated teachers might want to try a variety of tools and engage in network activities beyond what is proposed during training sessions. Therefore, it seems a good idea to offer some additional tools and activities for teachers from the very start of their training activities, such as: electronic communication tools like e-mail, discussion groups, participation on international collaborative projects, computer conferencing, accessing a-la-cart educational resource-banks on the web, specialized portals, etc.

APPENDIX 3. LINKS TO EDUCATIONAL RESOURCES

1. Educational Projects and Sites

Canada: SchoolNet: http://www.schoolnet.ca/
SchoolNet's website comprises more than 7,000 learning resources. Its mission statement is as follows: *SchoolNet readies learners for the knowledge-based society. It champions lifelong learning and the creation of world-class educational resources through information and communication technology (ICT) and partnerships*

Chile: Enlaces and EducarChile: http://www.educarchile.cl/
EducarChile is the most comprehensive educational web site in Chile, developed by the Ministry of Education through its Enlaces (http://www.redenlaces.cl/) program and Fundación Chile. Its content includes resources for all levels of education, from K-12 to universities.

Colombia: Conexiones: http://www.conexiones.eafit.edu.co/
Conexiones is a project to research, develop and evaluate new learning environments in basic education. Conexiones aims to foster the use of new pedagogical methodologies based upon the flexibility and adaptation of the curriculum, encouraging individual capabilities to reach group goals, teacher training, and community involvement. To accomplish this goal Conexiones has been deploying a pilot communications network now linking 35 public and private schools in urban and rural areas of Medellín, Colombia

Costa Rica: Fundación Omar Dengo. http://www.fod.ac.cr/
The Omar Dengo Foundation is a private, non-profit organization created in 1987 to promote the economic, social and human development of Costa Rica, implementing innovative programs to improve the quality of education. The Foundation is a pioneer in the introduction of computer technologies, innovative educational programs and new learning environments into the country's public elementary school system. It stimulates learning processes, creativity and development of thinking skills in public education and in the different situations in which learning takes place. The organization was founded by a group of Costa Rican intellectuals and entrepreneurs, who are a source of ideas for the development of projects and implementation of innovative financing schemes. (from the Omar Dengo web site).

México: RedEscolar: http://www.redesc.ilce.edu.mx/
RED ESCOLAR has a flexible ICT model that is adaptable to each school reality. The model is based on the educational uses of TV and ICT by using the EDUSAT satellite network and Internet connection. RedEscolar provides each school with computers, Internet connection, a TV set and a wide range of educational resources.

Spain: Generalitat Catalunya: http://www.edu365.com/
Educational portal of the Generalitat de Catalunya, Departament d'Ensenyament. It is in Cataluna but has numerous resources for all levels of education.

USA: Challenge Multimedia Project 2000 http://pblmm.k12.ca.us/ is part of the "21st Century Education Initiative," a Silicon Valley-based educational effort starting in the early 1990s, with the goal of achieving world-class educational standards for its schools. According to their own definition, *the Challenge 2000 Multimedia Project is an innovative program that harnesses the power of multimedia to engage students in challenging learning activities. Students complete projects that draw on real-world information and research methods and design them as sophisticated multimedia presentations. Students learn coursework and technology skills in a way that also fosters valuable work place competencies such as teamwork, communication, planning and problem solving. Students display their work at Project-sponsored multimedia fairs.*

In September 2000, the Project's success earned its recognition from the U.S. Department of Education as one of only two "exemplary" educational technology programs in the nation.

A number of projects and educational web sites are not directly related to a particular country, but have a more global perspective. They provide educational resources or work with schools in many countries, fostering international collaboration through educational projects developed by teachers and students through the Internet.

I*Earn: http://www.iearn.org/ (from I*Earn site): *iEARN (International Education and Resource Network) is a non-profit organization made up of more than 4,000 schools in nearly 100 countries. iEARN empowers teachers and young people to work together online at very low cost using the Internet and other new technologies. Since 1988, iEARN has pioneered on-line school linkages to enable students to engage in meaningful educational projects with peers in their countries and around the world. iEARN is:*

- *an inclusive and culturally diverse community*
- *a safe and structured environment in which the young can communicate*
- *an opportunity to apply knowledge in service-learning projects*
- *a community of educators and learners making a difference as part of the educational process*

European Schoolnet: http://www.eun.org *"The European SchoolNet is an international partnership of 23 European Ministries of Education developing learning for schools, teachers and pupils across Europe. It provides insights into the use of ICT in Europe for policy-makers and education professionals. This goal is achieved through communication and information exchange at all levels of school education using innovative technologies, and by acting as a gateway to national and regional school networks. Teachers find resources, news, practice examples and collaboration opportunities at eSchoolnet the educational portal for schools in Europe".* (from SchoolNet site).

Becta: http://www.becta.org.uk The British Educational Communications and Technology Advisor is a British government (Department of Education and Employment) initiative to advise and help on issues related to ICT in education. *"The Becta web site provides information, advice and dialogue related to ICT in education for the schools and FE sectors. From case studies and examples of good practice to practical guidance on using ICT within the curriculum and for administration, the Becta web site keeps you up-to-date with this fast-moving world, and you'll be losing out if you don't stop off here regularly".* (from Becta site).

The **Imfundo** Initiative http://www.imfundo.org *Imfundo is a unique initiative, providing partners with a rare opportunity to help transform the education sector in Africa*…Imfundo's unique contribution is the way *in which our ResourceBank combines the skills and contributions of a wide range of different partners to help African governments achieve the international development targets of gender equality and universal primary education. Working together, we are able to achieve far more than we could alone. With DFID funding, the hardware, software and management expertise of the private sector, the research skills of universities, and the local expertise and involvement of civil society organizations, we can help to create innovative and sustainable solutions. Our KnowledgeBank is designed to share* information about the use of ICT for enhancing education across Africa. We are keen to build it *up to provide a wealth of material of relevance not only to government officials, but also to teachers and practitioners throughout Africa.* (from Imfundo site).

ISTE. http://www.iste.org/ International Society for Technology in Education.
A nonprofit professional organization with a worldwide membership of leaders and potential leaders in educational technology. We are dedicated to providing leadership and service to improve teaching and learning by advancing the effective use of technology in K–12 education and teacher education. We provide our members with information, networking opportunities, and guidance as they face the challenge of incorporating computers, the Internet, and other new technologies into their schools. (From ISTE web site).

UNESCO: http://portal.unesco.org/ (United Nations Educational, Scientific and Cultural Organization) is a comprehensive UN web site with many ICT related educational resources.

WorldLinks: http://www.worldbank.org/worldlinks/ *World Links for Development (WorLD) began in 1997 as a philanthropic pilot initiative in response to widespread requests from developing countries to assist them in preparing their youth to enter an information age and participate effectively in the global economy of the next millennium. Reaching over 200,000 teachers and students in 22 developing countries, WorLD provided sustainable solutions for mobilizing the equipment, training, educational resources and school-to-school, NGO and public-*

private sector partnerships required to bring students in developing countries online and into the global community. (from WorLD web site).

2. Educational Software

The following is a short list of some interesting internet sites, with Spanish and English versions (when language is relevant) of web-based content and software.

- Educational software magazine: Children's Software & New Media Revue: http://www.childrenssoftware.com/ (English)

- BECTA educational software database: http://besd.becta.org.uk/ (English)

- HomeWorkSpot is a web site with many links to educational resources, including educational software, organized by grade and subject matter. http://homeworkspot.com and http://www.startspot.com/network/

- EDUCARCHILE software database: http://www.educarchile.cl/ (Spanish)

- Science: http://www.sln.org/ The Science Learning Network (SLN) is an online community of educators, students, schools, science museums and other institutions demonstrating a new model for science education inquiry. Contains information and links to sites in many languages, including English and Spanish.

- MicroWorlds: http://www.microworlds.com/ interactive environment for educational project building. Used mostly in primary schools but it is also useful in all grades.

- KidPix: http://www.kidpix.com/ creative painting and story animation for primary schools. It can be used in arts and early literacy.

- Eduteka (Spanish) http://www.eduteka.org/

- K-12 Mathematics.
- NRICH: http://nrich.maths.org/
- Illuminations. http://illuminations.nctm.org/
- Interactive Mathematics. http://matti.usu.edu/nlvm/nav/index.html
- ENC (math and science): http://www.enc.org/

- Mathematics for primary education: Math Arena, from Sunburst Technology http://www.sunburst.com/matharena/ has been awarded the 2001 Bologna New Media Prize in the Best Educational Software category.

- Mathematics for secondary education. Freudenthal Institute for secondary education http://www.fi.uu.nl/wisweb/welcome_en.html

- Mathematics from grade 5 through college: Geometer's Sketchpad. http://www.keypress.com/sketchpad/ . List of web sites related to Sketchpad: http://www.keypress.com/sketchpad/sketchlinks.html

- Cabri Geometre: interactive geometry for secondary schools. With a large community of users and links for educators. http://www-cabri.imag.fr/

- Modellus: http://phoenix.sce.fct.unl.pt/modellus/index.htm to create and explore mathematical models.

- SimCity:http://simcity.ea.com/ simulation for primary and secondary schools.

- A.D.A.M.: The Inside Story. Life science. http://education.adam.com/ A multimedia introduction to the human body for grades 5-8.

- Abrapalabra (Spanish) http://www.unlimited.cl/. Early literacy software.

- Red Escolar Nacional Venezolana (Spanish). http://www.rena.e12.ve/

- Creative Writer. http://www.microsoft.com/kids/default.asp. Learning to write and to publish on the web; also for school newspaper projects.

- Content producing tools (authoring tools) for secondary school projects involving programming (extracurricular). High level multimedia authoring tools:
  Metacard:: http://www.metacard.com/
  Toolbook: http://home.click2learn.com/en/toolbook/index.asp
  Revolution: http://www.runrev.com/
  Hyperstudio: http://www.hyperstudio.com/

  Comprehensive programming environments: Director, Dreamweaver and Authorware from Macromedia: http://www.macromedia.com/).

  Graphics design and sound edition software: Photoshop or Illustrator from Adobe: http://www.adobe.com/

3. Educational Magazines and ICT related Research Organizations

Techknowlogia. http://www.techknowlogia.org/

Interactive Educational Multimedia. http://www.ub.es/multimedia/iem/welcome.html

eLearn Magazine. Education and Technology in Perspective. An ACM Publication. http://elearnmag.org

Educational Technology. Educational Technology Publications. 700 Palisade Avenue, Englewood Cliffs, New Jersey 07632-0564

Educational Leadership. ASCD Association for Supervision and Curriculum Development. e-mail: el@ascd.org

Educational Technology Research and Development (ETR&D). A quarterly publication of the Association for Educational Communications and Technology. 1800 North Stonelake Drive, Bloomington, IN 47404. USA.

IFIP: International Federation for Information Processing. http://www.ifip.or.at/

Computers & Education. Elsevier Science Ltd. http://www.sciencedirect.com/

The Journal of the Learning Sciences. Lawrence Erlbaum Associates, Inc. http://www.catchword.com

British Journal of Educational Technology. Blackwell Publishing on behalf of the British Educational Communications and Technology Agency. http://www.ingenta.com/

Educational Technology & Society. http://ifets.ieee.org/periodical/

International Journal of Educational Research. Elsevier Science Ltd. http://www.sciencedirect.com/

Educational Research. Routledge, part of the Taylor & Francis Group. http://www.catchword.com

British Educational Research Journal. Carfax Publishing, part of the Taylor & Francis Group. http://www.catchword.com

ITALICS. Innovations in Teaching And Learning in Information and Computer Sciences. http://www.ics.ltsn.ac.uk/pub/italics/index.html

Journal of Computing in Childhood Education is Published Quarterly by the Association for the Advancement of Computing in Education (AACE). Charlottesville, VA 22902, USA. e-mail and URL: aace@virginia.edu, www.aace.org

Journal of Interactive Learning Research is Published Quarterly by the Association for the Advancement of Computing in Education (AACE). Charlottesville, VA 22902, USA. e-mail and URL: aace@virginia.edu, www.aace.org

International Journal of Educational Telecommunications is Published Quarterly by the Association for the Advancement of Computing in Education (AACE). Charlottesville, VA 22902, USA. e-mail and URL: aace@virginia.edu, www.aace.org

Journal of Educational Multimedia and Hypermedia is Published Quarterly by the Association for the Advancement of Computing in Education (AACE). Charlottesville, VA 22902, USA. e-mail and URL: aace@virginia.edu, www.aace.org

Education and Information Technologies. Official Journal of the IFIP Technical Committee on Education. Kluwer Academic Publishers, 101 Philip Drive, Assinippi Park, Norwell, MA 02061, USA. e-mail: Kluwer@wkap.com

Journal of Technology and Teacher Education is Published Quarterly by the Association for the Advancement of Computing in Education (AACE) and Society for Information Tecnhology and Teacher Education (SITE). Charlottesville, VA 22902, USA. e-mail and URL: info@aace.org , www.aace.org

APPENDIX 4. INDICATORS FOR PRODUCT EVALUATION

Action	Definition	Indicators	Example or Formula
Teacher Training	Execution of the task (to train) and the quality of the training (defined through its goals and standards).	1. Nr. of training sessions per school 2. Nr. of training hours per school 3. Nr. of teachers trained per school 4. Percentage of teachers trained 5. Training goals 6. ICT standards	1. # of training sessions done/expected # of training sessions 2. # of training hours done / expected # of training hours 3. # of teachers trained / expected # of teachers 4. Teachers trained / total teachers in the system 5. Contents to be learned by each trained teacher 6. Expected ICT skills to be acquired by each trained teacher
Technical Support	Execution of the task and quality of the service provided	7. Nr. of support visits (preventive and corrective support). 8. Average time per-visit 9. Response time 10. Number of problems solved	7. # of support visits done/expected # of support visits. 8. Hours that the technician spent at the school 9. Time between call for failure and response 10. # failures reported and fixed / # failures reported
Hardware Provision	Quality of the hardware, its distribution, installation process and of the warranty service provided by the company. Another aspect which can also be evaluated is the actual use of the hardware provided.	11. Technical specifications of the hardware 12. Installation schedule 13. Data network standards 14. Power network standards 15. Furniture standards 16. Student /computer ratio 17. Teachers / computer ratio 18. Time of use of the hardware 19. Number of students and teachers using the hardware	11. Defined specifications of the hardware compared with the real characteristics of the hardware 12. Defined schedule for installation of the hardware at each school compared to the real installation dates (days behind schedule) 13. Technical specifications of the local area networks at each school's laboratory 14. Technical specifications of the electrical installation at each school's laboratory 15. Technical specifications of the furniture provided for each school's laboratory (tables, chairs) 16. Average in the country of (# of students at a school / # of computers available for students in a school) 17. Average in the country of (# of teachers at a school / # of computers available for teachers in a school) 18. Average hours per week that computers are used per students 19. Number of students and teachers that have access to use the computers per week

Action	Definition	Indicators	Example or Formula
Software Provision:	Quality of the software, its distribution and usefulness of the software.	20. Technical specifications of the software 21. Pedagogical specification of the software 22. Installation schedule 23. Software licenses / Student ratio 24. Software licenses / Computer ratio 25. Number of students using the software 26. Reported usefulness of the software	20. Defined specifications of the software compared with the real characteristics of the software 21. Degree to which the software provided addresses subjects or goals of the curriculum 22. Defined schedule for installation of the software at each school compared to the real installation dates (days behind schedule) 23. Average in the country of (# of students at a school / # of licenses of software available for students in a school) 24. Average in the country of (# of computers for students at a school / # of licenses of software available for students in a school) 25. Number of students per week that use the software 26. Degree to which teachers report that the software is useful in their pedagogical practice
Internet Provision	Services such as web hosting, Internet access and others such as e-mail, chat, video conferencing, etc. Generally, these services are provided by external agencies (communications companies) so it is advisable to define clear standards and monitoring procedures.	27. Availability of service (time up) 28. Accessibility (quality of internet the connection and lines) 29. Response rate on request 30. Number of hits 31. Number of users connected simultaneously	27. # hours that the service is available / # of hours that the service should be available 28. Average Internet connection speed of each school 29. Average time spent between a service request (web page) and response 30. Number of visits per day (week, month) to given web pages 31. Supported number of users simultaneously connected
General	It is important to evaluate the perception of the quality of each service provided. This can help to redefine the standards defined for each service.	32. Degree in which teachers and students perceive that the services fit their expectations.	32. Teachers' and students' perception about the quality of the services provided (hardware, software, training and Internet).

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