

SECTION 4

TECHNOLOGIES FOR TEACHER PROFESSIONAL DEVELOPMENT—COMPUTERS AND THE INTERNET

GUIDING QUESTIONS

- In what parts of our school systems are teachers ready to develop the intermediate and advanced skills supported by computers and the Internet?
- How will computers and the Internet extend and improve our TPD efforts?
- To take advantage of available capacities and infrastructure, and to meet teachers' needs, should we locate computers for TPD in schools, teacher training colleges, or regional centers?
- What is the outlook for gains in national electrical infrastructure? In technical-support capacity? How do these projections affect planning for the use of computers and the Internet?
- Do other technologies, such as radio, or other models, such as site-based TPD, have greater potential to meet our objectives?

IN THIS SECTION

- Potential Uses and Benefits
- The Uganda VSAT Rural Connectivity Project
- Lessons Learned
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SUMMARY

Computers and the Internet can benefit all parts of the education system, including student learning, teacher development, school leadership, and management. Teachers may gain benefits from using these tools in the areas of content, curriculum, instruction, and assessment. Computers are best used to help teachers build *intermediate* and *advanced* skills.

In teacher training colleges, computers and the Internet can be used to increase teachers' basic skills and subject mastery, to provide access to resources that can later be used in classrooms, and to help teachers build familiarity with specific instructional approaches. However, if teachers will not have access to computers after they are posted to schools, the cost of helping teachers acquire computer skills may outweigh the benefits of computer use during their pre-service education.

In schools, computers and the Internet can serve as flexible resources to support TPD and student learning. Teachers can have just-in-time access to learning resources as they are preparing for lessons; can communicate with mentors and colleagues as part of TPD follow up; and can enroll in distance-based certification

programs. In addition, as students gain computer skills, teachers can integrate the use of computer productivity tools and knowledge resources into their approach to learning in all areas of the curriculum.

Barriers to effectively using computers and the Internet in developing countries include poor infrastructure and limited technical capacity. However, many of these barriers have been successfully overcome through comprehensive project design and good management. Successful projects may minimize risk by growing slowly at first before implementation accelerates.

Several projects, including *Enlaces* in Chile and the Uganda VSAT Rural Connectivity Project, have demonstrated that computers and the Internet can have a positive impact on both teachers' practices and students' learning.

In regional teacher centers, computer support for TPD may offer an effective balance of access and considerations of cost, infrastructure, and technical support. Such centers can be situated in "hub" primary schools, secondary schools, teacher training colleges, or district offices, and can offer teachers opportunities to build skills, find resources, and participate in TPD. However, it is critical that TPD in teacher resource centers remain appropriate to the conditions that confront teachers in their schools.

Capital and recurring costs for nationwide implementation of computers and the Internet are high. For example, total funding for the *Enlaces* project, enabling computer access in over 5,300 schools, was approximately US\$160 million over ten years. However, sustainability often poses a greater challenge: monthly connectivity costs for schools in the Uganda VSAT Rural Connectivity project are US\$305 per school, with additional costs for computer maintenance, repairs, and replacement.

POTENTIAL USES AND BENEFITS

Computers and the Internet offer a wide range of supports for teaching and learning. Accordingly, this section addresses computers and the Internet in three situations:

- Teacher training colleges
- Schools
- Regional teacher centers

Personal computers are designed to empower users to find or make information resources, and to communicate with anyone else who uses a computer as a communication tool. When properly presented within the context of TPD, these capacities can help teachers address many of the instructional challenges that they face.

If implemented properly, computers and the Internet can:

- Enhance student learning, teacher development, school management, and community development
- Provide access to new learning resources, including content, lesson plans and assessments
- Enable self-directed learning using resources from CDs and the Internet, or via online distance-learning courses
- Offer access to new learning resources, including content, lesson plans and assessments prepared by ministries of education
- Contribute to national e-Readiness

The potential is there. The challenges to realizing this potential in the resource-strapped environments of LDCs are significant, but they are not insurmountable.

THE UGANDA VSAT RURAL CONNECTIVITY PROJECT: PERSEVERANCE PAYS OFF

In January 2002, SchoolNet Uganda and its partners³ launched the Uganda VSAT Rural Connectivity project, in which 15 rural secondary schools were connected to the Internet by high-speed VSAT⁴ terminals. Several of these school-based telecenters were the first Internet “points of presence” in their regions. The pilot project was designed to test the viability and the impact of the satellite-connected VSAT hardware and 15-unit computers labs, augmented by teacher professional development. In Year One of the two-year project, monthly connectivity costs were partially subsidized, but schools paid all other recurrent costs.

At the end of Year One, the U.S.-based VSAT service provider entered bankruptcy and ceased providing satellite service to Africa. After a year spent developing their educational and community-outreach programs, all 15 schools were without Internet connectivity for the first 9 months of 2003. Near the end of this period, an African VSAT company, AFSAT, established operations in Uganda and determined—in part based on the example of the VSAT Project—that schools comprised a credit-worthy market for rural high-speed Internet. AFSAT began offering lower-speed VSAT service at a reduced rate of US\$305 per month.

However, AFSAT used a different frequency, requiring VSAT hardware that was entirely different from the hardware already installed in the schools. To keep the project alive, the staff of SchoolNet Uganda re-allocated 75 percent of their salaries for 2004 toward the purchase of AFSAT-ready hardware.

All 15 schools in the VSAT Project were again online and—as a result of lower monthly access fees—were entirely self-sustaining. In addition, these schools were joined by other Ugandan schools, many of which became members of SchoolNet Uganda. As of November 2004, 44 Ugandan schools were operating affordable VSAT Internet connections. SchoolNet Uganda has entered into a close working relationship with the Ministry of Education and Sport, and has received grant funding from several sources to expand its programs.

LESSONS LEARNED

What initial lessons can be learned from the experience of the Uganda VSAT Project? Among them:

- Flexibility and perseverance are critical, as unforeseen challenges will arise.
- Local solutions, when available, are preferable to out-sourcing solutions internationally.
- Decentralized solutions—in this case involving an independent NGO, a private-sector provider, and school administrations with reasonable autonomy—may be most effective during the early phases of ICT adoption.

The change in regulations by the Ministry of Education and Sport (MOES) to allow schools to raise fees at their own discretion was a key factor in the success of the Uganda VSAT project. Decentralization of financial and operational controls of schools is *one* means of facilitating the diffusion of computers in schools. In Uganda, schools have been aggressive and successful in raising funds and securing donations of hardware. As a result, AFSAT and other private-sector vendors of ICT goods and services have begun marketing to schools directly.

This aspect of project evolution is addressed from other perspectives in the *Section 10: Effective Partnerships for ICT-supported Teacher Professional Development*.

COMPUTERS AND THE INTERNET IN TEACHER TRAINING COLLEGES

The design of computer-enabled TPD *must* be appropriate for the school environments in which teachers are working. When computers or the Internet will not be available to teachers in schools, their use for pre-service professional development in teacher training colleges should be shaped by this constraint.

³ Organizations contributing to the Uganda VSAT Rural Connectivity Project included the Ugandan Ministry of Education and Sports, the World Links organization, World Bank Institute, Schools Online, and the Gates Foundation.

⁴ VSAT (Very Small Aperture Terminal) refers to a satellite ground station that can be used to transmit information and communications.

TPD objectives that can be supported by computers in teacher training colleges include:

- Building teachers' numeracy and literacy skills, including spoken and written language
- Building teachers' more advanced subject mastery, including understanding of key concepts
- Building familiarity with approaches to teaching and learning
- Providing access to information resources and tools that can be used in classrooms

Student teachers can benefit from appropriate online distance learning courses that engage student teachers in understanding specific issues in learning and pedagogy. A student teacher might, for example, complete a course on teaching reading that describes stages in learning to read and that introduces specific activities for each stage. For more information, refer to *Section 8: Online Distance Learning for Teacher Professional Development*.

Connect-ED Uganda: Piloting Computer Use in Teacher Training Colleges

Launched in 2000, the Connectivity for Educator Development (Connect-ED) project in Uganda installed computer labs and Internet connections in eight of Uganda's 39 rural primary teacher training colleges plus Kyambogo University (KyU). Project objectives include providing ICT training to teachers and teacher trainers, and using Internet connectivity and new digital learning resources to enhance the teachers-college curriculum.

In the first phase of the project, tutors and teacher trainers received ICT training in the use of Microsoft Office, use of the Internet for educational research, and development of Web sites for education. Once stationed in primary schools, however, those teachers had little opportunity to use their new skills: As of 2004, less than one percent of Uganda's 13,500 primary schools were connected to the Internet.

Initial experience led to recommendations for a second phase of the project, in which "ICT in colleges should be looked at as a tool for learning but not as a subject."⁵ Web- and CD-based resources were developed to support e-learning. These were hosted at KyU and were made accessible to the eight teacher training colleges. Lessons now provide student teachers with access to detailed content across the primary curriculum. Each topic is supported by ideas for classroom activities.

Questions for Further Discussion

Planning for the Connect-ED project should have included consideration of several questions:

- Could a combination of print-based learning resources and the use of more dynamic media (e.g., video, simulations) lead to improved learning outcomes at a reduced cost?
- Could those print resources be made available to all teacher training colleges in Uganda?
- How will computer-lab installations be acquired by the remaining 31 teacher training colleges?
- What is the impact, if any, of unequal access to computers in Ugandan teacher training colleges?

A first step in the design of a project evaluation involves identifying key questions. What questions could be addressed to help assess the impact of Connect-ED? A sample might include:

- How do the online curriculum resources affect learning among student teachers?
- To what degree do student teachers retain subject mastery after one year in the field?
- Do they implement activities in their classrooms that they have encountered online?

By shifting to online distance learning as a means of delivering courses to student teachers, Connect-ED sought to increase the value of its computer installations in the project's Phase II. *If the online courses result in increased subject mastery* among the student teachers, the return on investment in infrastructure and content-development will be positive.

⁵ Additional Internet resources were also consulted. Connect-ED is a project of the Ministry of Education and Sport, Uganda, Academy for Education Development, Education Development Center, and Dot-EDU, funded by USAID.

Consider Computers and the Internet in Teacher Training Colleges When...

Minimum capacity and infrastructure requirements can be met, including:

- Stable electricity is supplied to 90 percent of the teacher training colleges targeted
- Local technical support is available
- Ministry or other long-term financial support is available

Appropriate content is available or can be developed, including:

- Interactive multimedia and simulations targeting specific learning outcomes
- Repositories of graphics, texts, audio, and video to support independent research and lesson-plan development
- Interactive online courses

TPD addresses objectives such as:

- Building mastery of key concepts in subject areas (e.g., through the use of interactive simulations)
- Preparing teachers to integrate computers in teaching and learning *in the schools where they are posted*
- Preparing teachers to access Internet content and other learning resources *from their schools*

COMPUTERS AND THE INTERNET IN SCHOOLS

In schools, computers and the Internet can take on entirely new roles in support of TPD, helping teachers refresh or upgrade content skills, develop curriculum and assessment resources, and learn about new approaches to instruction. When computers are connected to the Internet, teachers can share experiences with online mentors or with peers across the country or continent.

Most initiatives placing computers in schools target students. These projects provide an ICT infrastructure that can be used—and ultimately *must* be used—for TPD as well.

Appropriate objectives for the use of computers and the Internet in schools to support TPD include:

- Providing follow-up support for face-to-face professional development
- Supporting the integration of ICT and other areas of the school curriculum

In addition to these objectives, computers and the Internet in schools may *also* support objectives previously identified for teacher training colleges: enhancing basic skills, building subject mastery, and increasing access to information.

Today, more than 2 million primary and secondary students have access to the *Enlaces* network in their schools. Seventy thousand Chilean teachers have been trained—50 percent of all the teachers in the country.

Questions for Further Discussion

Enlaces is among the world's most successful ICT projects in education. In considering the project's overall impact, key questions might include:

- How well does the project serve children in Chile's poorest communities?
- What impact has the project had on the ways that teachers teach and students learn?

Although 90 percent of Chilean students are served by the project, the remaining 10 percent—often in small schools with a single teacher and a multi-grade classroom—are those students who are far from cities, in rural and mountainous areas that do not have electricity or telephone connections. In cities and towns, however, *Enlaces* has been successfully implemented in schools in disadvantaged communities.

ENLACES: CHILE'S NATIONWIDE LEARNING NETWORK

Chile's *Enlaces* program, now based at *Universidad de la Frontera* in the small southern town of Temuco, began in 1990 in 12 schools in Santiago. Network access in schools was provided by very slow dial-up modems that supported email only. The World Wide Web had yet to launch.

Enlaces has a dual focus: to make ICTs an integral part of learning in Chilean schools, and to improve the performance of students and teachers in all areas of the curriculum.

A key element in the program's initial adoption in schools was the development of a customized user-interface, *La Plaza*, a cartoon representation of a familiar town square that enabled users to launch e-mail applications, explore the network, and access multimedia CDs. Students and teachers could achieve success before they mastered the operating system and file management.

TPD is provided on-site in *Enlaces* schools by a network of over one thousand trainers, coordinated locally and regionally by 35 Chilean universities. At each school, TPD provides 20 teachers with:

- Two-year training covering use of e-mail, the Internet, and educational and office software; creation of teaching materials, and maintenance of hardware and software
- One year of follow-on technical assistance, focusing on incorporating ICT into learning and guiding the school as it develops maintenance and management skills

In addition, teachers attend local "Education Information Technology Encounters" where they exchange experiences and identify best practices.

Impact of Computers in Schools on Teaching and Learning

The educational impact of computers in developing countries has not been extensively studied. A lack of evaluation of, or demonstrable results in pilot phases, combined with the challenges of implementation, create barriers to project extension, replication, and scaling.

Enlaces succeeded in the transition from small-scale pilot to national program in part because its objectives linked directly to proposed goals for educational reform. The project also built a network of partnerships extending from the government, to Chilean universities, to multinational telecommunications and computer companies.

A series of evaluations from 1993 to 1998 showed significant changes in student creativity and reading comprehension, but the project's impact on teachers' behaviors was less clear. *Enlaces* teachers demonstrated improved classroom-management practices, increased comfort with the use of ICTs as educational tools, and increased motivation to participate in TPD. However, changing teachers' approaches to classroom activities and student learning remains a challenge.

Quantitative analysis of the Uganda VSAT Project shows that the project has resulted in measurable changes in teachers' practices and in students' learning. Teachers in schools with computer labs are:

- Four times more likely to assign independent research
- Four times more likely to assign collaborative projects

The combination of factors contributing to these changes includes the computers and the Internet connection, TPD, school leadership, and changes in curriculum and assessment introduced by the Ministry of Education and Sport.

Consider Using Computers and the Internet for TPD in Schools When...

Minimum capacity and infrastructure requirements can be met, including:

- Stable electricity is supplied to 90 percent of the schools targeted

- Local technical support is available
- Ministry or other long-term financial support is available
- Schools are able to raise student fees to cover costs

Curricula have been reformed to emphasize:

- Collaborative work by students in groups
- Independent research and writing
- Use of office productivity software by students to *directly* support learning

TPD addresses objectives such as:

- Preparing teachers to integrate computers in teaching and learning
- Building ICT skills among teachers to support student use of computers
- Establishing online mentoring and TPD follow-up
- Facilitating teacher participation in online communities

COMPUTERS AND THE INTERNET IN REGIONAL TEACHER CENTERS

There are cost-benefit trade-offs to computer-supported TPD in schools and in teacher training colleges:

- Installations *in teacher training colleges* may minimize costs, but may also limit access to pre-service teachers
- Installations *in schools* may provide access to in-service teachers and students, but involve much larger implementations that entail high costs and high levels of infrastructure and technical support

Regional teacher centers of various kinds can serve as cost-effective alternatives to computer labs in teacher training colleges and schools. Computer-supported regional centers can be located in “hub” primary schools, in secondary schools, in teacher training colleges, or in district offices—or in a combination of these facilities. Regional teacher centers can also complement cluster-based methods of TPD, such as lesson study.

The EFA Curriculum Project in Uganda encountered obstacles stemming from inadequate TPD. Teachers were asked to learn via “top-down” instructional methods, both in relation to ICT and in relation to pedagogies. No effort was made to incorporate modeling of desired forms of learning. Though teachers gained skills in using computers, and gained exposure to active-learning pedagogies, they were not adequately prepared to design or build learning resources to enhance instruction.

THE UGANDA EFA CURRICULUM PROJECT: PROVIDING ALTERNATIVE FOR ACCESS

In 2004, three schools involved in the Uganda VSAT Project served as sites for a pilot project in which 27 primary teachers participated in over 70 hours of professional development. TPD led by curriculum-development specialists addressed:

- Using computers and the Internet
- Implementing new teaching and learning techniques
- Developing lesson plans and learning resources

Primary schools were selected on the basis of proximity to VSAT Project schools and as a result of the enthusiasm of head teachers and faculty. In most cases, teachers were able to walk to VSAT Project computer labs in less than 15 minutes. Over the course of the nine-month project, the primary-school teachers averaged five hours of computerlab use per month—subsidized by vouchers from the project funders.

Participating primary schools received low-cost, battery-powered AlphaSmart keyboards to enable teachers to work without visiting the VSAT labs. AlphaSmarts create documents compatible with Microsoft Word. In addition to using the VSAT Project labs, teachers reported that they were able to successfully and valuably use the AlphaSmarts to develop materials for their lesson plans and student activities.

The principle of computer-supported regional teacher centers, however, remains sound. Resource-center access to ICT for primary teachers is being tested in countries such as Bhutan, Rwanda, Namibia and Nicaragua. Regional teacher centers have the potential to maximize access while minimizing costs, and to help overcome inadequate infrastructure: The 15 VSAT terminals installed in secondary schools for the Uganda VSAT Project, for example, have the potential to provide reliable high-speed internet access to teachers in dozens of nearby primary schools.

Consider Using Computers and the Internet for TPD in Regional Teacher Centers When...

Local capacity and infrastructure present obstacles, including:

- Insufficient/unreliable electrical power in rural areas
- Lack of local technical support

TPD objectives include:

- Providing follow-up, mentoring, or collaboration to support pre-service TPD
- Providing primary teachers with access to knowledge resources and communication tools

COST CONSIDERATIONS

Capital costs for projects involving the use of computers and the Internet are high. During pilot phases, these costs are often borne by donor agencies and other external entities. When the pilot phase is finished, however, both financial and technical sustainability of the computer installations can be problematic for schools.

When projects are brought to scale, much higher capital costs are incurred by country governments and are typically covered by loans or credits. In large-scale projects, capital costs are annualized across three to four years—the typical corporate service life of a desktop computer.

Recurrent costs, including Internet connections, hardware maintenance, and ongoing TPD are often more challenging and may limit project success, growth, and sustainability. Some costs are often passed on to schools, which may require changes in financing rules to meet them.

Cost information is provided for the purposes of illustration only; it should not be used as a basis to predict costs in other contexts.

Overall Costs, Enlaces

Enlaces is funded primarily by the Chilean government, with additional contributions toward recurrent costs by schools and communities, and significant in-kind support from Chilean telecommunications companies.

- Total project funding to reach 5,300 schools is estimated at US\$160 million over ten years.
- Lab installations range in cost from US\$5,880 in small schools to US\$20,932 in large schools.

Recurrent costs (TPD, maintenance, electricity, connectivity, etc.) comprise 40 percent of annual costs. Recurrent costs are higher in larger *Enlaces* schools, because these schools must hire lab coordinators and pay for additional printing, repairs and other operational costs.⁶ No information is available on the cost of teacher training.

⁶ In 1998, *Enlaces*-related recurrent costs per student (in other words, not including the cost of hardware) were reported between 4 and 8 percent of total average recurrent costs per student.

For information about the expansion of *Enlaces* from 1992 to 2003, refer to *Strategic Planning for Computer Support of TPD*, in this section.

Installation, Operating and TPD Costs, Uganda VSAT Project

Two-year funding for the Uganda VSAT Rural Connectivity project was approximately US\$900,000. Per-school installation costs were US\$23,480. Internet connectivity and other recurrent costs were typically met by increasing student fees. These increases averaged US\$3.95 per term, or 3 percent of total average fees.

Cost of TPD was US\$ 15,000 per year (or US\$ 1,000 per school) and included salary of one full-time employee plus travel, communications, and other expenses. Roughly 25 percent of teachers received 200 hours of TPD each; cost per teacher trained was approximately US\$80 per year.

STRATEGIC PLANNING FOR COMPUTER SUPPORT OF TPD

In developing countries with emerging economies, there have been a handful of centrally driven, large-scale projects providing computers to schools. Some, such as the Basic Education Project in Turkey (Phase I, 1998 – 2001), have focused on providing near-universal access to computer hardware and the Internet as rapidly as possible. In such instances, challenges can arise in several areas relevant to TPD:

- Lack of locally tested, proven, and replicable models of ICT use in schools
- Lack of organizational infrastructure to provide TPD

In the Basic Education Project, approximately 8,000 secondary schools received computer labs over the course of two years. Quickly developing capacity to provide computer training on a nationwide scale is well beyond the capacities of most ministries of education.

In most countries, providing training to even one or two school faculty “champion trainers” would require contracting an outside organization. Providing *effective* TPD focused on sound pedagogy, in-depth integration of ICT, and adequate follow-up poses a far greater challenge. Meeting this objective may be beyond the capacities of even the largest private-sector providers, as well as the ministry of education.

In Turkey, the project’s limited TPD was supplemented after several years by the Intel Teach to the Future program. Since 2003, the Intel program has provided intensive training to more than 250 Turkish “master teachers”; in a Cascade-model program, these master teachers have provided TPD to more than 25,000 teachers.

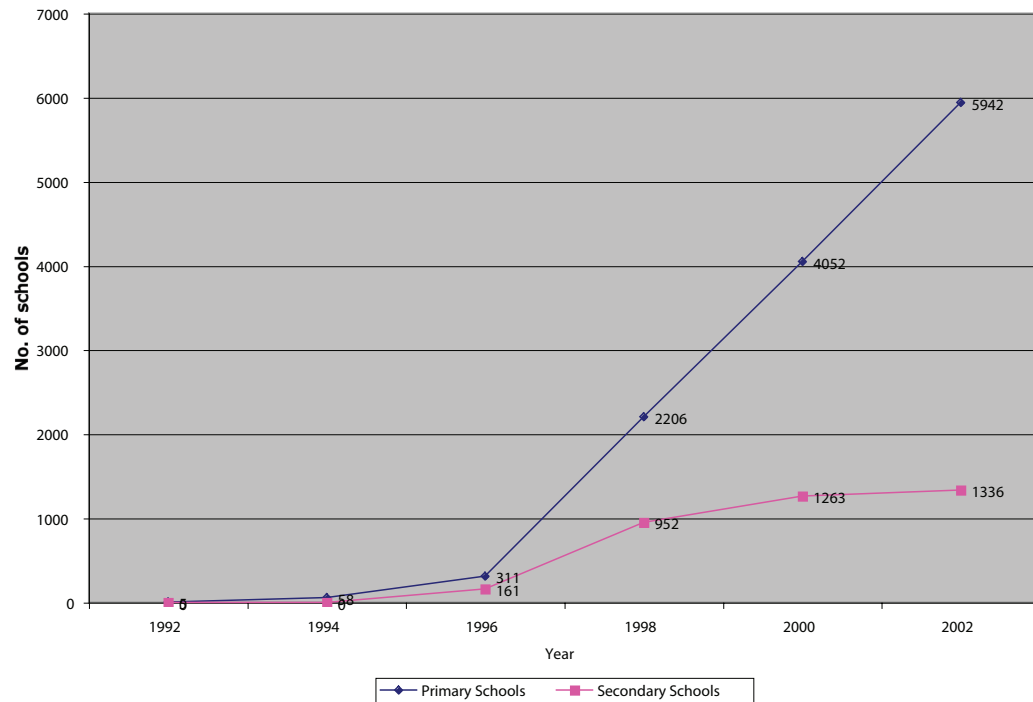
Several areas of inquiry may be instructive in relation to large-scale computer implementations:

- What problems are caused by lag times between lab installation and participation in TPD?
- How do these problems relate to the service lifecycle of computer hardware, the annualization of capital costs, and plans for sustainability?
- What lessons can be drawn for program design and scaling?
- What are the pros and cons of relying on the Intel Foundation to provide all TPD for the project?

Starting Slow: Enlaces

The launch and growth of the *Enlaces* program in Chile offers an example of successful lab installation and TPD in schools. Nationwide access developed gradually over the course of a decade. The project demonstrated success at both the *pilot* level and in several *mid-level* phases before funding to support participation by all Chilean schools was committed.

FIGURE 2: GROWTH IN PRIMARY AND SECONDARY SCHOOLS PARTICIPATING IN ENLACES



Initial implementation involved only five schools. During this pilot phase, both the technical and the pedagogical models were tested and refined. By 1994, 58 schools were included in the project. After refining its models for pedagogy and TPD, *Enlaces* began more rapid expansion in 1996, as shown in Figure 2.

In 2001 *Enlaces* launched a Web-based portal to replace *La Plaza* in most schools. The new *Educar* portal (<http://www.educarchile.cl>) gives students and teachers access to a wider range of more sophisticated learning resources, and includes separate areas for families, school administrators, and researchers.

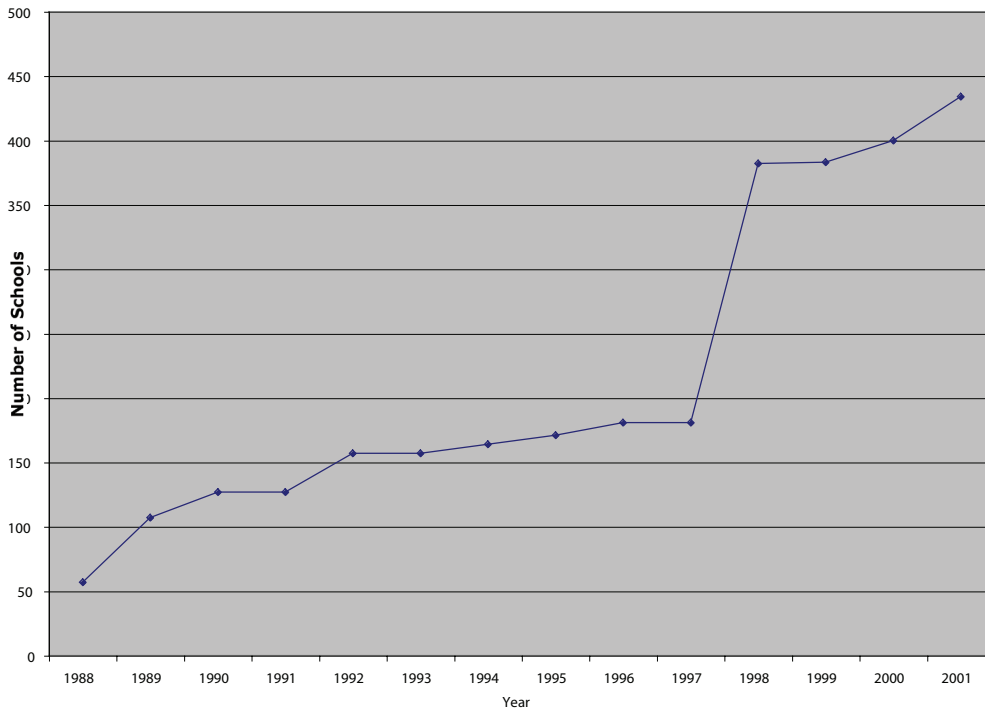
The gradual expansion of *Enlaces* enabled the program to develop TPD capacity to keep pace with the addition of schools.

Focus on Primary Schools: Omar Dengo Foundation

Expansion of the nationwide *Programa de Informática Educativa* (PIE) program in Costa Rica also demonstrates a gradual approach and reliance on a proven model. However, with fewer primary schools and fewer barriers of geography or demographics, the growth of the PIE program is relatively constant—arriving at 90 percent coverage through gradual increases in the number of schools served. (The substantial leap in 1998 resulted from expansion to 116 regular primary schools plus the launch of a new program to serve 69 rural one-teacher multigrade schools.)

The program's small scale, relative to the size of the *Enlaces* program, allows specialists at the Omar Dengo Foundation to meet all requirements for TPD.

FIGURE 3: GROWTH IN NUMBER OF SCHOOLS PARTICIPATING IN THE PIE PROJECT



The PIE program focuses on “continuous” TPD through three complementary modes:

- Yearly TPD sessions for all teachers
- Mentoring and self-assessment
- Bi-annual national conferences

Pedagogy focuses on project-based learning: Student “researchers” at different schools and in different grades work together in teams to create reports, databases, charts, spreadsheets, concept maps, and other “artifacts” generated by the research process.

Question for Further Discussion

Both *Enlaces* and the PIE program are noteworthy—and rare—examples of successful nationwide projects in educational computing. Both projects began with significant efforts in primary schools.

- What advantages do educational-computing projects in primary schools have over projects in secondary schools? What disadvantages?
- What ramifications do primary-school computer projects have for TPD? How might those ramifications be addressed?
- What skills and knowledge should be addressed by TPD to enable teachers to implement project-based learning effectively?

COMPUTERS AND THE INTERNET IN TPD AT A GLANCE

Roles in TPD & education

- Provide productivity tools to write reports, make presentations, communicate, design animations, build Web sites, etc.
- Provide access to guided TPD resources and collaborative environments, and enable the creation of online communities of practice
- Enable acquisition of basic computer skills (ICDL), design skills (e.g., Web pages), programming, and hardware maintenance and repair
- Provide tools (e.g., spreadsheets, databases) that promote higher-order thinking
- Flexible and powerful—can be used to develop materials, access resources, and communicate
- Multiple media and platforms combine text, audio, video, animation, and interactivity
- Centralized and decentralized communication supports dissemination of resources and essential feedback from schools
- May enable learner-centered and active-learning pedagogies
- Enable communication with experts—including TPD mentors, master teachers, and help desks
- Improve subject mastery through Computer-Assisted Instruction (CAI), simulations, and other tools
- Provide support for collaboration—individuals, pairs, and groups of teachers or students can use computers to collaborate online and face-to-face
- Support assessment and recordkeeping—accredited ODLE courses, electronic portfolios, etc.
- Potential for revision and new versions supports reflection, self-assessment, and other learning-related activities

Strengths

Limitations

Cost profile

Other considerations

- Complex tools require both time and TPD to be effective
- Hardware, software, and operating systems are fragile—subject to damage by users, viruses, fluctuating electrical power, etc.
- Hardware and software lose value and utility as they age—corporate and institutional users plan on 3 years of service
- Highly dependent on infrastructure—electrical, telecommunications, road (for repairs), and human (for maintenance and management)
- Without support from leadership and system-wide commitment to new modes of teaching and learning, impact is limited
- Variable production costs—new software tools (e.g., Flash, Director, etc.) drive down production costs of digital content
- Variable content-distribution costs are contingent on Internet connectivity and resource format
- Significant installation, maintenance, and repair costs
- Total Cost of Ownership (TCO) model mandates periodic upgrades
- May contribute to overall e-Readiness
- Advances in wireless, VSAT, and other communications tools may increase Internet access
- Advances in hardware design may increase ruggedness and decrease power requirements
- Mobile devices (handheld computers, phones) have potential to change TPD-focused communications and access to resources
- Focus on tools may distract from curriculum-centered learning

WEB RESOURCES

■ *Connecting Student Learning and Technology*

Computers are not inherently instructional tools, and most teachers need suggestions for using them. This guide provides such suggestions. It is not a nuts-and-bolts manual, but a discussion about using technology in environments that support learning, offering suggestions for using computers as instructional tools in environments that support learner-centered approaches. Educational computing use is examined by application (word processing, spreadsheets, etc.).

<http://www.sedl.org/pubs/tec26/flash.html>

■ *Technologies for Education: Potentials, Parameters and Prospects*

A joint effort of UNESCO and the Academy for Education Development (AED), this document provides a comprehensive and informative compendium of information on the range of issues associated with computers in education—from policy, to hardware and software provision, content and teacher training.

<http://www.aed.org/ToolsandPublications/upload/TechEdBook.pdf>