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Educational Quality Improvement Program
Classrooms ▪ Schools ▪ Communities

First Principles:

Designing Effective Education Programs Using Information and Communication Technology (ICT)

Compendium

Credit: American Institutes for Research

This *First Principles: Designing Effective Education Programs Using Information and Communication Technology (ICT) Compendium* provides important overview guidance for designing and implementing education programs that use technology. The principles and indicators are primarily meant to guide program designs, including the development of requests for and subsequent review of proposals, the implementation of program activities, and the development of performance management plans, evaluations, and research studies. The *First Principles* are intended to help USAID education officers specifically, as well as other stakeholders—including staff in donor agencies, government officials, and staff working for international and national non-governmental organizations—take advantage of good practices and lessons learned to improve projects that involve the use of education technology. The guidance in this document is meant to be used and adapted for a variety of settings to help USAID officers and others grapple with the multiple dimensions of ICT in education and overcome the numerous challenges in applying ICT in the developing-country contexts. The last section provides references for those who would like to learn more about issues and methods for supporting the education of the underserved. This document is based on extensive experience in, and investigation of, current approaches to technology in education and draws on research literature, interviews with USAID field personnel, and project documentation. It also includes profiles of projects funded by USAID and others. This *Compendium* provides greater depth for those who are interested in knowing more on this topic. A shorter companion piece called a *Digest* provides a brief overview of key considerations in the planning and implementation of education technology projects.

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EQUIP1: Building Educational Quality through Classrooms, Schools, and Communities is a multi-faceted program designed to raise the quality of classroom teaching and the level of student learning by effecting school-level changes. EQUIP1 serves all levels of education, from early childhood development for school readiness, to primary and secondary education, adult basic education, pre-vocational training, and the provision of life-skills. Activities range from teacher support in course content and instructional practices, to principal support for teacher performance, and community involvement for school management and infrastructure, including in crisis and post-crisis environments.

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Acronyms

ADSL	Asymmetric Digital Subscriber Line
AED	Academy for Educational Development
CAI	Computer-Assisted Instruction
CD-ROM	Compact Disc–Read-Only Memory
CFSK	Computers for Schools Kenya
CPU	Central Processing Unit
CSR	Corporate Social Responsibility
DBE	Distributed Basic Education
DCGEP	Discovery Channel Global Education Partnership
DFID	UK Department for International Development
DVD	Digital Video Disc
EAC	East Africa Commission
EDC	Education Development Center
EEH Project	Expanding Educational Horizons Project
EMIS	Education Management Information System
EQUIP	Educational Quality Improvement Program
ESMIS	Education Sector Management Information System
EU	European Union
FOD	*Fundación Omar Dengo*
FQEL	Fundamental Quality and Equity Levels project
GDA	Global Development Alliance
GIS	Geographic Information Systems
GPS	Global Positioning System
GPRS	Global Packet Radio Switching
GTL	Group Teaching and Learning (software)
HEART Trust/NTA	Human Employment and Resource Training/National Training Agency
ICT	Information and Communications Technologies (also "IT," as in "IT curriculum" or "IT teacher")
IDB	Inter-American Development Bank
IDRC	International Development Research Center
iNET	Initiative for Namibian Education Technology
INTALEQ	Innovations in Technology-Assisted Learning for Educational Quality
IRI	Interactive Radio Instruction
JSAS	Jamaica School Administration Software
JEI	Jordan Education Initiative

KERIS	Korean Education & Research & Information Service
LDC	Least Developed Country
LOP funding	Life of Project funding
M4Ed4Dev	Mobiles for Education for Development
MINEDUC	Ministry of Education of Rwanda
MOE	Ministry of Education (multiple countries)
MOEY	Ministry of Education and Youth (Jamaica)
MOU	Memorandum of Understanding
NIIS	National Integrated Information System
NEI	National Education Indicators
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
OER	Open Educational Resource
OLPC	One Laptop Per Child
PC	Personal Computer
PEP	Primary Education Project
PHARE	*Programme Harmonisé d'Appui au Renforcement de l'Education*
PMO	Project Management Office
SDS	School Data System
SEAMOLEC	South East Asia Ministers of Education Regional Open Learning Centre
SIEEQ	*Stratégies Intégrées pour une Education Equitable et de Qualité*
SQL	Structure Query Language
SSTC	Student Support Technician Club
T4 Project	Technology Tools for Teaching & Training Project
TCO	Total Cost of Ownership
ToT	Training of Trainers
TRIMS	Tool for Reporting and Information Management in Schools
USAID	United States Agency for International Development
USF	Universal Service Funds
VOIP	Voice Over Internet Protocol
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal
WCE	World Computer Exchange
WEF	World Economic Forum
3G	Third Generation (wireless)

Contents

Introduction

The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn.

—Alvin Toffler, American Futurist

The emergence of information and communication technologies (ICT) as a force in social and economic development presents a wide range of possibilities to the education systems of developed and developing countries. ICT also creates challenges: By accelerating the expansion of information and increasing the value of knowledge, technology challenges schools to support learning that helps them build skills that they can use now and that will support their participation in civic and economic life in a dynamic future.

Technology has transformed social and economic life in countries with emerging economies, in many developing countries, and in many communities in Least Developed Countries (LDCs). The scope of change includes sectors such as finance, manufacturing, health, agriculture, and government. As these changes are taking place, ministries of education (MOEs) and donor agencies grapple with questions about appropriate, effective, and valuable uses of education technology for learning, teaching, and strengthening educational systems: Is ICT the most cost-effective way to improve our students' performance? How can we connect our ICT projects in schools to improved youth employment? How should we gauge the support that technology companies are offering? Should we invest in a "one laptop per child" initiative?

Credit: Edmond Gaible/The Natoma Group

In many developing countries, efforts to build strong educational foundations benefit from the use of technology to address problems that cause chronically poor learning outcomes. Such problems frequently include teachers' limited capacities, the lack of textbooks or other resources, poor school management, poor central decision making, and lessons that are irrelevant to the lives of students. These systemic problems limit the development of literacy and numeracy skills, as well as the higher-order thinking skills essential for participation in the global economy. Well-conceived uses of radio, mobile phones, computers, the Internet, and other tools can help provide large-scale solutions to those problems: The USAID-supported Technology Tools for Teaching & Training (T4) program, for example, uses radio, video, computers, multimedia content, and the Internet to reach 42 million students in eight states in India.[1] Interactive Radio Instruction (IRI), a relatively low-cost use of technology, has been shown to have a positive impact on learning through different approaches across many different countries.[2] In addition, many smaller-scale studies have demonstrated the connection between the effective use of computers and the Internet in schools and the development of a range of 21st century skills.[3]

1 http://t4india.idd.edc.org

2 *Tuned in to Student Success: Assessing the Impact of Interactive Radio Instruction Summary,* by Jennifer Ho and Hetal Thurkal (Newton, Mass: Education Development Center; 2009; http://idd.edc.org/resources/publications/tuned-student-success-assessing-impact-interactive-radio-instruction-summary; accessed January 13, 2011).

3 References include *Are the New Millennium Learners Making the Grade?* (Paris: OECD Centre for Educational Research and Innovation; 2010); *Laptops and Literacy,* by Mark Warschauer (New York: Teachers College Press; 2006); and a meta-analysis of research, *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Studies,* by Means et al. (Washington, DC: U.S. Department of Education; 2009). Additional sources are summarized in *ICT Policies and Educational Transformation,* by Robert Kozma (New York: UNESCO; in press).

What do we mean by "ICT"?

In this *First Principles* document, information and communication technology or "ICT" includes "tools and resources used to communicate, and to create, disseminate, store, and manage information."[4] Such tools are frequently lumped together as, simply, "technology." However, the initial definition frames a rapidly expanding group of different tools used in education and in development.[5] Broad categories of these tools include radio (and audio recordings), television (and video recordings), mobile telephones and smart phones, desktop and laptop computers, and local networks and the Internet. But in each category, new products are being developed, adapted, or marketed all the time for use in developing-country schools and communities. New tools specific to education include the One Laptop Per Child (OLPC) Children's Machine XO and the Intel Classmate netbooks. Commercial and NGO-focused ICT tools that have proven useful in schools and communities range from the Freeplay hand-crank and solar-rechargeable radios[6] to Frontline SMS[7] communications software to VSAT satellite Internet connectivity.[8]

A brief list of key resources on ICT in education is presented at the end of the document.

ICT includes multiple technology platforms and approaches

The range of ICT projects in education is broad, with many different kinds of tools used in many different configurations. Some examples follow:

- Television broadcasts to create "virtual classrooms" for junior secondary students (*Telesecundaria,* Mexico,[9] and the USAID-supported Mindset Primary School Channel, South Africa[10])
- Radio broadcasts to deliver effective English-language lessons to primary students (T4, India, *Sous la fromager, Pas a Pas,* The Gambia, and *Programme Haïtien d'Appui à la Réforme de l'Éducation* (PHARE), Mali[11])
- DVD recordings of televised wildlife shows for use in science class (Discovery Channel Global Education Partnership, Romania[12])
- Digital camcorder recordings of teachers' classroom activities to support training (SIEEQ, Congo[13])
- Mobile-telephone-based SMS messages to request downloadable video resources (Text2Teach, the Philippines; Bridge*it,* Tanzania[14])
- Education management information system (EMIS) and databases for school-based reporting (e.g., Kenya, Egypt, Guatemala)

4 "New Directions of ICT-Use in Education," by C. Blurton (New York: UNESCO; 1999); http://www.unesco.org/education/educprog/lwf/dl/edict.pdf

5 "ICT4E" and "ICT4D," respectively.

6 www.freeplayenergy.com.

7 Frontline SMS (www.frontlinesms.com) enables NGOs, civil-society organizations, and others to use a computer or mobile phone to send text messages (or "Short Message Service" texts) to many users at one time and to store both users' telephone numbers and their responses locally.

8 "Very Small Aperture Terminal" or VSAT dishes have proven useful in bringing Internet connectivity to remote locations.

9 *Television for Secondary Education: Experience of Mexico and Brazil,* by Laurence Wolff, Claudio e Moura Castro, Juan Carlos Navarro, and Norma Garcia; *ICT in Education Toolkit* (http://www.ictinedtoolkit.org/usere/library/tech_for_ed_chapters/10.pdf; accessed January 16, 2011).

10 Africa Education Initiative: South Africa Case Study (USAID; 2005; http://pdf.usaid.gov/pdf_docs/PNADG232.pdf; accessed January 15, 2011).

11 "Tuned in to Student Success: Assessing the Impact of Interactive Radio Instruction for the Hardest-to-Reach," by Jennifer Ho and Hetal Thukal, *Journal of Education for Internatioal Development,* v4n2, Dec09.

12 "Learning Center Project in Romania: Evaluation Report," by Corina Cace and Sorin Cace, *Virtual Resources Center in Social Work,* v12, Jun2010 (http://ideas.repec.org/a/lum/rev6rl/v12y2010ip1-99.html; accessed January 15, 2011).

13 dot-EDU quarterly report, January-March 2007 (http://pdf.usaid.gov/pdf_docs/PDACK572.pdf; accessed January 15, 2011).

14 *Metasurvey of ICT in Education in Asia and the Pacific,* edited by Glen Parks and Cédric Wachholz (Bangkok: UNESCO; 2003).

Trends in ICT innovation

The development of new information and communications tools is dynamic and accelerating. Rapid changes in the marketplace challenge governments and education systems to keep up to date, but also present many opportunities to extend access to ICT in schools and rural areas, and to engage teachers and students in new ways.

Over the past 20 years, ICT in schools has been commonly associated with desktop computers and fixed-line Internet connectivity. However, throughout that period, radio and television (and DVDs, audio tapes, CDs, and other media) have also been deployed in large-scale projects and have been shown to increase student motivation, promote change in classroom practices, and support other improvements in education systems. Today, reductions in the cost, size, and power requirements of microchips have lowered the cost and increased the flexibility of ICT. These changes have been accompanied by the creation of digital versions of familiar tools such as cameras and telephones, and by the emergence of new, less familiar tools such as tablet PCs and wireless data networks. Non-digital innovations, such as flexible and portable solar cells have also been combined with digital technologies to extend the reach of ICT to infrastructure-poor areas.

As the boundaries between different kinds of devices have blurred, the pathways for introducing technology into schools have multiplied. Interactive whiteboards, or "smart boards," enable teachers and students to write, draw, and erase, just as teachers do using traditional chalk boards. But smart boards also enable them to show images and videos, and record and export their writing as digital files. Mobile phones combine telephone functionality with databases of contacts, SMS, cameras, and video cameras, while smart phones go several steps further, adding data communications and more powerful processors to support email and web browsing, Global Positioning System (GPS) functions, and catalogs of downloadable purpose-built tools ranging from dictionaries to scanners to knowledge-management systems.

The emergence of new tools and the blurring of boundaries between tools combine to greatly increase the possibilities for the use of technology in schools. The principles presented in this document, however, focus without exception on considerations with regard to planning and management, not on the tools themselves. These principles and the core strategies elaborated under them can be (and should be) applied to projects that are exploring "leading edge" technologies and implementation models, and to projects that draw strongly from proven tools and models.

Drivers of ICT adoption in developing countries

Country governments and donor agencies, including USAID, have made substantial investments in education technology. Developing and emerging-economy countries that have launched nationwide programs include Argentina, Armenia, Chile, The Gambia, Jamaica, Jordan, Mexico, Namibia, Peru, Russia, Rwanda, Sri Lanka, Syria, Turkey, Uruguay, and many others. Some of these programs have used broadcast technologies such as radio (The Gambia) or television (Mexico). Others have established web portals[15] to disseminate learning resources and teacher resources (Argentina, Chile), while still others have launched one-to-one (1:1) initiatives using low-cost laptops (Peru, Rwanda, Uruguay).

In addition to these large-scale programs, donor agencies, governments, and other organizations have launched hundreds of pilot projects to test and improve approaches to using technology to improve teaching, learning, and school management, while school committees and parents in countries around the world have used their own resources to give their children access to computers and the Internet in schools.

All of these efforts are underpinned by the shared belief that ICT has enormous potential to transform education and that schools will fall into irrelevance if they are unable to incorporate technology into their operations, especially into teaching and learning. The increasing importance of the knowledge economy challenges education systems to improve their performance overall and to integrate new competencies, new procedures, and new ways of interacting both into their own operations and into students' learning.

Technology also enables developing-country governments to address many of the systemic challenges to their efforts to increase access to and improve the quality of education cost effectively and at scale.

In light of these rapid and far-reaching changes, the principles that follow are for the most part "platform neutral" in terms of technology. They pertain to any project that seeks to leverage technologies to increase its scope, scale or impact—whether that project involves the use of radio in classrooms, teachers' mobile phones, or school computer labs. These principles are accompanied by examples of relevant and innovative projects

15 www.relpe.org provides a list of education portals in Latin America.

Credit: Cassandra Jessee/AIR

that reflect good practices. These principles and projects are intended to serve as guideposts to the effective use of technology to support schools now and in the future.

These principles have emerged over more than 15 years of efforts to use technology to strengthen schools in developing countries. Many project planners, when they consider the use of ICT, underestimate the challenges of introducing any new technology into school environments. Poor electrical power, unsustainable maintenance costs, inadequate Internet connectivity, resistant or unmotivated teachers, outdated or unproven technologies—these and many other factors have diminished the impact of education-technology projects time and time again. As important, schools and school systems themselves contain many factors that create resistance to change: Existing curricula, textbooks, and high-stakes assessments—for example—all constrain teachers to follow traditional methods of instruction, to minimize the use of new tools, and to focus students' learning on mastery of the narrowest possible skill sets and bodies of knowledge. The principles presented here can identify and help overcome barriers that arise in the use of ICT and can help ensure that ICT is used effectively to improve education.

Linking ICT in education to levels of development

Many studies find that educational success is an important factor in individual earnings and in economic and social development.[16] Accordingly, in many developing countries, improving learning and strengthening educational systems are considered imperatives.[17] Introducing computers and the Internet is frequently viewed in developing countries as a swift and at times futuristic measure to modernize schools. A senior education specialist at the USAID mission in Macedonia frames a range of ambitious potential impacts to be achieved through the use of technology in schools:

> "The role of ICT can be to provide alternative sources of information, outside of textbooks. Technology is another source of quick information, available in a few minutes. Schools don't need to have sophisticated labs. Students can perform virtual experiments,

16 "Economic Outcomes and School Quality," by Eric Hanushek (Paris: UNESCO; 2005).

17 "Leadership, Education Change and the Knowledge Society," by Edmond Gaible (Dublin, Ireland: GeSCI; 2010) (http://www.gesci.org/assets/files/Education%20change,%20leadership%20and%20the%20knowledge%20society.pdf; accessed May 20, 2011).

work with 3D math images—to help make up for resource and teaching aids that are not available. And technology promotes the exchange of information, through social networks, forums, blogs, so that there's a quick exchange of information among students. And these students are already using computers to communicate outside of school."

Macedonia's successful Primary Education Project (PEP) has, over the course of its implementation, realized the potential of technology to help schools achieve such high levels of engagement with information, resources and peers.

However, in many countries, infrastructure, technical skill and the technology private sector, teachers' levels of education and professionalism, and a host of other factors are not yet ready to support either the tools or the practices used in PEP. Approaches to the use of technology in schools and school systems should be appropriate to a country's *current* level of social and economic development, and to the capacity levels in schools and in the ministry of education. Initiatives that transform teaching and learning in one country can entail high risks in another.

Underlying many of the principles in this document—and underlying all good practices in the use of technology in schools—is the precept that program goals, activities, tools, and resources must be matched to the conditions in schools and in society.

(For more information, refer to *Principle 10: "It takes capacity to build capacity" – System strengthening precedes system transformation.*)

USAID programming in ICT for education

USAID is among the world's largest bilateral supporters of technology projects in education. Such projects use technology to increase access to basic education, to support the development of literacy and numeracy skills, to improve the management of schools and education systems, to enhance the relevance and quality of learning, and to extend educational opportunities to marginalized and vulnerable populations, including those in crisis and conflict environments.

Technology and the USAID 2011 Education Strategy

The current *USAID Education Strategy,* released in February 2011, specifically identifies "innovation, science and technology" as the main elements of comparative advantage of U.S. education assistance,[18] linking ICT directly to the need to increase access to education and to improve the quality of instruction in specific high-need areas.

Most important, the *Strategy* makes "scale" the highest priority criterion for determining the readiness of country programs to receive support for educational programs.[19] Goal 1, to achieve "[i]mproved reading skills for 100 million children by 2015,"[20] quantifies the need to increase the reach of education initiatives to reach the largest possible number of students and schools. As demonstrated by the T4 project in India, and by many other projects presented in this document, the use of broadcast and network technologies has the potential to expand services and increase access cost effectively.

(For more information about the T4 project, see *Principle 5: Explore technology alternatives to find appropriate solutions*.)

When technology is used to increase program scale, it is functioning as part of the "education infrastructure," supporting the operations and services that are essential to the education system. In this way, technology can be integrated into program designs to support other key points of focus identified in the *Strategy,* such as:

Improved reading

Improved reading forms the cornerstone of the USAID *Education Strategy*. Technology offers many proven means of supporting students' efforts to improve their reading skills, including assistive technologies such as text-to-speech. Jamaica's Expanding Educational Horizons (EEH) project, profiled in this document, pilot tested the use of "talking word processors" to help students improve spelling, grammar, and other basic reading and writing skills.

Gender equality

The *Strategy* specifies that program designs should "promote gender parity, gender equity and focus on improving education quality for both boys and girls."[21] Although technology is

18 *Education Strategy: Opportunity Through Learning,* Washington, DC: USAID; 2011, p 7.

20 Op. cit., 7.

20 Op. cit., 9.

21 Op. cit., 8.

frequently seen as more appealing to boys,[22] specific content and approaches can be crafted to enhance girls' education, as they are in the T4 project.

Workforce-relevant skills

The *Strategy* highlights the need for education, including secondary-level vocational and technical education, that helps young people to build "relevant knowledge and skills" that will enable them to "fully participate in and contribute to economic development."[23] Technology plays a dual role in this effort, as an enabling tool and as a subject.

Access in crisis and conflict environments

Ensuring the safety of students, teachers, trainers, and aid workers poses one of the critical challenges to expanded access to education in areas of crisis and conflict. The *Strategy* lists the goal of "increased equitable access to education in crisis and conflict environments for 15 million learners by 2015."[24] The infrastructural function that technology plays has high potential to provide opportunities for direct instruction of learners and for support for teachers in challenging and dangerous areas by enabling the safe delivery of high-quality learning resources in electronic form, and by supporting communications, distance learning, and other means of providing access to education in remote, crisis, and conflict conditions.[25]

In addition to its impact on learning, technology is also vital to the effort to improve decision-making through the aggregation and analysis of information. The *Strategy* includes the goal of "increas[ing] accountability through the measurement and disclosure of information about education program effectiveness, relevance and efficiency."[26]

(For more information about the broader uses of ICT to make significant improvements in learning and livelihood, and for additional information about the concept of "education infrastructure," refer to *Principle 1: Use ICT to achieve education and development goals*.)

22 For a nuanced and experimentally based discussion of girls' and boys' approaches to technology, see *The Second Self: Computers and the Human Spirit* (New York: Simon & Schuster; 1985).

23 Op. cit., 12.

24 Op. cit., 13.

24 Op. cit., 13.

25 *Open and Distance Learning for Basic Education in South Asia: Its potential for hard-to-reach children and children in conflict and children in conflict and disaster areas,* Kathmandu, Nepal: UNICEF; 2009.

26 USAID, op.cit., 15.

Credit: Edmond Gaible/The Natoma Group

10 Key Principles for Developing ICT in Education Programs

The "first principles" that follow are intended to guide conceptualization, design, development, and implementation of ICT projects in education.

First Principles: Designing Effective Education Programs in Using ICT

- Principle 1: Use ICT to achieve education and development goals.
- Principle 2: Use ICT to enhance student knowledge and skills.
- Principle 3: Use ICT to support data-driven decision making.
- Principle 4: Include all short- and longer-term costs in budget planning.
- Principle 5: Explore technology alternatives to find appropriate solutions.
- Principle 6: Focus on teacher development, training, and ongoing support.
- Principle 7: Explore and coordinate involvement of many different stakeholders.
- Principle 8: Develop a supportive policy environment.
- Principle 9: Integrate monitoring and evaluation into project planning.
- Principle 10: "It takes capacity to build capacity"—System strengthening precedes system transformation.

Under each principle is presented a series of related core strategies.

Principle 1: Use ICT to achieve education and development goals.

Technology is a cross-cutting resource that should be seen as a sustainable, accessible, and valuable means of supporting efforts to improve teaching, learning, school operations, and the education sector as a whole. Projects using technology can entail risks that arise from costs, complexity, and resistance to change at many levels. To make such risks worth the reward, technology should be used to address areas where system capacity is poor, schools are underperforming, or there are gaps in student learning.

A well-designed technology deployment can be used to disseminate resources, connect students to information, enhance teachers' practices and students' performance in all subject areas, improve school management, and support data-driven policymaking. Initial deployments can focus on establishing necessary foundations of hardware, communications, and human capacity. Once developed, such foundations can support improvements in all areas of school operations and system management. When ministries and implementing agencies possess—or build—the necessary skills in planning, management, and implementation, such improvements can begin to be extended system-wide.

Core strategies include the following:

Address areas of high need.
Given range of areas where technology can support improvement, projects can target specific factors or problems that have the potential to yield high impact or support further improvement—e.g., essential gaps in student learning, barriers to effective teaching, limitations in information management. In many schools in developing countries, effective classroom instruction is still unattainable. Teachers lack knowledge of their subjects and understanding of good classroom practices. Such needs are addressed via Interactive Radio Instruction (IRI) in Mali's PHARE project through broadcast of lessons providing instruction directly to students. In Indonesia, students in rural schools frequently lack textbooks and other learning resources; these gaps are addressed via television in the *TV Edukasi* program, which broadcasts animations that can help build literacy, numeracy, and other skills. In Georgia and Tanzania,[27] computers in schools are used in conjunction with Education Management Information System (EMIS) software to enable schools to

27 USAID, *USAID/Tanzania Education Strategy for Improving the Quality of Education,* FY 2009-2013.

compare themselves with other schools in their districts and regions and throughout the country.

Conceive of technology as "education infrastructure." Projects that establish the use of technology in schools—whether the tools used are radio, video, mobile phones, or computers—contribute to the strengthening of a school system's education infrastructure. Once established, such infrastructure can be used to support an array of activities. In some instances, such infrastructure is composed of real hardware and networking: The government of Sri Lanka, for example, has invested in computer facilities and broadband Internet for all senior secondary schools, with approximately 10 percent of schools currently connected. The Ministry of Education uses its network (the schools are connected in a virtual private network, or VPN[28]) as infrastructure to support improved education: to disseminate learning resources, to provide professional development to teachers and direct instruction to students, and to bring teachers and students together in online forums.

In many instances, however, the education infrastructure built in the course of an ICT project should be conceived of as *both* the physical hardware that is installed *and* the human capacity that is built in the course of planning and managing an ICT-in-education project and in using ICT in schools. The e-Learning Jamaica Project, [29] for example, has already overseen provision of multimedia computer facilities and Internet connectivity to all 162 of Jamaica's secondary schools, plus training of the system's 11,400 teachers, and dissemination of e-learning materials that support concept development (via video) and test preparation. Following these accomplishments, and having developed both technical and management capacity, e-Learning Jamaica has been tasked by its stakeholders, including the Ministry of Education and Youth (MOEY), with extending services to Jamaica's primary schools. In contrast, Costa Rica's *Fundación Omar Dengo* (FOD or the Omar Dengo Foundation) first worked in the nation's primary schools to prove the value of computers, robot kits, and other tools supporting the development of higher-order thinking skills. After demonstrating success—and building

Credit: Edmond Gaible/The Natoma Group

a high degree of capacity—FOD was asked to manage the introduction of technology-supported learning in Costa Rican secondary schools, vocational schools, and communities.

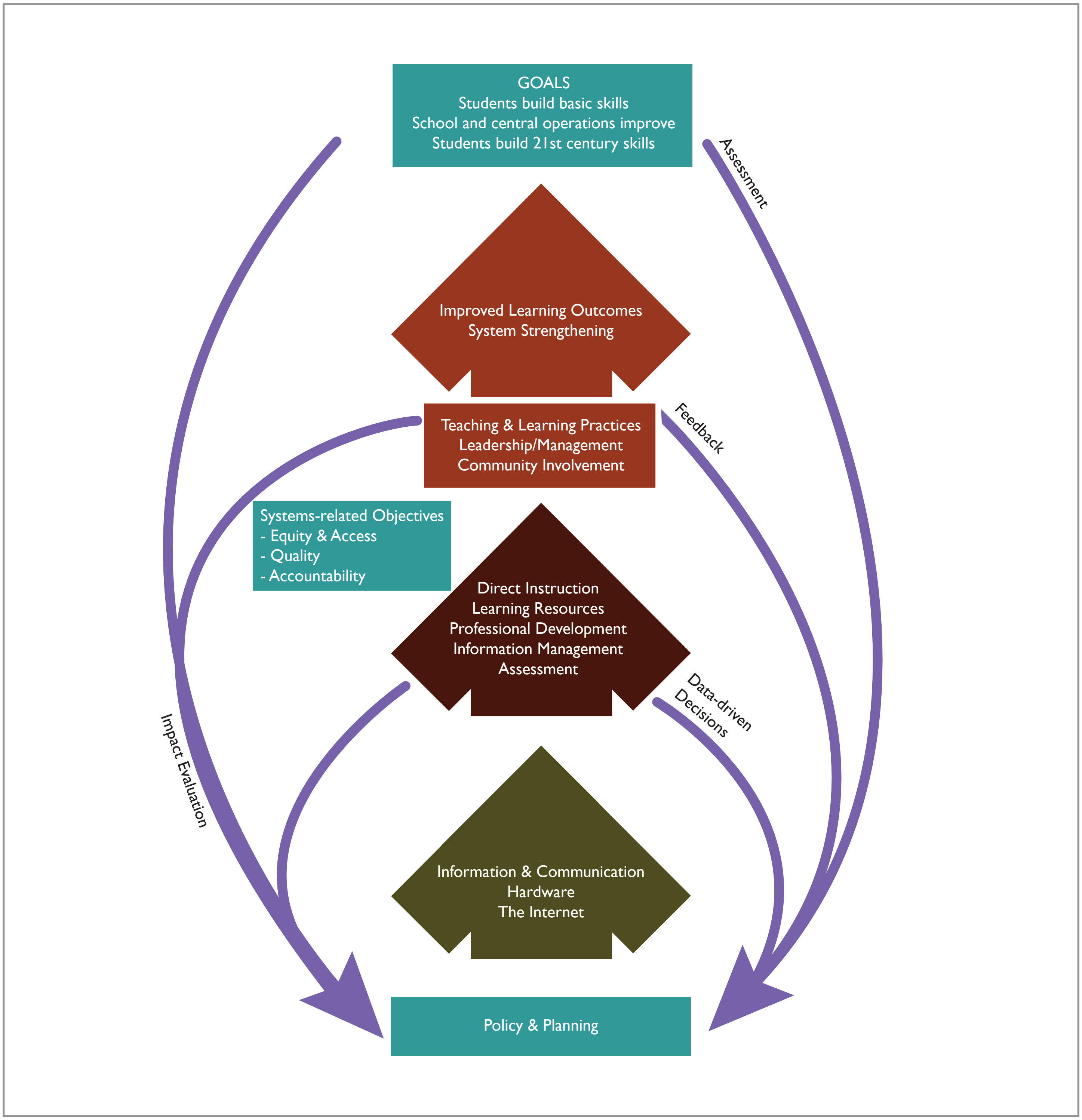
Use ICT to support comprehensive change. While education-technology projects often focus on single areas of activity, such as introducing digital learning resources, the cross-cutting quality of technology can enable comprehensive approaches that extend to many core components of the education system. Such approaches, building on technology-supported education infrastructure, offset the high capital and operational costs of ICT projects by delivering improvements in major components and activities of the education system: information management and school leadership, teacher development, learning-resource distribution, and direct instruction. Improvements in the ways schools conduct these activities, in turn, can lead to increases in reading and mathematics skills, development of other basic skills, and the development of key 21st century skills.[30]

28 VPNs are used by many education systems to connect schools securely to each other, to the national ministry of education, and to the Internet. VPNs enable students' access to the Internet to be filtered or otherwise controlled and to ensure that unauthorized users are not entering in to the school network. VPNs can be difficult to administer over large areas, however, and can slow Internet access substantially in low-bandwidth environments.

29 http://www.e-ljam.net/

30 For more information about 21st century skills, refer to the Partnership for 21st Century Skills (www.p21.org).

Figure 1: Comprehensive approach to ICT for sector strengthening in education



Comprehensive approaches to sector improvement can make use of technology to support different components in the education system. The same functions that make ICT an important resource for classroom practice and activities can also expand teachers' access to a broader range of professional development: The SEAMOLEC HyLite program[31] enables Indonesian teachers enrolled in skills-upgrade courses at regional universities to spend most of the semester at home in their communities, teaching class while using computers and the Internet to receive course materials and return assignments. In Zambia, an EQUIP2 project with support from USAID connected seven teacher-training colleges to the Internet and developed a Global Learning Portal that includes an online repository for learning resources and a platform for collaboration.

Comprehensive deployments of ICT can be challenging. Planning and implementation require political commitment, effective project design and management, and high levels of capacity within the education system and among all stakeholders. In lower-capacity education systems in particular, additional investigation is required to determine key characteristics that lead to positive impact.[32] In education systems where there are "capacity gaps," adopting focused, "appliance style" approaches to the use of ICT can be good first steps, and can begin the development of the broader capacity required by more complex projects.

(For information about appliance-style approaches to education technology, refer to *Principle 10: "It takes capacity to build capacity"—System strengthening precedes system transformation,* in relation to this concept.)

Decentralized Basic Education, Indonesia: A comprehensive approach to school improvement supported by ICT

The USAID-supported Decentralized Basic Education (DBE) program in Indonesia, running from 2005 to 2010, was intended to improve the delivery of basic education in Indonesia. Technology was used in each of the three program components, taking advantage of the fact that approximately 50 percent of Indonesian primary and junior-secondary schools have computers for teacher and administrative use (Government of Indonesia estimate).

DBE1 addressed school-based management and governance in 1,074 schools in 50 districts across eight provinces. Activities included strengthening school leadership and community involvement, supporting the development of school-improvement plans, and increased reporting of schools' unit-costs—all of which have contributed to increased school funding. To increase the use of information at the school level and to improve reporting, an easy-to-use, spreadsheet-based School Database System (SDS) was designed. The SDS supports school-improvement planning, budgeting and financial reporting, school accreditation applications, and school report cards to be shared with the community.

DBE2 and DBE3 focused on improving teachers' competencies, certification, and classroom practices through a wide range of activities. ICT support included providing high-quality learning resources, such as Interactive Audio Instruction (IAI) for kindergarten students, which involved 106 40-minute programs prompting hands-on and active learning, and DVD-based "earthquake preparedness song and dance" lessons, which combined music and movement.

31 "Hybrid Learning for Indonesian Teachers," a project of the South East Asia Ministers of Education Regional Open Learning Centre. For more information about the *HyLite program, see HyLite Program: An ICT-Based ODL for Indonesian Teachers Education,* by P. Pannen, R. Riyanti, and B. Pramuki, 2007 (http://digilib.unsri.ac.id/download/2D3_Pannen-Hylite.pdf; accessed January 30, 2010).

32 *Knowledge Maps: ICTs in Education,* by Michael Trucano (Washington, DC: infoDev/World Bank; http://www.infodev.org/en/Publication.159.html; accessed April 2010).

Decentralized Basic Education, Indonesia: A comprehensive approach to school improvement supported by ICT (continued)

In the Developed Active Learning with ICT (DALI) program, a pilot project within DBE2, active- and project-based-learning approaches were supported by introducing one computer and one digital camera for use in the classroom; by providing downloadable and DVD-based teacher-training materials; and by offering an e-learning version of the Better Teaching and Learning course for junior-secondary teachers, in partnership with SEAMOLEC.[33] DALI teachers used the computers for small-group instruction and as part of station-based learning activities.

The three component programs of DBE in combination make up a comprehensive and well-integrated approach to deploying ICT in education. A wide range of tools was used to support the critical aspects of school operations and classroom activities.

Principle 2: Use ICT to enhance student knowledge and skills.

ICT can be used to help students build knowledge across all areas of the curriculum and to help them build higher-order cognitive and life skills. If schooling is intended to be relevant to work and important to a society, success in school should be accompanied by the development of a broad body of knowledge and a complete range of skills—including literacy, numeracy, information literacy, and independent-learning skills that contribute to achievement in later life. ICT should be deployed to help students build these skills. Although policymakers and ministries of education frequently promote ICT curricula and building technology skills, the return on investment is greatest when technology use is combined with learning about school subjects.

Technology in schools can also help students progress along the school-completion continuum, from primary to secondary to completion of higher education. Among the earliest research findings in relation to the instructional use of technology was a strong correlation with increased students' motivation to learn—and motivation has been shown to be an important factor influencing both student performance and school completion.[34]

Core strategies include the following:

Help students build reading skills and basic skills in all subjects.
Although research results are mixed in relation to the impact of computer and Internet use, Interactive Radio Instruction (IRI) and other specific-use tools have proven their ability to improve basic skills. In Guinea, the Fundamental Quality and Equity Levels (FQEL) project used IRI to reduce the gap between rural and urban students in French-language skills.[35] Many of the Intel Skoool resources localized for use in Yemen's INTALQ project present learners with visualizations—of static equilibrium in physics, for example—and invite them to adjust variables, observe changes in outcomes, and build their understanding of key concepts.[36]

Help students build 21st century life and learning skills.
Many proven teaching and learning techniques that can help students master school subjects and build more advanced skills have been adapted for use with ICT. The DBE2 DALI program in Indonesia helps primary-grade teachers guide their classes through interdisciplinary learning activities in one-computer classrooms. Following on a donation of 6,000 computers by the Chinese government, the USAID-funded Macedonian e-Schools project provided teacher development and an education portal to link school communities together and promote project-based learning. (Research findings suggest that technology helps students remain engaged through active-learning strategies such as project-based learning.)[37]

33 "Decentralized Basic Education 3 Brochure: *What is DBE3 doing*" and "Decentralized Basic Education 2 Brochure: *Our Programs,*" USAID (http://www.dbe-usaid.org/about; accessed January 16, 2011).

34 *What the Research Says About ICT and Motivation,* by Becta (United Kingdom: Becta; 2003; http://research.becta.org.uk/upload-dir/downloads/page_documents/research/wtrs_motivation.pdf; accessed January 23, 2011).

35 *Improving Educational Quality Through Interactive Radio Instruction,* by Stephen Anzalone and Andrea Bosch (Washington DC: The World Bank; 2005).

36 www.skooolyemen.com

37 "Student Motivation and Internet Technology: Are Students Empowered to Learn Science?" by M. Mistler-Jackson and N.B. Songer, *Journal of Research in Science Teaching,* v37n5, 2000, pp. 459–479.

Focus on learning outcomes.
When education-technology projects involve student or teacher use of technology, project designs should focus on meaningful improvements in instruction and learning. Education projects that make use of computers and the Internet are frequently framed in terms of "performance objectives," such as successful procurement and installation of a certain number of computers, the provision of training to a specific percentage of teachers, and computer access by a certain percentage of students. Objectives such as these inflate the importance of access to technology and diminish the impact of technology on student learning.

Projects that rely on familiar tools and less-complex approaches are more likely to be designed and assessed in terms of improved learning. A meta-analysis of IRI conducted by Ho and Thurkal analyzed results of IRI projects targeting numeracy in Haiti, India, Sudan, and Zambia, and found that participating students received on average a 16-percent "boost" in their math ranking.[38] A study of activities of the Discovery Channel Global Education Partnership (DCGEP) in Romania, where the project combined video and broadcast programming content with teacher development, found significant impact on students' written-language competencies and their inferential and creative thinking skills.[39] All of these projects, relying on simple tools, were designed from the outset with a focus on improved learning outcomes.

(For more information about the value of familiar tools and simple project designs, refer to *Principle 10: "It takes capacity to build capacity"—System strengthening precedes system transformation.*)

Projects that deploy computers, the Internet, multimedia, and other complex learning technologies are more frequently framed and assessed in relation to their successful implementation. But such projects should *also* focus on—and be evaluated on!—their impact on teachers' behaviors and students' learning.

(For more information about project evaluation, refer to *Principle 9: Integrate monitoring and evaluation into project planning.*)

38 Ho and Thurkal, op. cit.

39 Cace and Cace, op. cit.

Credit: American Institutes for Research

Expand the use of computers and the Internet beyond the "IT curriculum" and ICT skills or teachers.
Computers and the Internet are frequently treated as a subject in the curriculum and a as subject to be mastered by teachers in their professional development. Countries that focus on an IT curriculum, but then later seek to shift the use of technology to support learning in all subjects, can find their prior support for an IT curriculum creates barriers to change. Computer labs, IT teachers, national IT exams, and the beliefs of school leadership can combine to impede the transition to using computers for learning in all subjects.[40] And although students do need to develop computer skills if computers are to be used for learning, the IT curriculum—sometimes spanning six years of classes and monopolizing computer use in schools—is an ineffective way to build those skills: Results from the 2007 regional IT exams in the Caribbean suggested that students completing IT curricula did not develop mastery and were not building skills that matched up with the needs of business.[41]

40 *Bridging the Digital Divide? Educational Challenges and Opportunities in Rwanda,* by E. Were, J. Rubgiza, and R. Sutherland (EdQual working paper, presented to the 10th UKFIET International Conference, University of Oxford, pp. 15–17, September 2009). See page 12 for a description of the group's findings.

41 *Critical Survey of ICT in Education in the Caribbean,* by Edmond Gaible (Washington, DC: infoDev; 2009).

Expanding Educational Horizons, Jamaica: A technology-intensive comprehensive approach

One of several USAID-supported education projects in Jamaica, Expanding Educational Horizons (EEH) focused on improving the literacy and numeracy skills of approximately 30,000 children (6–14 years) through formal, school-based interventions as well as through support to non-formal, non-governmental organization (NGO) work with at-risk youth. The project has also increased stakeholder support for education activities in 71 schools and six NGOs. EEH also builds capacity among schools to assess their own progress and students' performance by using the Jamaica School Administrative System Software (JSAS), a school-based computerized data management system.

Among the most effective tools in use in EEH schools is the Renaissance Learning NEO netbooks—low-cost, low-power computers—with software that enables students to use a talking word processor and drill-and-practice software for math skills. The NEO netbooks are "easy to manage, you turn it on and start typing," says Melody Williams, literacy coordinator for the project. The NEO offers many features that help young writers: typing-tutorial software; infra-red "beaming" to share files between writing groups, and quiz-construction software. The NEO is also light, portable, and inexpensive—it can easily be shared within a group to support collaborative writing exercises. "We found that students who didn't like to write were more willing to write; they wrote more," says Williams.

In-service professional development was a primary activity in EEH, with teachers participating at their schools, with other teachers at "cluster" schools, and in central locations. As part of their professional development, teachers were also asked to share "action research" reports of their activities using the NEO, collaborative learning, and other aspects of the project. Teachers with Internet connections could also access "miniguides" supporting reading-comprehension instruction, math activities, and other instructional and technical content created for the project.

Life-of-Project (LOP) funding for the EEH project was approximately US $9,131,000 over five years (2005–2009). [42]

Principle 3: Use ICT to support data-driven decision making.

Regular and reliable data are essential to planning and policy, financial management, management of school facilities, decisions about school personnel (including teachers), and support for student learning. United States Secretary of Education Arne Duncan has issued a national call for schools to collect and use data to improve teaching and learning.[43]

Although the effective use of Education Management Information Systems (EMIS) has encountered many challenges, technology-supported data-management initiatives show great potential to improve policy making and decision making.[44] As of 2010, USAID was supporting EMIS and data-driven school-improvement initiatives in countries that include Djibouti, El Salvador, Ethiopia, Guatemala, Jamaica, Liberia, Tanzania, Uganda, Yemen, and Zambia. Many of these initiatives focus on improving data collection at the school level by providing training on spreadsheet-based reporting forms; other initiatives address central management of school information to support policy and planning.

How schools themselves *use* data is equally important. USAID has supported school-based reporting in many projects. In addition, USAID has recently entered into an umbrella agreement with the Peace Corps to support training of volunteers to guide school leaders and community members in capturing, analyzing, and graphically representing school data, using tools such as geographic information systems and mobile phones.

42 Information about project funding related to the use of ICT has been included when appropriate. In many instances, however, funding is distributed among many program activities, making accurate or relative analysis difficult in this brief document.

43 "National Education Policy Organization Recognizes 'Using Data' for Helping Schools Narrow Achievement Gaps, Improve Achievement," *eSchool News,* October 13, 2009 (http://www.eschoolnews.com/2009/10/13/national-education-policy-organization-recognizes-using-data-for-helping-schools-narrow-achievement-gaps-improve-achievement/; accessed January 17, 2011).

44 *Critical Survey of ICT in Education in the Caribbean,* by Edmond Gaible (Washington DC: infoDev; 2009, pp. 35–41; www.infodev.org/en/Document.591.pdf; accessed January 17, 2011).

Core strategies include the following:

Keep tools simple at the school level.
Data-collection tools that require too much technical expertise or high-quality Internet connectivity can create challenges at the school level and reduce overall participation. Reporting using the PadatiWeb program in Indonesia is extremely limited, in part because of the poor Internet backbone that limits school connectivity across the eastern half of the Indonesian archipelago. In contrast, the SDS (School Data System) implemented under DBE1 is a simple spreadsheet-based reporting form, supporting participation by schools in low-infrastructure environments. The SDS format has since been adapted in the Tool for Reporting and Information Management in Schools (TRIMS), which is being introduced to more than 200,000 Indonesian schools.[45]

Collect data that address goals.
Data should be relevant to sector objectives and activities, with a specific focus on student performance. Collecting too much data (such as information about teachers' spouses) increases the burden on school and district personnel and decreases participation. In Egypt, a partnership between USAID and the Ministry of Education led to the development of a set of 36 National Education Indicators (NEI) and the strengthening of EMIS, which together promised to return information of high value to the ministry. As a result, the ministry has taken steps to strengthen technical capacity, improve analysis, and promote consistent and reliable reporting practices. Overall, the project has stimulated demand in the central government for higher-quality information and analysis to support improved decision making.[46]

Ensure that data can be easily accessed and shared.
Education data are most valuable when they can be easily accessed, combined with other data sources, and effectively disaggregated and analyzed. (For example, student data are frequently disaggregated, or separated, by gender and class or grade; project evaluations often disaggregate data from urban and rural schools.) Databases and other tools should conform to current standards and be based on common or shared models and standards.[47] When multiple data-collection efforts are taking place, or when several databases are maintained, *great* care must be taken to avoid overlap or conflicting data formats and to ensure that databases are "interoperable"—that they can share their data.

In Guatemala, a USAID-supported EMIS project providing public access to education data has achieved a high standard of interoperability. With that EMIS system as a foundation, a national information system has been developed that connects data from the Ministries of Education, Health, and Finance. (See the project profile at the end of this section.)

Develop information-management tools in stages.
Effective EMIS and other information-management tools are challenging to develop or customize. They must support the needs of central policymakers and decision makers, conform to the way the education system operates, and be integrated into school routines. Achieving a comprehensive and effective system that also meets the needs of users in schools is best accomplished through stakeholder consultations, field trials, and many iterations. Current USAID-supported improvements to Tanzania's Education Sector Management Information System (ESMIS) will introduce the collection of data on primary students' reading and math skills, while complementary efforts will improve the timeliness and accuracy of schools' reporting.

Support the use of data in schools and communities.
Schools can compare their own information in combination with information about other schools to assess their current situation, make plans, enlist community and government support, and gauge subsequent progress. As of 2011, Indonesian school principals will use the spreadsheet-based TRIMS tool to improve the performance of their schools and also to make requests to the Ministry of Finance for support for school operations. In Tanzania, additional development of the ESMIS will enable school data to be output as school report cards to be used locally.[48]

45 Personal communication by the author with Sheila Town (World Bank), January 19, 2011, and Dr. Mohamed Ragheb, independent EMIS specialist, May 10, 2010.

46 Haiyan Ha, op. cit.

47 "Shared models" refers to data models and formats and to interoperability frameworks such as the IMS Learner Information Packaging specification.

48 *USAID/Tanzania Education Strategy for Improving the Quality of Education (2009–2013).*

Credit: Cassandra Jessee/AIR

The use of data by schools also improves the overall quality and reliability of education systems' data collection and management activities. When principals or school heads build information they can use from the effort that they expend on reporting, their participation in data collection increases. As important, when they see and use their own data, principals confirm the reliability of the information that has been recorded.[49]

One challenge in the use of data is the inability to share and compare findings among different programs and countries. An informal consortium of development agencies and other organizations is engaged in establishing a core set of national indicators for ICT in education. Organizations include the UNESCO Institute of Statistics and UNESCO-Bangkok, the IDB, the OECD, the EU, KERIS, and the World Bank, among others. Most of these organizations share their draft core and supplemental indicators.[50]

(These indicators are designed to give comparable images of national education systems. Project evaluations of ICT initiatives in education will require evaluation designs, including indicators, that reflect their objectives and the unique social, economic, and educational environments in which they take place. See *Principle 9* for additional information.)

49 *Putting Data Into Practice: Lessons From New York City,* by Bill Tucker (Washington, DC: Education Sector; 2010), p. 9.

50 Web links to various organizations' indicator-related resources can be found at http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTEDUCATION/0,,contentMDK:22245929~menuPK:617610~pagePK:148956~piPK:216618~theSitePK:282386,00.html.

EMIS in Guatemala: A springboard to a national information system

Launched in 2007, the EMIS initiative of Guatemala's Ministry of Education demonstrated the value of reliable data to support policy, planning, and management across many government ministries, and led to the National Integrated Information System (NIIS). The project arose out of the need for improved education data to support investments in the sector, the professionalization of teaching, and increased accountability for student performance. With funding from, and working in partnership with, USAID, the ministry revamped its EMIS tools and processes; integrated GIS software, business intelligence software, and other tools; and made ministry data freely available through the Internet. As a result of these upgrades, the value of data as a strategic resource became clear.

In response to the demand for accessible data across the social sector, the Ministry of Education–USAID partnership developed the NIIS, integrating information from the Ministries of Health and Finance and from the National Institute of Statistics. Education data, such as enrolment, student performance, and school infrastructure, could be analyzed in relation to information such as disease prevalence, government financial support, and demographics among different cities and regions.

Technical challenges were significant but were comparable to the broader challenges of capacity and the absence of a "culture of information." One of the key technical challenges was the use of dissimilar data tools, including Excel, SPSS, Access, Oracle, SyBase, SQL Server, and paper, both within the Ministry of Education and among the other social-sector institutions. As development proceeded, USAID funded the purchase of a countrywide license to business-intelligence software that supported the use of EMIS data, ensuring that any interested user in Guatemala could access NIIS data through the Internet. (Business-intelligence software is part of a class of "decision support" tools that help analysts make sense out of data.)

USAID and the Ministry of Education recognized the need to increase awareness and capacity among researchers, other university personnel, and NGO staff, among others. This recognition led to the creation of a third organization, also part of the partnership, Dialogue for Social Investment, which provided, among other inputs, a series of training workshops for potential users from universities, research centers, NGOs, and civil-society organizations. These training sessions led to the emergence of a strong community of information users.

NIIS in Guatemala has emerged as a landmark data-sharing project in Latin America, an early example of open access to government data across the social sector, and the region's first governmental use of business-intelligence software.

Principle 4: Include all short- and longer-term costs in budget planning.

Estimating full capital and operating expenses of technology projects in schools requires consideration of all equipment and activities needed to ensure that hardware (and software) are installed, operated, maintained, repaired, and replaced, and that teachers and other personnel have the skills and resources they need to use their new tools to meet project goals. Education projects that rely on computers and the Internet frequently underestimate the costs of connectivity, maintenance, security and facilities upgrades, and essential educational components such as teacher development. In the Barbados EduTech 2000 project, the failure to accurately budget the costs of facilities upgrades led to years-long project delays with effects that "cascaded" through hardware procurement, teacher training, donor funding, and many other program components.[51]

Even when capital and donor-funded operating costs are correctly estimated, "mainstreaming" operating costs into the regular education budget can still pose challenges. In the Macedonian e-Schools project, USAID jump-started the development of a national broadband network for education with a small catalytic investment; the project, however, faced challenges when the connection grants to schools ended.

51 *Survey of ICT and Education in the Caribbean,* by Edmond Gaible (Washington DC: infoDev, 2009; http://www.infodev.org/en/Document.591.pdf).

Credit: Edmond Gaible/The Natoma Group

Similarly, the end of connectivity subsidies in the Uganda VSAT Rural Connectivity Project caused several schools to shut down their Internet connections.[52]

Broadcast technologies such as educational radio and television typically have high up-front costs to develop programming, teacher guides, and management capacity. However, operating costs are typically much lower than in computer-based projects and, because they involve fewer variables, can be more reliably estimated.[53] Recurring costs of Interactive Radio Instruction (IRI) include broadcast airtime, radios and batteries, printing and distribution of materials, and training and support of teachers.

Broadcast airtime presents a challenge to the sustainability of some IRI programs. When support from USAID or other donors ends, ministries of education or communications frequently eliminate educational programming rather than pay recurring airtime costs. USAID education officers in some countries are currently exploring longer-term funding of airtime costs that is gradually reduced as government funding or support from other donors increases. Technology alternatives, especially for established programs, include transitioning from broadcast to recorded lessons using cassettes, CDs, MP3 players, or flash drives, and broadcasting over less-expensive satellite or digital radio.

The considerations that follow focus on programs using computers and Internet connectivity because they present substantial challenges in the form of high costs, complex budgeting, and procurement issues, among others. However, these considerations can be adapted, as appropriate, to other technologies.

Base program budgets on the Total Cost of Ownership (TCO) of the technology to be used.

Capital costs of computer- and Internet-based projects, such as hardware, software, networking equipment, and facilities upgrades, typically receive ample attention as budgets are being planned; it is critical, however, to ensure that hardware maintenance and all other operating costs are accurately reflected, as such costs can exceed 80 percent of the total budget over the life of a project. Essential budget items frequently include electricity; security; maintenance and repairs of hardware, software, and networks; training or professional development; and replacement costs of hardware, among others. Tools developed by CoSN,[54] GeSCI,[55] and SchoolNet Africa[56] provide support for calculating TCO.

In considering TCO, it is critical to distinguish among costs to be paid centrally and those to be paid by schools themselves, or at the district or provincial level. Hardware maintenance, for example, might be addressed in purchasing agreements made by the national government, while schools themselves might be asked to pay operating costs such as electricity or Internet connectivity. Increased local costs must be balanced by budget

52 *An Overview of the Uganda Rural Connectivity VSAT Project—Project History & End of Pilot Examination of Sustainability,* by Robert Hawkins, Michael W. van der Ven, and Justine Rubira (Washington, DC: World Bank Institute; 2004).

53 Anzalone and Bosch, op. cit.

54 Consortium for School Networking (http://www.cosn.org/tco/).

55 Please see http://www.gesci.org/knowledge-tools.html#tco for more information about GeSCI's Total Cost of Ownership Toolkit (accessed August 2010).

56 SchoolNet Africa. http://www.schoolnetafrica.org/english/index.htm (accessed May 2010).

allocations or revenues if projects are to be sustained.

Ensure capacity to conduct effective procurement.
Experience, knowledge, and careful structuring of purchase agreements can influence a project's success. However, many ministries of education in developing countries, as well as some ministries of finance, lack experience and capacity in the large-scale procurement of technology goods and services. Procurement processes are frequently guided or constrained by government and donor requirements, increasing their complexity.

Typical considerations include the decision to purchase or lease equipment, negotiation of maintenance and service contracts, one- and two-stage bidding processes, and the format of bid-preparation documents, among others. Challenges often arise from overreliance on vendors' sales representatives, inflexible contracts or ones that are unfavorable to the purchasers, and problems arising from delays in the release of funding.

Procurement of technology must find a balance among fairness and transparency, responsiveness to rapidly changing products and services, the desire on the part of many stakeholders to develop products locally, and other relevant factors. When complex products such as education portals or EMIS are being procured, for example, two-stage bidding processes can enable many vendors to share information about their products in initial proposals, leading to revision of bidding terms that accurately reflects products in the marketplace. Such processes, however, require far greater interaction and coordination among national governments, implementing organizations, donor agencies, and other stakeholders.[57]

Investigate hardware and software alternatives that reduce costs.
Alternatives to new, standalone desktop computers can offer equivalent or appropriate features at lower cost. "Desktop virtualization" computer networks such as those offered by n-Computing and Wyse provide computer rooms or computer labs with "client" or "dumb" terminals that all share the storage and processing power of a central server.[58] Netbooks—small, low-power laptops that use solid-state storage memory instead of hard drives—offer a lower-cost alternative that also supports flexible configurations in schools. Thin-client networks and netbooks can also reduce operating costs. Both systems require less electrical power than standalone desktop computers. With fewer moving parts, these systems can be more reliable in hot, dusty, or humid environments.

57 Templates for bidding documents (e.g., "instructions to bidders") in donor-financed technology projects can present problems. Such templates are frequently out of date in relation to fast-paced developments in the technology field. Problems can arise as a result of a focus on hardware to the exclusion of software or web components, overly rigid specification of hardware or networking equipment, inability to accommodate current web-development platforms or tools, and so on.

58 Such networked computer schemes are also known as "thin-client networks."

Credit: Edmond Gaible/The Natoma Group

Refurbished computers are another way to lower capital costs. International NGOs such as Computer Aid[59] and World Computer Exchange (WCE[60]) accept used computers as donations, wipe them of data, refurbish them, and offer them at low cost to organizations in developing countries. In some countries, local organizations also provide refurbishing services. At Computers for Schools Kenya (CFSK),[61] student volunteers refurbish and redistribute computers donated by local businesses and in the process build their own technical skills.

In some instances, lower-cost hardware can be combined with open-source software, such as Linux and Edubuntu,[62] to achieve further cost reductions. DVDs and external hard drives with preloaded website content, such as E-Granary,[63] can significantly reduce costs of connectivity by enabling offline access to learning resources. Technology alternatives can also have drawbacks, and should be researched thoroughly in relation to program goals and organizational capacities before they are adopted.

(For more information about alternative technologies, refer to *Principle 5*.)

Core strategies include the following:

Establish budget and capacity for maintenance and repairs.

It is essential to ensure that computers and networks are fully functional *throughout* a project. Although hardware repair costs might be included under vendors' warranties in the first years of a project, on-site maintenance services and technical support help ensure that technology is working properly in schools. Maintenance processes and agreements will vary with procurement and with the "profile" of private-sector technology vendors in a given country. In many countries, large-scale school-based computer projects can be supplied by multinational vendors or their national representatives; in these instances, hardware maintenance is likely to be addressed by one-to-three-year warranties and by service agreements. In more remote areas or in countries without large private-sector technology firms, procurement and service might require negotiations with local vendors or a number of smaller firms, or the payment of additional service fees when on-site maintenance is required.

Periodic on-site maintenance of local networks, anti-virus software, and backups can be performed by private-sector technicians; IT teachers or coordinators, if they have capacity; or in some cases by students. The USAID-supported Macedonian Primary Education Project (PEP) is establishing Student Support Technician Clubs (SSTCs), in which interested older students (Grades 7 and 8) maintain and supervise the school computer facilities. However, even activities that develop in-school capacity for maintenance require planning, management, and inventories of replacement power supplies, hard drives, motherboards, and other components that are likely to fail.

Projects that are scaled up from field trials or pilot stages frequently encounter maintenance challenges stemming from the attempt to expand structures and processes that were never designed for larger-scale operations. Computer and network maintenance, for example, can be assumed during pilot projects by the ministry of education's ICT unit—especially if the schools are nearby or bring their computers to the central unit. This unit's primary responsibility, however, is ensuring that the ministry's internal computers and communications tools are up to date and functioning properly. When such an organization is tasked with technical support, maintenance, and repairs as a project expands to 500 or 5,000 schools, its capacity is quickly overwhelmed.

Credit: Edmond Gaible/The Natoma Group

59 www.computeraid.org

60 www.worldcomputerexchange.org

61 www.cfsk.org

62 http://www.edubuntu.org/about

63 http://www.widernet.org/egranary/

A technology and math-learning specialist for the Expanding Education Horizons project in Jamaica, describes some of the challenges the project faced in providing technical support and hardware maintenance to schools in rural areas:

"Difficulties with technical support could be a real problem. If the computer became infected with viruses, it was out of commission. The warranties varied, sometimes the school would have to pay for support. And some of the teams in rural areas, with no Internet access, it was difficult to update their anti-virus software. If they had a problem, and they were using cell phones, they couldn't call. We had an 800 number, which is toll free, but not when you call from a cell."

Plan and fund disposal of e-waste.
Disposal of "e-waste" can be part of technology projects in schools. At some point, all computer hardware can no longer be repaired, or lacks up-to-date functionality.[64] Old hardware contains toxic materials, including metals such as lead, mercury, cadmium, and copper, and chemicals such as dioxin. Improper disposal results in toxins entering water supplies, food chains, and other parts of the ecosystem. Responsibly disposing of computer hardware involves salvaging usable parts; recycling metals, glass, plastic, and other materials; and disposing of remaining materials in ways that keep toxins out of the environment. In many developed countries, the cost of e-waste disposal is now included in the purchase price of computer hardware, and manufacturers or vendors are required to establish processes for receiving and disposing of old computers. In many developing countries, whose disadvantaged populations are likely to be more exposed and more vulnerable to environmental toxins, the requisite regulations and facilities are not yet established.

The computer-refurbishing organizations Computer Aid and WCE, which import older computers into developing countries, mitigate possible negative impacts through educational programs addressing e-waste disposal and the environment. CFSK, as with many other local refurbishing organizations, does not accept donations of computers from overseas and mitigates the issue of e-waste disposal by keeping used machines in service—although all hardware will eventually become unusable!

Principle 5: Explore technology alternatives to find appropriate solutions.

The proliferation of new tools and new approaches is accelerating in both developed and developing countries; these innovations challenge project developers to think creatively about emerging opportunities. Program designers should consider alternative ways of meeting proposed educational objectives, including broadcast or other technologies, low-cost/low-power computers, and mobile telephones.

Core strategies include the following:

Use technology that is appropriate to available infrastructure.
New means of accessing information and communications are emerging almost daily, driven in part by demand for mobile services in both developed and developing countries. The GATHERdata reporting platform, for example, enables users to access databases to submit or retrieve information by using text messaging, voice recognition, and web pages. GATHERdata is an open-source platform developed by the Academy for Education Development (AED), and is currently deployed in Liberia to improve the quality of education information. In Cambodia, the Educational Support to Children in Underserved Populations project deployed thin-client computer networks in remote schools to achieve cost savings. Thin clients are less susceptible to damage from heat and humidity, and in Cambodia their low energy use enables schools to run computer rooms on solar power—helping increase the likelihood that computer operations are sustainable.

64 Most Pentium I computers, for example, cannot run Windows XP (or even Windows 98) and cannot launch current versions of Microsoft Office. While such computers can be (and are) used for typing and even word processing or spreadsheet data-entry in individual schools, they are not likely to be reliably useful to new projects.

In countries such as Brazil, Chile, and Indonesia, private-sector roll-out of mobile-broadband network infrastructure is reducing costs and increasing the availability of Internet access in peri-urban and rural areas.[65] Schools in such areas are increasingly finding ways to fund connections to the Internet, whether via funding from the Ministry of Education, through independent approaches to parents' committees or local businesses, or by shifting their own budget allocations.

Use technology that is appropriate to teachers' skills and capacities.
Teachers—especially teachers in poor communities and under-resourced school systems—can face significant challenges learning to use computers to support their classroom practices and student learning. Part of the value of Interactive Radio Instruction (IRI), in contrast, is that IRI can provide instruction directly to students and *at the same time* help teachers whose capacities are minimal improve their classroom practices. The Guinean IRI program *Sous le fromager,* part of the FQEL project, guided teachers in leading in-class activities and provided audio examples and instructions directly to students. IRI typically incurs high costs to develop effective programming and to publish supporting printed materials, whereas recurrent costs on a per student basis are quite low. Because broadcast scheduling can sometimes be difficult to synchronize with school schedules, IRI is frequently delivered as audio recordings via cassette players or MP3 players. The *English in Action* IRI series in South Africa has demonstrated test-score gains that range from 6.7 percent to 24 percent and correlate to the number of lessons received by students.[66]

Over the last 35 years, more than 30 countries, including Bolivia, the Dominican Republic, Honduras, Lesotho, South Africa, Thailand, and Zambia, have implemented IRI programs, primarily to provide basic instruction in schools where teachers have few skills and little knowledge of their subjects.

IRI an more in India: Technology Tools for Teaching & Training (T4) Project

Funded by USAID and implemented by the Education Development Center (EDC), India's T4 project uses Interactive Radio Instruction (IRI) as its central means of improving instruction. T4 IRI is focused on English language learning and, in the *Jhil Mil* series, on math, environmental science, and social science. Program evaluations have found high levels of impact on student learning: In the state of Bihar, for example, Class 5 IRI students performed significantly better than their non-IRI peers in math (8.5 percent better), environmental science (10.1 percent) and social science (8.9 percent). In all eight states, evaluations have found that students using IRI make learning gains.

These positive results and other factors have led to rapid expansion of T4, made possible in part by the low capital costs and requirements for support of IRI. Begun in 900 schools in three states in 2003, T4 has grown to provide instruction and support in over 300,000 schools in eight states, and has reached over 42 million students.

In addition to IRI, T4 also provides resources for use in one-computer classrooms. One example is Group Teaching and Learning (GTL) software, which provides CD-based multimedia programming that engages both teachers and students in classroom learning activities. Building off of the IRI model, GTL (via teachers' manuals) guides teachers in conducting whole-class activities that involve song, movement, small groups, and students interacting with the computer. In addition to GTL, the T4 project also provides instructional audio and video support for learning life skills, plus multimedia kits—incorporating audio, video and print content on CD-ROMs—that help students understand concepts and practices in math and science.

In a comprehensive approach to improving teachers' classroom practices and students learning, T4 complements its technology-based direct instruction and classroom activities with professional development for teachers and with leadership development for ministry administrators.

65 Broadband connectivity in schools is now typically provided using Asymmetric Digital Subscriber Line, or ADSL, which relies on land-based copper telephone lines. Such telephone networks are expensive to install, especially with the price of copper increasing. Mobile broadband, also known as General Packet Radio Switching (GPRS) and as 2.5 G or 3G wireless (with "G" standing for "generation"), can be delivered using upgraded mobile-telephone networks. Mobile broadband networks are less expensive to install and can offer Internet connectivity at lower cost to users. Computers can use 3G modems to access mobile broadband.

66 *Using Technology to Train Teachers: Appropriate Uses of ICT for Teacher Professional Development in Developing Countries,* by Edmond Gaible and Mary Burns (Washington DC: infoDev; 2006).

Take advantage of what is familiar and what is already in use.

When familiar tools—radios, telephones, cameras, even television—can be used, professional development can focus on improvements to teaching, learning, and school management rather than on basic ICT skills. USAID has provided US $2 million in grant funding to Tanzania's Bridgeit project, which combines smart phones with mobile-broadband Internet and video to improve learning.[67] Teachers in 150 Bridge*it* schools use the smart phones to search for and download 5-to-7-minute videos, which are then integrated into classroom instruction. The videos support life skills, mathematics, and science learning, and are complemented by print-based lesson plans for learner-centered classroom activities.[68] Bridge*it* represents an innovative solution to the lack of high-quality education content and teacher capacity in Tanzanian schools.

Use technology that is appropriate to education objectives.

Comparisons of alternative tools should be based on all relevant factors—such as cost, infrastructure, the school environment, and social context—but it is critical to ensure that tools and platforms are appropriate to educational objectives. IRI has proven effective at helping students build language and numeracy skills; however, its reliance on direct instruction does not build mastery of more extensive bodies of knowledge or more complex cognitive skills. More information-rich and flexible platforms, such as Internet-connected computers, can support a wider range of educational objectives—if challenges such as infrastructure, financial sustainability, and teacher development can be addressed successfully. The Innovations in Technology-Assisted Learning for Educational Quality (INTALEQ) project in Yemen uses Intel Skoool interactive-multimedia learning resources to support improved mathematics and science learning. In combination with teacher development focused on introducing student-centered instructional approaches, INTALEQ targets the development of 21st century skills such as digital literacy, problem solving, and critical thinking, among others.[69]

Open Educational Resources (OERs) are public-domain teaching and learning resources that can be freely used, repurposed, and adapted. They include courses, textbooks, videos, tests, simulations, and other tools that are useful in schools. Claire Spence, education officer, USAID Jamaica, offers advice regarding taking advantage of OERs and other free resources:

"There's a lot of free stuff that's available. Once we are able to help people to understand the computer, the power of the Internet, the power of free software, and once we can incorporate that into teaching and learning, teachers can be empowered to make use of it."

The OER movement includes an increasing number of platforms that empower users to search for, discover, and make use of free materials for teaching and learning.[70]

Be cautious about relying on new or unproven technologies.

Additional care is needed when considering unproven hardware (and software) solutions. EduTech 2000 in Barbados, in an innovative pilot program that aimed to deliver 1:1 computing to schools, installed "package" style solutions combining rugged student laptops with local area networks (LANs) based on infrared technologies. Both the laptops and the networks were developed by a U.S.-based education-technology start-up company. Initial problems plagued the hardware package—the laptops lacked adequate memory and were unreliable, and the infrared networks rarely worked. Before these problems could be addressed, the start-up eliminated all hardware from its product line and shifted to online learning resources. Shortly afterward, Wi-Fi emerged as the worldwide standard for local wireless networking.[71] The innovative technologies designed into EduTech 2000 were compromised before the

67 Project planners taking advantage of smart phones and mobile broadband should be sure to account for the costs of mobile-data access—which can be substantially higher than the costs of simple telephony.

68 *Bridgeit: Improving the Quality of Education Through the Innovative Use of Mobile Technology,* by USAID (http://edutechdebate.org/wp-content/uploads/2010/09/BridgeIT_July_2010.pdf; accessed January 20, 2011).

69 Announcement at brownbag-lunch-style presentation, Monday, March 8, 2010 (provided by USAID).

70 Many OER initiatives, such as the MIT Open Courseware Initiative, focus on higher education. However, there are an increasing number of programs offering OERs that are appropriate for primary and secondary schools. See OER Africa (www.oerafrica.org) and Curriki (www.curriki.org) for more information.

71 "Wi-Fi" is the popular name for wireless networking using the 802.11 standard recognized by the Institute of Electrical and Electronics Engineers (IEEE).

project started to deliver services. Although EduTech 2000 has made impressive progress since these initial challenges, its early history is a reminder of the risks posed by unproven approaches and tools.

Education-specific versions of commercial technologies are being developed to increase the value of ICT in schools. Among the most heavily promoted tools are low-cost laptops, such as the Children's Machine XO or the Intel Classmate, that support 1:1 ratios of students and computers. Although 1:1 computer projects have demonstrated terrific potential in some implementations in OECD countries,[72] such projects can pose significant challenges, especially in project management, technical support and maintenance, teacher development, school improvement, and costs.[73]

Lower-profile technologies have also been developed specifically for schools and in some cases for specific learning objectives. Microsoft has released MultiPoint Mouse software, which enables many students to share one computer for whole-class activities. MultiPoint has led to the development of education-software applications and activities in Belarus, China, India, Russia, and other countries.[74] The talking word-processor software used in the Jamaica EEH project was developed specifically for the NEO keyboard, a low-cost, easy-to-use, dedicated word-processing tool.

As important, innovations in commercial products are being deployed in schools to take advantage of features that include mobility, low energy consumption, and ease of use. The use of phones and mobile-broadband connectivity in the Bridge*it* project in Tanzania is a cost-effective improvement on Text2Teach, an earlier project in the Philippines that used costly VSAT connectivity. "Pico" (very small) projectors reduce costs and energy requirements. The Worldreader e-book reader (similar to the Amazon Kindle) is currently being pilot-tested by a USAID-supported project in Ghana as a way of supporting the efficient distribution of learning resources.[75]

Credit: Edmond Gaible/The Natoma Group

72 *Laptops and Literacy,* by Mark Warschauer (New York: Teachers College Press; 2006).

73 *Child Laptop Scheme Held Back by Training Shortage in Peru,* by Zoraida Portillo (SciDev Net, July 20, 2010; http://www.scidev.net/en/new-technologies/digital-divide/news/child-laptop-scheme-held-back-by-training-shortage-in-peru.html; accessed January 20, 2011). For a more detailed first-person account of the *Una laptop por niño project,* refer to *OLPC in Peru: A Problematic* Una laptop por niño *Program,* by Christoph Derndorfer (infoDev EduTech Debate, http://edutechdebate.org/olpc-in-south-america; accessed January 20, 2011). Additional results include the 2011 study by published by IDB, *One-to-One Laptop Programs in Latin America: Panorama and Perspectives,* by Eugenio Severin and Christine Capota (http://www.eduinitiative.net/2011/04/one-to-one-laptop-programs-in-latin.html; accessed May 20, 2011).

74 For information about a more nuanced use of multiple-mouse activities, in which student inputs support personalized learning, refer to "Multiple mice-based collaborative one-to-one learning," by Cristián Infante, Pedro Hidalgo, Miguel Nussbaum, Rosa Alarcón and Alvaro Soto, *Computers & Education,* v53n2, Sept09, 393–401.

75 "Almost There Now: World Reader Folks Busy Opening Boxes in Ghana," blog post. November. 28, 2010 (http://www.ebookanoid.com/2010/11/28/world-reader-busy-soring-our-kindles-in-ghana-ereaders-for-the-schools-almost-ready/; accessed January 20, 2011).

Mobiles for Education for Development (M4Ed4Dev)

In 2010, USAID launched its M4Ed4Dev effort, intended to enhance current practices and knowledge in relation to the use of mobile devices in education.

Mobile telephones and other mobile devices have had a strong impact on social and economic development. Research conducted on behalf of the Department for International Development (DFID) in the United Kingdom found that when one person in a rural village in Tanzania acquired a mobile telephone, incomes from agriculture for the whole village increased.[76] (Interestingly, the addition of a second phone was found to yield little increase—because key information was shared by the owner of the first phone.) Mobile banking is transforming remittance transfers. Tools such as MedicMobile (www.medicmobile.org, formerly FrontlineSMS: Medic) are used to improve coordination of healthcare workers, data collection, and patient-clinic communications, and to mobilize communities for vaccinations and clinics. Newer mobile technologies, such as smart phones and 3G wireless, will broaden the use and increase the impact of mobile devices on development as they penetrate developing-country markets.

M4Ed4Dev aims to strengthen the use of mobile devices to achieve equivalent results in schools and education systems. M4Ed4Dev is a collaborative effort, involving USAID and other government agencies, higher-education institutions, foundations, NGOs, development organizations, and the private sector. At present, M4Ed4Dev conducts the following:

- **Research Roundtables** bring together researchers and practitioners to discuss the current use of mobile devices in the field of education, identify research gaps, develop new collaborations, and spur further research.

- **Monthly seminars and Infobriefs** invite researchers, practitioners, NGO representatives, vendors, and others to present the results of their work on mobile devices (or mobiles) in education. Seminars are held on the second Thursday of each month in the Ronald Reagan building in Washington, DC. Each seminar is accompanied by an Infobrief or 5-minute digest, giving a compressed and useful version of the information to be covered. Among the topics that have been addressed are: mobile gaming for literacy, mobiles for classroom assessment, e-book readers, and one mobile per school.

For more information, contact Anthony Bloome at abloome@usaid.gov.

Principle 6: Focus on teacher development, training and ongoing support.

In-service teacher professional development is frequently among the most important and complex components in an education-technology project. Teachers are essential to student learning outcomes, even if a teacher's primary task is to facilitate IRI by ensuring that the class timetable synchs up with an IRI broadcast. In many cases, however, teachers are unfamiliar with the tools they are asked to use, or they lack necessary skills. Even more important, they are frequently tasked with using these new tools and undertaking new practices within the routines of their normal class periods and workdays—without appropriate training or support. Personnel involved in the Bridge*it* project in Tanzania, which relies on relatively easy-to-use and familiar tools—smart phones, videos, and video players—attribute the project's success to its intensive focus on teacher development in relation to its learner-centered lesson plans.[77]

Core strategies for teacher professional development that involves developing technology-related skills and practices include the following:

76 Private communication, Simon Batchelor of Gamos, Ltd. (www.gamos.org), February 21, 2008.

77 "Checking in With BridgeIT in Tanzania: Using Mobile Phones To Support Teachers," blog post, by Michael Trucano (http://blogs.worldbank.org/edutech/checking-in-with-bridgeit-in-tanzania-using-mobile-phones-to-support-teachers-0; accessed January 21, 2011).

Credit: Edmond Gaible/The Natoma Group

Design professional development to meet teachers' needs and program objectives. (Avoid focusing on basic ICT skills!)
Teachers must meet many responsibilities in their workdays, including progressing with their classes through the curriculum and ensuring that students master necessary skills and knowledge. When technology-focused professional development helps teachers learn to integrate new tools into their classroom practices or professional routines, enables them to save time, and improves their performance or enables their students to improve, teachers are more likely to adopt the new tools, explore new practices, and continue learning on their own. Teachers benefit from building basic computer skills within the context of their professional activities, with training built around accessing online lesson plans, conducting web searches for new resources, completing attendance records, preparing resources for presentation in class, and performing other relevant tasks.

In contrast, when professional development simply trains teachers to build technology skills, those skills are de-contextualized, and teachers have little incentive to continue their learning after training is complete. They, and school leaders, are also more likely to focus on helping students build a similarly narrow range of skills, rather than on using technology to master reading and math or build content knowledge and thinking skills.

Connect professional development to recognized teacher standards for technology use.
Linking professional development curricula to standards can enhance the overall quality and impact of training and can give teachers a roadmap and milestones for developing their craft and professionalism. Links to standards can also support the development of indicators for evaluating the training effort. (See *Principle 9* for more information.)

Standards for teachers characterize the knowledge and skills that teachers should build as they proceed in their professional development—what teachers should know and be able to do. Teacher standards commonly address subject knowledge, pedagogical skills, attitudes toward knowledge and learning, and other important topics. Several organizations have also developed technology standards specifically for teachers. Two of the more relevant and influential are the UNESCO ICT Competency Standards for Teachers (CST)[78] and ISTE National Education Technology Standards.[79]

The UNESCO ICT CST help teachers locate their professional development in the use of technology on a three-stage continuum, from "technology literacy" through "knowledge deepening" to "knowledge creation." These standards have

78 http://cst.unesco-ci.org/sites/projects/cst/The%20Standards/Forms/AllItems.aspx

79 International Society for Technology in Education - (http://www.iste.org/standards.aspx)

been localized by several developing-country governments, including the Ministry of Education (MINEDUC) in Rwanda.

The ISTE NETS have been localized in several OECD countries, as well as in Costa Rica, Malaysia, Mexico, the Philippines, and Turkey. The ISTE NETS standards for teachers are accompanied by standards for students and for administrators.

Complement teacher professional development with training for school leaders.

Principals and head teachers are key to the success of education-technology initiatives in their schools. Professional development (or orientation, depending on the project) for school administrators and leaders can help ensure that teachers are supported throughout program implementation and that technology resources are used to support program objectives.

Professional development for school leaders should ensure that those leaders understand the objectives of the program, its importance to the ministry of education, the role of technology, and ways to address potential barriers at the local level. In the absence of professional development, principals can, for example, restrict teachers' and students' access to technology resources out of concern that these resources will be damaged. Principals' engagement may also be critical to ensuring that electricity and connectivity costs are paid or that parents' committees understand and support students' use of new tools. Preliminary results from the IDB evaluation of Peru's OLPC project suggest that principals and teachers (and families) keep children from using laptops or taking them home because they are worried the laptops will be broken.[80]

Inflexible, information-dense curricula and high-stakes assessments pose challenges to teachers when they are asked to integrate new technologies or new pedagogies into their classroom practices. Properly trained and engaged school leaders can be instrumental in helping teachers address these obstacles through measures such as using more effective timetabling, keeping computer rooms open after school, or simply encouraging teachers to experiment.

Build technology-focused professional development around hands-on methods.

Professional development that involves building new technology skills should be based on "learning by doing" models, not on "learning by hearing" abstract concepts or theoretical information. Although it *might* be important for teachers to know that a computer includes a keyboard, a mouse, a monitor, and a central processing unit or CPU, this knowledge will be meaningless to them if they have no experience of using computers. And as mentioned, the instructional methods that teachers experience in training can influence the instructional approaches they take back to their classrooms. Meaningful, active, hands-on learning is best for children *and* adults!

An education specialist from USAID/Macedonia, describes the importance of building enthusiasm among teachers:

"Some things happened spontaneously in schools. Massive public trainings on basic computer use, free trainings countrywide for the general public. When the schools got computers, the teachers got small laptops and the teachers felt so empowered. They took their laptops home and used them. It was as if someone opened a window in a very stuffy room."

Conduct professional development in environments that duplicate school conditions.

Technology-focused professional development is most effective when teachers learn to overcome obstacles posed by poor local infrastructure and limited technology resources. When professional development takes place in infrastructure-rich environments—where participants can work individually on computers, with reliable electricity and high-quality Internet connections—rural-school teachers (and even trainers) spend too little time preparing for the conditions they will encounter in their schools. Teachers working with poor-quality Internet connectivity, for example, can cache web content so that students can later access it locally; the concept of caching is frequently introduced in professional development sessions with high-speed broadband, but the allure of swift page-loads leaves the technique underexplored.

High-quality Internet connectivity and 1:1 computer access do support teachers' learning and their hands-on cataloging of web resources for use in class. Where possible, training can alternate between connectivity-rich and connectivity-challenged sessions: Internet connectivity can periodically be limited with bandwidth-management software; teachers can be required to work in groups of three or more at a single computer. (Moreover, when teachers work together, those

80 IDB, op. cit., p. 6.

with better technology skills can help their peers progress—modeling a technique that all teachers can use in their classes.[81])

Synchronize professional development with the roll-out of technology to schools.
Effective professional development is coordinated with the roll-out of technology. When professional development is delivered prematurely, teachers' new skills can fade, requiring costly refresher training; when professional development is delayed well past the arrival of technology, the importance of the project and the commitment of its sponsors are called into question, and teachers are less likely to make the effort to participate or to make desired changes to their current practices.

In large education systems—or in systems with schools in remote areas—it can be difficult to find an adequate number of accessible training sites with computers and Internet connectivity. Other challenges in large-scale projects include finding sufficient numbers of trainers with technology skills and experience as teachers, delivering Training of Trainers (ToT) in a timely manner, and developing training courses that focus on program objectives. In addition, one set of courses is rarely enough: A single school might require professional development for the head teacher, for two or more subject teachers, and for a technician or an ICT coordinator before the school can fully participate in a project.

Senior staff member of the Expanding Educational Horizons project in Jamaica, underscores the importance of linking PD to the roll-out of technology:

"If you're starting out, there can't be any gaps between training and hardware possession. Sometimes purchasing of the hardware is delayed, and you feel you have to go ahead with the training. But you need the hands-on, and the practice."

Use ICT to provide follow-up and support to professional development.
The effectiveness of technology-focused professional development can be increased through technology-*supported* professional development. Action research, narrative reflection,[82] and other crucial forms of follow-up and support can be provided through various forms of ICT. Where Internet infrastructure and other factors permit, education portals such as those developed in the Macedonia e-School project, the INTALEQ project in Yemen, and the State of the Art Technology project in Guatemala can support teacher-to-teacher collaboration and mentoring, as well as action research and other follow-up methods.

ICT-focused and ICT-supported professional development should be "mainstreamed" into national education budgets whenever longer-term commitments to the use of technology are planned. On the one hand, teachers who are not familiar with new technologies or with new classroom practices typically require more support than they receive in "cascade" training or other workshop-based models. On the other hand, teachers who successfully develop ICT skills can find that new job opportunities are open to them, so retaining faculty can become more difficult. Ongoing professional development helps ensure that new tools and practices are used as planned in schools, and that turnover among staff who have completed their training does not undermine outcomes.

81 Professional development can also introduce the concept of students as "co-educators," taking leadership roles in technology-supported classes to help other students learn.

82 *Teacher Action Research: Building Knowledge Democracies,* by Gerald Pine (California: SAGE; 2009). For more information and for resources describing action research in developing-country teacher professional development, re fer to *In-Service Teacher Professional Development* (compendium) in this *First Principles* series published by USAID under EQUIP1 (page 11).

SIEEQ: Using video to support professional development in Congo

The Stratégies Intégrées pour une Education Equitable et de Qualité (SIEEQ) project of the Democratic Republic of the Congo, which ran from 2004 to 2007, provided professional development in student-centered learning, discovery-based learning, and gender equity in the classroom to 1,212 teacher and 150 school heads. Project participants were supported by access to computers, the Internet, and professional development videos that were shot and edited in Congo. Initially, Congolese teachers were videotaped teaching in their classrooms; these videos were edited and then published to DVD. Using the DVDs in the project's professional development workshops, teachers could observe specific pedagogies demonstrated by their peers.

Follow-up support for the professional development also relied on video. When SIEEQ trainer teams visited schools, they videotaped the project's teachers and uploaded the videos onto laptops (which they charged with inverters running off their cars' alternators). They then shared the videos immediately with the teachers as the basis for encouragement and constructive suggestions.

LOP funding for SIEEQ totaled approximately US $6,500,000.

Principle 7: Explore and coordinate involvement of many different stakeholders.

It is vital to engage multiple stakeholders in education-technology projects. Such projects frequently cut across several sectors and entail great expense as well as technical and organizational complexity. Valuable contributions can be made by international and local organizations, including donor agencies, charitable foundations, NGOs, private-sector technology firms, and government agencies, in addition to ministries of education. However, the value of such contributions increases with effective coordination of stakeholders' inputs and participation.

Core strategies include the following:

Seek out dynamic local NGOs that can contribute to program success.

The activities of local NGOs are frequently high impact and cost effective; engaging such organizations can draw advantage from their expertise and energy while enabling them to expand the scope and scale of their activities and impact. In some instances, larger organizations have entered into partnerships with ministries of education to become key implementing partners in longer-term projects. In Costa Rica, the government-supported *Fundación Omar Dengo* (www.fod.ca.cr) assumed responsibility for the design and implementation of a nationwide roll-out of computers, learning resources, and professional development, funded by USAID, to support the development of higher-order thinking skills among primary students. (See *Principle 1* for more information.) SchoolNet Namibia (www.schoolnet.na) was formed in 1999 with support from the International Development Research Center (IDRC) and served for a decade as an early source of Internet connectivity for schools, providing them with refurbished computer hardware, solar-powered equipment, and technical support, and using teams of at-risk youth as technicians. In 2001, USAID partnered with SchoolNet Namibia and the Ministry of Basic Education, Sports and Culture on the Initiative for Namibian Education Technology (iNET), building the capacity of Namibia's four colleges of education and the ministry's 13 regional education offices to support students' development of technical skills, basic computer literacy, and subject mastery across the curriculum.[83]

Explore the potential of local private-sector technology firms.

Local technology-related firms can make substantial contributions to school technology projects. As discussed under *Principle 4: Include all short and longer-term costs in budget planning,* project expansion can strain government agencies by making them responsible for installing and maintaining school ICT resources on a scale that far exceeds their mandates, resources, and capacities. Similarly, professional-development initiatives on a nationwide scale can exceed existing government capacity. Local and national technology and training firms can step in to provide installation and on-site maintenance of hardware, software, and networks; perform repairs (including repairs covered under warranties); and ensure that sufficient numbers of teachers gain basic ICT skills at the outset of a project.

83 http://www.usaid.gov/na/success2.htm

(Such training sessions should, as mentioned, *always* be situated within educational contexts and should be accompanied by professional development addressing teaching and learning or other areas of change.)

Organizations that install computer facilities in schools frequently are best positioned to service those installations and to make repairs. In Indonesia, for example, computer hardware for schools is generally procured directly from local firms via block grants; these firms then take on responsibility for service and repairs. To increase local capacity to install and maintain computer facilities, Inveneo, the ICT-focused social enterprise based in San Francisco, California, has established a training and certification program, "Inveneo Certified ICT Partners," that has established networks of local firms in 21 African countries and in Bangladesh, Haiti, and Nepal.[84]

Engage with national and international private-sector firms.

Larger private-sector firms have interests in education, economic and social development, and community relations, as well as interests in specific provinces, cities, and towns; these interests can help motivate companies to support education-technology projects in a range of ways, often as part of programs in Corporate Social Responsibility (CSR). Contributions can include sponsoring hardware acquisition in specific areas, supporting the development of digital learning resources, supporting outreach and advocacy, and supporting specific curricula such as environmental education or health and hygiene. CSR and other partnerships can be explored with firms in many different sectors; CSR partners do not need to be technology firms.

In addition, firms operating in technology-related sectors frequently can offer in-kind or financial support for ICT projects in education. Telecommunications companies, for example, operate in a sector that typically is regulated in ways that shelter such companies from competing firms and new technologies (e.g., VOIP[85]). Partly as a result of their close relationships with country governments, telecommunications firms are frequently asked to provide special pricing to schools—or even free connectivity. In Indonesia, the SchoolNet program administered by the government agency *Pustekkom* offers schools low-cost ADSL connectivity, provided by the telecommunications giant PT Telkom.[86] In other instances, telecommunications companies support activities that are not related to their core businesses: As part of the Jordan Education Initiative (JEI), the Fastlink company, the first Jordanian mobile-phone service provider, funded the development of the science e-curriculum.

(See the project profile that follows for more information about JEI.)

Universal Service Funds (USF) obligations frequently require telecommunications firms to furnish voice telephony to rural and remote areas that are not viable markets. In some countries, such as Colombia, Morocco, and Turkey, telecommunications operators have met USF obligations by supporting hardware installations and Internet connectivity in schools.[87] Although USF is not yet commonly used to drive the extension of data communications, changing regulatory practices and the proliferation of mobile-broadband networks will likely lead to the emergence of USF-derived Internet connectivity in developing countries in the near future.[88]

Take advantage of USAID's Global Development Alliance program.

Under its Global Development Alliance (GDA) program, USAID partners with U.S.-based and multinational technology corporations to expand access to education and technology. Key GDA education partners include Cisco Systems, Microsoft, and Intel. These three GDA partners have established programs that specifically address the needs of education-technology projects in developing countries. Key programs include the Cisco Networking Academies and Entrepreneurship Institutes, Microsoft Partners in Learning, and Intel Teach.[89] Intel Teach typically provides the training courseware and master trainers to help build and conduct large-scale professional development

84 http://www.inveneo.org/?q=ictpartners

85 Voice Over Internet Protocol is the primary means of connecting telephones via the Internet. At least 15 countries that do not belong to the Organization for Economic Cooperation and Development (OECD) block or restrict VOIP to protect government-owned or national telecommunications companies.

86 "Telkom organizes national education network in almost 20,000 schools throughout Indonesia" (company media release, http://www.telkom.co.id/media-corner/press-release/telkom-organizes-national-education-network-in-almost-20-000-schools-throughout-indonesia.html; accessed January 21, 2011).

87 Intel eLearning Deployment Guide: How to Integrate ICT in Education for the 21st Century (www.intel.com/Assets/PDF/.../WA-Intel-eLearning-Deployment-Guide.pdf; accessed January 21, 2011).

88 For more information, refer to the infoDev ICT Regulations Toolkit (http://www.ictregulationtoolkit.org/en/Section.1740.html). See also *Principle 7* in this document.

89 Web addresses for these programs are: http://cisco.netacad.net, http://www.microsoft.com/education/pil/, and http://www.intel.com/about/corporateresponsibility/education/programs/intelteach_ww/index.htm.

operations through the cascade training model; participating teachers build ICT skills and begin to integrate school technologies into their classroom practices.

Advantages of these and other off-the-shelf programs by GDA partners stem from their proven quality, along with other factors. Intel Teach, for example, has been used in more than 60 countries to help provide professional development to more than 7 million teachers and has been extensively evaluated. With five technology-focused courses, Intel Teach provides developing-country ministries of education with branded, high-quality (and low-risk) professional development. Intel Teach also greatly reduces the cost of courseware development.

In general, Intel Teach, as well as the other technology-focused GDA education partners, has offered limited potential for customization or the incorporation of local content. Helping teachers overcome barriers to the adoption of technology in schools frequently requires very localized approaches and, as mentioned, extensive follow-up and support. Intel Teach, however, has recently been working with USAID missions to increase the potential for customization of its programs.

While Intel Teach provides proven professional-development courses, implementation costs remain the responsibility of the national education ministry or other local partner. Intel Teach does not pay implementation costs, which dwarf courseware-development costs. As a result, the effectiveness of an Intel Teach professional-development program can be limited by factors that fall outside the framework of the partnership. In Indonesia, for example, the Ministry of National Education's three-year GDA partnership with Intel Teach concluded in 2010, after enabling more than 15,000 teachers to participate in the program's first-level course, Getting Started. However, Indonesia has more than 2.5 million teachers in more than 200,000 schools. As a result of cost, capacity, and commitment limitations within the ministry, among other factors, the Intel Teach program has not reached beyond a small fraction of Indonesia's teachers.

Credit: World Education

An Education Team Leader from USAID in Tanzania, describes the process of building an agreement using GDA partnerships:

"So with [introducing computers] as a top priority I was able to go ahead and make arrangements with private-sector partners to see who might be interested in doing an MOU [Memorandum of Understanding] to come and work here. And I based that on similar work that had been done in Kenya, where they had an MOU between Microsoft, Cisco and Intel, and USAID Kenya…. So I ended up making contact with people from Cisco, Intel, and Microsoft, and we started a dialog, and basically said, All right, why don't we just start meeting, and try to figure out what each one of you would like to contribute? So we did that for quite a long time, came up with an MOU that we liked, sent it to all of our legal people, and everybody signed off on that. We started to put together the request for applications, which was based on the MOU. We were able to get a number of applications, and we were able to get a technical evaluation committee that included members of government—both the mainland and Zanzibar[90]—and the private sector, the international partners Cisco, Microsoft, and Intel, and two local ISPs.[91] We reviewed all the applications and selected one that we thought would work the best. Now we basically have signed that cooperative agreement with Creative Associates. And now, we are getting into a dialog of exactly what we are talking about in terms of how we are going to do this."

For more information about the GDA, please see USAID regional GDA alliance builders. You can also visit the USAID GDA partnership web page: http://www.usaid.gov/our_work/global_partnerships/gda/

Within any GDA alliance, it is critical that a program ensures that skills gaps and local education objectives remain at the forefront in project design and implementation.

Weigh the benefits and risks of private-sector contributions of products and services.

Decisions about education-technology hardware and software can be distorted by market trends and corporate objectives. Multimedia education software, tablet computers (such as the iPad), interactive whiteboards (or smartboards), and implementation models such as 1:1 computing are currently receiving attention in education systems worldwide. Although these and other solutions might be effective in specific circumstances and in relation to specific objectives, their current popularity exceeds their likely contributions.[92]

Build appropriate mechanisms for coordinating stakeholder efforts.

As additional stakeholders become involved in projects, requirements for coordination increase—and as mentioned, education-technology projects can have many organizations making diverse contributions: Within 20 months of its launch, JEI had been joined by more than 30 public- and private-sector stakeholder partners. In Pakistan, the Punjab IT Labs project received contributions from many international and national private-sector companies, enabling the installation of computer labs in 4,286 schools in 110 days. Without proper planning, however, even an achievement of this type, accomplished through effective management and with strong stakeholder contributions, can strain related efforts to train teachers and develop learning resources.[93]

An education specialist at USAID/Macedonia, pinpoints the value of donor coordination:

"It is very important for the donor community to be synchronized. If they are conflicting, that's not good. The donor community is small, but if all donors are in agreement it is powerful."

90 Tanzania has both a national government, the laws and acts of which pertain to the mainland and to all aspects of the union of Tanganyika and Zanzibar, and a government in Zanzibar, including a House of Representatives that can make laws for all parts of that semi-autonomous island.

91 Internet service providers.

92 "The (Murky) Writing on the Wall in High-Tech Classrooms; Some Question If Gadgets Truly Aid Achievement," by Stephanie McCrummen, *Washington Post,* June 11, 2010 (http://www.washingtonpost.com/wp-dyn/content/article/2010/06/10/AR2010061005522.html; accessed May 20, 2011).

93 See punjabitlabs.edu.pk. This section is not intended to suggest that the rapid roll-out achieved by the Punjab IT Labs project has exceeded program capacities in other areas.

Even without private-sector involvement, duplication of activities, as well as gaps or conflicts in approaches, can occur in the absence of strong multi-stakeholder coordinating mechanisms. Such projects require effective coordination between the ministries of education and telecommunications to avoid such problems as multiple installations in some schools and no installations in others; heterogeneous hardware that complicates maintenance, professional development, learning-resource development, and interoperability; and lack of linkage between professional development and education plans and policies. As discussed in relation to *Principle 8,* planning and coordination across ministries or across sectors can be improved by policies and plans that specify the goals of using technology in education and by effective central agencies with responsibility for coordinating the deployment of technologies to achieve these goals.

Jordan Education Initiative (JEI): Managing stakeholder contributions

JEI was launched in 2003 at the World Economic Forum (WEF) by a consortium of partners, including Cisco Systems (whose CEO, John Chambers, originated the idea), the Hashemite Kingdom of Jordan, USAID, UNESCO, Intel, Microsoft, and others. Its purpose was to improve the quality of education through public-private partnerships, enhance the quality of education through technology, build capacity in the local technology sector, and establish a program model for global replication.[94] The multi-stakeholder partnership supported the development of six "e-curricula" that, in concert with the introduction of computers and Internet connectivity, were to be fully integrated into teaching and learning in more than 100 "Discovery Schools," with approximately 80,000 students and more than 2,300 teachers.

Jordan Education Initiative (JEI): Managing stakeholder contributions (continued)

Project management and coordination among public- and private-sector and local and international organizations broke new ground—but also revealed major challenges. By 2005, 45 public- and private-sector organizations were contributing to the project, with each international organization matched to a local partner. A central Program Management Office (PMO) was established with USAID support and with staffing by personnel seconded from the international private sector. While it was effective, the PMO encountered a number of challenges in its staffing and resourcing and in the roll-out of school technologies and teacher development. Most critically, the PMO was conceived of and resourced as a coordinating body, while the complexities of the partnerships, capacity limitations within the Ministry of Education, and the project's management requirements forced PMO staff to assume responsibility for the project's day-to-day management and troubleshooting—tasks that go far beyond project coordination.

In November 2006, JEI was established as a Jordanian NGO under the auspices of Her Majesty Queen Rania Al Abdullah, assuming responsibility for financial management, project management, stakeholder coordination, monitoring and evaluation, and other program components. JEI is now better able to manage stakeholder contributions; however, in some arenas, the impact of early lapses and overlaps continues to be felt.

94 *The Jordan Education Initiative: A Developing World Education Program,* by Michelle Selinger (Cisco Systems; 2005).

Credit: World Education

Principle 8: Develop a supportive policy environment.

Establishing policies, plans, and central agencies to shape the use of technology in education can help ensure that initial expenditures and activities support government objectives, and that high-impact activities receive ongoing funding.

Core strategies include the following:

Facilitate the development of education-technology policies and achievable plans that align with national objectives.

Policies in ICT in education should be developed in relation to broader national policies, plans, or strategies for development. The Government of Rwanda's approach to ICT and development exemplifies a comprehensive and integrated process of policy and planning, leading to, among other outcomes, a well-founded and clear approach to education technology. At the highest level, the *Vision 2020* statement identifies the goal of transforming Rwanda into a middle-income country by the year 2020 by supplanting the country's economic base in subsistence farming with a knowledge economy. A national ICT policy supports *Vision 2020,* outlining the government's commitment to a strategy to "transform the education system using ICTs with the aim to improving accessibility, quality and relevance to the development needs of Rwanda."[95] The implementation of the policy is guided by a series of five-year plans that address ICT in relation to "pillars" of development that include infrastructure, social development, the private sector, and education, among others. Based on the country's second five-year plan (2005–2010), MINEDUC in 2008 released a draft "ICT in Education Policy" that delineates strategic approaches to curriculum, content, and assessment; infrastructure; EMIS implementation; and eight other areas.

(Rwanda's effective policy making and planning activities, confronted with the realities of poor infrastructure and low capacity organizations, underscore the challenges of implementing technology infused development.)

Technology projects in education can also intersect policies related to job creation and employment, health, agriculture, and telecommunications, among other sectors; effective policy and planning are critical to ensuring that project objectives in education and other sectors are coordinated to achieve maximum impact.

Support policy development that frames education-related goals.

The goals and objectives framed by policies that address ICT in education should identify improvements to the education system as a whole, improvements to school operations, and changes in teaching practices and learning outcomes. Policymakers and politicians limit the influence of such policies when they enumerate performance metrics—"50 percent of rural schools will have Internet access"—rather than identify education-focused goals and outcomes. First, framing goals in relation to students' activities and competencies helps keep project designs open to the best possible tools, solutions, and activities. Second, policies that frame education-focused goals enable the development of outcomes-based objectives, which support comparisons of cost *and* effectiveness among different approaches. Examples of outcomes-based educational objectives might include: "Students read at grade level in their mother tongue as demonstrated in standardized assessments" or "Third-grade teachers lead classes in reading-fluency exercises using downloaded materials." Broader goals for technology-in-education projects could include "Students improve reading skills" or "Schools meet monthly reporting requirements."

Especially when they connect to policy goals, well-articulated project goals and objectives support outcomes-based evaluations. When evaluations reveal positive outcomes, education leadership can argue forcefully in favor of mainstreaming or scaling up successful initiatives. (See *Principle 9: Integrate monitoring and evaluation into technology-project designs* for more information.)

95 *An Integrated Socio-Economic and ICT Policy and Strategies for Accelerated Development,* by Government of Rwanda (http://www.uneca.org/aisi/nici/country_profiles/rwanda/rwanpap3.htm).

Explore enfranchisement of a central agency for education technology.

Education policy and subsequent planning can support the centralization of responsibility for education technology, benefiting program coordination, implementation, impact, and data-driven decision making. Such organizations, including Becta in the United Kingdom, the Korean Education & Research & Information Service (KERIS) in Korea, *Enlaces* in Chile, and *Fundación Omar Dengo* (FOD) in Costa Rica, among others, have played vital roles in the evolution of technology use to support education in their countries and worldwide.[96] The effectiveness of these organizations and of others like them depends on continued political and financial support. (Becta, among the most innovative of these agencies, was scheduled for closure by the United Kingdom government in 2010 as part of across-the-board budget cuts.)

Including the establishment of central agencies in relevant policy can help these agencies receive the support they need to adapt and facilitate successful educational improvement. Such agencies have emerged from a diverse array of circumstances—as university programs (*Enlaces*), as government agencies (Center for Education Projects, Armenia), as NGOs (FOD, JEI), and through legislation and policy (KERIS). As a result, many of these organizations face challenges as their mandates change—from providing technical expertise, for example, to providing expertise in educational uses of technology—or as a result of changes in their political and economic contexts.[97]

Guide policy development and planning toward broader and longer-term goals.

Program officers, project designers, and others need to be alert to the possibility that policymakers and politicians will see political advantage in education-technology projects and steer those projects toward short-term or superficial objectives. There is great danger in considering computers and the Internet as "magic bullets" that will radically improve low-performing schools and provide jobs that do not yet exist. But such attitudes can lead to projects that fund hardware while ignoring professional development or that exceed the capacity of local infrastructure and the implementing organizations, and that overlook the range of vital considerations that are identified in this document.

Policy that links ICT use to longer-term challenges in the education system, such as increasing teacher capacity, offering better-quality learning resources, or improving students' competencies across the curriculum, can help mitigate these problems.

A USAID education specialist frames the problems that can arise when political considerations drive education programs:

"Here, decisions are made by ministers themselves, not by experts, and that creates problems. It is difficult to communicate at the level of the Prime Minister; he was the person who said we should have a one-to-one program—it was difficult to convince him that it's not needed. We were not successful. They bought the computers.

"Engage them [ministers] as early as possible. Educate them that hardware alone is not enough. It's not even a beginning—before procuring, there must be planning, planning, and more planning."

Ultimately, ICT policies in education can help ensure that projects and strategies gain the political support that they need to achieve sustainability and impact. If projects funded by fixed-term grants and discretionary budgets are to be continued—or expanded—beyond the term of grant funding, their costs should be integrated into annual budgets. The influence of policymakers and politicians is critical to achieving such transitions. These decision-makers are, in turn, influenced by outcomes that link to policy.

96 It is critical to ensure that new agencies, if they are formed, have effective leadership and a mandate with sufficient scope and independence that they do not simply become new bureaucracies or extensions of existing ones.

97 The World Bank, KERIS, UNESCO, and other partners are currently documenting the experiences and effectiveness of central education-technology organizations. For more information, refer to coverage on the World Bank's EduTech blog (http://blogs.worldbank.org/edutech/building-national-icteducation-agencies; http://blogs.worldbank.org/edutech/seoul2010; http://blogs.worldbank.org/edutech/category/tags/keris).

Rwanda's ICT policy in education: Avoiding problems caused by lack of direction

Although policies and sector wide plans do not ensure that education-technology projects will deliver their intended outcomes, such policies and plans can help avoid common problems. Rwanda's draft policy identifies 10 "factors" that result from "the lack of clear ICT policy":

- Lack of alignment among initiatives
- Lack of proper planning and consultation
- Prioritization
- Saying "yes" to everything
- No clear understanding of what ICT in education is
- Different education agencies not talking to each other
- Ownership (of programs)
- Decentralization of program implementation
- Need for clear implementation plan
- (Lack of support for) Total cost of ownership

Clear, appropriately constructed policies can benefit the design and implementation of individual projects and can also help achieve overall coordination of ICT initiatives within education, and of education-related initiatives in other sectors, such as health, telecommunications, agriculture, and labor.

Principle 9: Integrate monitoring and evaluation into project planning.

Planning (and budgeting) for monitoring and evaluation of education-technology projects should begin during the first phase of project design. In most circumstances, it is important to emphasize using randomized studies and experimental statistics (e.g., multivariate regression and other means of determining correlations between inputs and outcomes); such methods typically require collecting baseline data or collecting data from control-group samples. Advance planning, budgeting, and preparation are essential if these measures are to be put in place.[98]

Although many of the core strategies outlined here can apply to evaluations of all education projects, they are critically important to projects that are supported by technology. Such projects can be complex and costly and can involve multiple stakeholders in multiple sectors. In addition, the introduction of new information and communications tools can be perceived as threats to cultural mores, can cut across different parts of school operations, and can be disruptive in both harmful and beneficial ways. Effective monitoring or formative evaluation enables detection of unanticipated obstacles as they emerge, and supports adaptations to address them; effective summative evaluation, in addition to identifying challenges and obstacles that influenced outcomes, can describe program impacts and help make the case for (or against) continuation or expansion.

Core strategies include the following:

Support outcomes-based evaluations as well as performance metrics.
In light of the management and implementation challenges that they pose, computer and Internet projects in schools are frequently evaluated in terms of project performance or successful inputs: "Were the computers installed on time and on budget?" "How reliable and fast was Internet access?" "How many computers were still functioning after one year of use?" and "How many teachers participated in professional development?" are frequent evaluation questions— assessing the number, type, and effectiveness of resources and activities that are introduced as part of a project.

To determine the value of technology projects in relation to their (sometimes considerable) costs, however, evaluation designs should go beyond the analysis of program implementation to assess real impact. In education-technology projects focused on teaching and learning, impact indicators (sometimes referred to as "outcomes") frequently center on teachers' actions, including their classroom activities as instructors and facilitators, on students' learning behaviors, and on students' learning outcomes. Impact indicators can be framed in many ways; simple indicators of impact for a program introducing Discovery Channel Global Education Partnership

98 For additional information about randomized evaluations based on experimental methods, including studies of education-technology projects in India, Colombia and other countries, refer to the Abdul Lateef Jameel Poverty Action Lab (J-PAL; http://www.povertyactionlab.org/).

programming, teacher development, and lesson plans could include "Students use more concrete examples when writing about science," "Students include more connections between different environmental threats in presentations," and "Students science writing in exams is higher volume."[99] (Indicators are also addressed in the *Examples of indicators* section.)

Technology projects can affect many aspects of education systems outside of classroom activities or learning. School report-card projects, for example, might target both improved collection of data on a nationwide basis and more effective use of information by school heads. Simple impact indicators might include: "Schools complete all reporting requirements electronically" and "School heads share school information with parents' committees."

Support for assessing project performance in terms of technology and implementation is important, but assessing project impact is essential!

Link indicators to project objectives and policy goals.
Project objectives can be a bridge linking the results of an evaluation to policy. Properly structured outcomes-based indicators should reflect project objectives, which can (and should) in turn reflect the broader goals articulated in national policies.[100] A project that demonstrates impact in these terms can receive rational, impassioned, and evidence-based support for being expanded, replicated, or mainstreamed into national education budgets.

Make evaluation a participatory process.
Evaluations should engage all stakeholders, ranging from the classroom level—talk to students!—to teachers, principals, and families, to key individuals in ministries and among the broader array of stakeholders. Different groups will highlight different objectives or outcomes and will provide different explanations for obstacles that have emerged. Broadening the scope of evaluation can help increase the accuracy and reliability of findings.

Include formative assessments.
In addition, formative assessment—whether formal or informal—is essential to the success of technology projects in education. The introduction of new tools and new pedagogies can encounter unanticipated barriers and challenges. Examples of challenges that can be revealed in formative evaluation include these: teachers don't have enough time to address all units in the curriculum and engage in project activities; schools stop paying for Internet connectivity; radio lessons are broadcast at inconvenient times. Formative evaluation can identify such obstacles early in a project and enable them to be overcome.

Use evaluation results in decision-making.
Summative and formative evaluations of ICT projects in schools convey objective information about infrastructure, school leadership, teachers' overall capacity and motivation, the challenges teachers face, and other factors that are critical to the efforts to improve schools. The results of evaluations should strongly influence decisions about whether and how projects should be scaled up or mainstreamed into ministry budgets. These results should also be considered as new programs are being designed and, in some instances, as sector-improvement plans are developed.

Share findings broadly and transparently.
Making evaluation findings—and models—widely available benefits everyone involved in education and in ICT for education. Technology has failed to achieve its full potential as a tool for education transformation in part because projects

Credit: Edmond Gaible/The Natoma Group

99 For more information, refer to "USAID evaluation policy," which establishes terms based on evaluation of impact or outcomes. The policy itself mandates performance evaluation of all projects with impact evaluations to be undertaken selectively by various missions (http://www.usaid.gov/evaluation/USAID_EVALUATION_POLICY.pdf).

100 "What Is Impact Assessment and Why Is It Important?" by David Streatfield and Sharon Markless, *Performance Measurement and Metrics,* v10n2, 2009; pp. 134–141. Streatfield and Markless have been instrumental in advancing the discussion of impact evaluation and indicator development within the international library community.

have repeated mistakes that have dogged technology projects in education for decades. Evaluation is about learning, about improvement, and about the future: Sharing and transparency are essential.

The NEPAD e-Schools Demonstration: A model for formative evaluation

The evaluation of the e-Schools Demonstration Project of the New Partnership for Africa's Development (NEPAD) included substantial and valuable formative assessment—essential for a project spanning 16 countries. The NEPAD e-Schools Demo ran from 2003 through 2007 and beyond in some countries that struggled with implementation. Beginning in January 2006, a series of interim internal reports was completed for the sponsoring East-Africa Commission (EAC). These reports highlighted implementation issues encountered in different countries and made recommendations for addressing these issues.

In light of the variable progress made in different countries, a "final" evaluation was submitted in 2007 that *also* presented the project as a work in progress but that emphasized lessons learned and recommendations that would be essential if and when the project is replicated, as initially proposed, in more than 550,000 schools in Africa. That evaluation was intended to support adjustments to ongoing project implementations, synthesize the lessons learned over the course of the project, and provide a model for further monitoring and evaluation at the local level. The final evaluation remained formative, but the results and lessons learned were widely shared both among participating organizations and at large.[101]

101 *The NEPAD e-Schools Demonstration Project: A Work in Progress,* by Glen Farrell, Shafika Isaacs, and Michael Trucano (Washington, DC: infoDev; 2007).

Principle 10: "It takes capacity to build capacity"—System strengthening precedes system transformation.

Developing-country school systems rarely have the capacity to effect substantial change in teaching, learning, or school operations—whether technology is used or not. In many instances, the range and intensity of problems are great: schools have no learning resources, teachers lack knowledge of their subjects and, worse, are often absent, and schooling, especially the secondary curriculum, doesn't improve students' lives or earnings. Infrastructure in the poorest countries and communities hobbles the potential introduction of technologies to address these deficiencies. In such circumstances, investing in computers and the Internet as the means of jumpstarting development of a 21st century workforce is wrongheaded or disingenuous.

As Thomas Hatch of Columbia University's Teachers College has said, "It takes capacity to build capacity."[102] Schools and school systems that lack basic levels of management, leadership, teacher professionalism, resources, and other core components must address these problems to build the stable foundation needed for the equitable and effective delivery of public education. Students are frequently ready to benefit from instructional methods that involve play, collaborative learning, problem solving and other learning activities that promote higher-order thinking,[103] while schools and teachers are challenged to help them build basic reading and math skills.

As the projects cited and profiled in this document demonstrate, technology can play a vital role in strengthening education systems. The system-strengthening process is, in most instances, an essential step in the transformation of schools and education systems into learning organizations that can help students build 21st century skills.

Core strategies include the following:

102 "When Improvement Programs Collide," *Phi Delta Kappan,* v83n8; 2002.

103 "Gaining Confidence through Collaboration," by Mary Burns (Washington, DC: EDC; 2010; http://t4india.idd.edc.org/2010/11/16/gaining-confidence-through-collaboration). This article describes a successful approach to collaborative learning in Karnataka State, India, that is part of the T4 project but that does not involve the use of technology.

Build on "appliance style" use of technologies.
Appliances are designed to accomplish specific tasks; they do not lend themselves to an array of different uses. When technologies are introduced into schools as appliances—devices to be used to accomplish specific, education-related tasks—implementation and adoption challenges are minimized and specific teaching activities and learning outcomes can be supported. Dedicated word processors, such as the Renaissance Learning NEO2 tools used in the EEH project in Jamaica, present new users with fewer options and features than laptop computers do. Their simple design and limited feature-sets can facilitate the adoption and use of these tools in schools; they can then help students, teachers, and school leadership build skills and practices that will support more powerful and complex tools when they are introduced.[104]

The Bridge*it* project in Tanzania demonstrates a variation on this approach. Nokia smart phones with mobile-broadband Internet are used for one purpose—to download educational videos over the Internet. The hones themselves are capable of Internet browsing and support many other tasks, but these features are not addressed in teachers' professional development. Training sessions focus on the teaching practices, lessons, and classroom activities that teachers need so they can use the downloaded videos. Again, technology is introduced as a way to accomplish a specific task; users' responsibilities (in terms of using the new tool) are simplified, possibly paving the way for more expansive use of the smart phones and the Internet at some time in the future.

The progression from simple tools and simple tasks to similar tools to accomplish more complex tasks is analogous to the familiar instructional technique of "scaffolding."

Scaffold approaches to technology integration.
A cart filled with laptops and a week of training in "integrating technology into the curriculum" can place real strain on a teacher who is unfamiliar with computers or who teaches by copying from a textbook and asking the students to do the same. Providing the same teacher with a netbook, projector, and another week of training provides a tool set that can support the teacher's traditional instructional method and save effort and class time. Later, after building familiarity and skills, the teacher can shift—with professional development and other support—toward more effective uses of the new tools to enhance student learning.[105]

The DALI project, run as a pilot project under the auspices of DBE2 in Indonesia, adopted a different approach to scaffolding primary teachers' progress. All DBE2 teachers participated in professional development to build capacity to conduct learner-centered classroom activities. The DALI teachers also participated in training in basic computer skills and how to conduct the same learner-centered activities using one computer in their classrooms. Field reports from the DALI project suggest that participating teachers show very high levels of computer use relative to teachers completing other technology-focused professional development programs in Indonesia.[106]

A technology specialist for math instruction for the Expanding Education Horizons project in Jamaica, describes teachers' adoption pathway from the NEO smart keyboard to using real laptops:

"Facility with the keyboard definitely reduced some of their anxiety. They learned to use the NEO keyboards first, and then worked with the laptops to add photos to the stories their students had written."

104 While the developer of the NEO, AlphaSmart, specialized in dedicated word processors for 20 years, the NEO represents a minor departure from its normal product line. Running the Palm Operating System, it has a feature-set similar to that of a personal digital assistant (PDA). The NEO is, however, much simpler and easier to use than a netbook or laptop. (Renaissance Learning acquired AlphaSmart in 2005 and renamed the company NEO Direct.)

105 The use of "scaffolding" throughout this section is more accurately framed as the related pedagogical concept, the Zone of Proximal Development (ZPD). ZPD is the zone of activity in which a person can produce something with assistance that he or she cannot produce alone. For a thorough discussion of scaffolding and ZPD, refer to "The Social and Technological Dimensions of Scaffolding and Related Theoretical Concepts for Learning, Education and Human Activity," by Roy D. Pea, *Journal of the Learning Sciences,* 2004, v13n3, pp. 423–451.

106 Personal correspondence between the author and Mary Burns, consultant to DBE, and with Prof. Lim Cher Ping and Mr. Jan Van Rees, members of the ICT-in-Education consultative team to the World Bank Jakarta office.

Credit: Cassandra Jessee/AIR

Develop ICT infrastructure to improve systemwide capacity.

Just as education systems at their most advanced develop "collective capacity" to improve, low-performing systems require scaffolded approaches to developing their capacity for education change.[107] When school systems lack foundational capacity, ICT can be used to establish education-technology infrastructure—school hardware, Internet connectivity, and human capacity—that can support incremental school improvements. Lower-risk, lower-complexity approaches can provide experience and build essential skills at the ministry, district, and school levels. The core competencies and key processes required—ranging from enacting policy to managing stakeholders to marshalling funds for sustained operations to using and maintaining tools for learning in schools—are linked to the principles and core strategies described previously.

Rwanda's ICT Policy Statement: First steps in a scaffolded approach to school improvement

In 2006, the Ministry of Education of Rwanda (MINEDUC) released a short policy "statement" two years in advance of the release of its 2008 draft policy for ICT in education. The statement was intended as an interim guide to the use of ICT. While *Vision 2020* calls for a workforce with skills required by the knowledge economy, and the policy document that emerged in 2008 outlines a broad array of activities focused on computers and the Internet, the 2006 statement describes a few cogent (and modest) steps centering on the use of ICT. The first two steps point realistically to the starting point for technology in Rwandese schools: "Preparing all sectors of the education system to understand the investment in and value of technology" and "Preparing schools to accept technology." These first steps are followed by a third incremental and scaffolded approach to technology-supported improvement: "[P]rocuring and installing the technology."[108]

As a landlocked, conflict-scarred Least-Developed Country (LDC), Rwanda faces nearly insurmountable obstacles in its approach to *Vision 2020*. Capacity across the Rwandese education system is very low. The first steps outlined here, however, have the potential to support system-wide change and accelerate the development of collective capacity in schools.

107 *All Systems Go: The Change Imperative for Whole System Reform,* by Michael Fullan (London: SAGE, Ltd.; 2010), p. xiii.

108 *ICT in Education Policy* (draft; Kigali: Ministry of Education of the Government of Rwanda; 2008).

Challenges and Limitations

There are limitations on the impact of ICT in schools. These limitations lie outside the challenges addressed in the principles of using technology to improve education.

Technology increases complexity in education systems. Technology adds an additional layer of complexity to school systems—a layer that encompasses more than the tools themselves, but also new skills, new activities, and new interactions. Ordering this layer of complexity to deliver educational value requires new organizational structures—to train teachers and students, create and disseminate resources, and assess progress, and to procure, install, and maintain the new tools. More flexible technologies, such as computers and the Internet, introduce higher degrees of complexity than appliance-style technologies, such as DVD players, and broadcast technologies, such as radio. But procuring, distributing, supporting, and integrating any of these tools requires new practices at every level to be effective.

Education-technology projects are subject to political and marketplace pressures.
Decisions about introducing ICT into schools on a large-scale or nationwide level are frequently influenced by factors outside the education system—most notably political and commercial interests. Delivering ICT to schools, whether the project is well designed and appropriate to the system or not, can be presented to the public as a bold, innovative, and impressive measure by politicians. As important, electoral timelines can shorten technology-project timelines, without scaling back projected results: Decision-makers responding to election cycles can sometimes influence project designs to "fast forward" technology roll-out, the projected building of teachers' skills, and students' achievement, accelerating timelines beyond the system's capacity for new practices or change.

Credit: Cassandra Jessee/AIR

Credit: Edmond Gaible/The Natoma Group

There is no "magic bullet"—the impact of technology is constrained by many factors.

Constraints on the impact of education-technology projects have been identified throughout this *First Principles* document. These constraints work in combination to limit what can be achieved in the short term. Such constraints include cost, infrastructure, teachers' skills, and organizational capacity, among others. Addressing one of these, such as infrastructure or teachers' skills, can intensify another, such as project cost or organizational capacity.

All of these constraints extend the time required to improve schools.

Educational improvement takes time.

In some instances, overcoming constraints requires waiting for actions outside of schools: Internet bandwidth is dependent in part on a country's Internet infrastructure and on its connection to international Internet "backbone." Resolving connectivity in schools when the primary constraint is poor national or international backbone lies well outside the education system.

However, overcoming school-specific factors, such as teachers' limited skills, also requires time, but time filled with effective action: If teachers currently teach through drills and memorization, a project design that advances from training them to use computers to the use of digital resources in classroom instruction to the introduction of tele-collaborative learning by students over the course of a single academic year is a compromised design. The approach might be pedagogically sound overall, and the use of technology might be appropriate and sustainable, but the proposed new skills, knowledge, and practices are beyond what can be accomplished in a short timeframe.

The ability of ICT to reach large audiences, to present compelling instructional materials, and to engage students and teachers in communication and collaboration is unchallenged. Realizing the enormous potential of technology to support system-strengthening requires sufficient planning, funding, and effective school-level inputs.

Suggested Indicators of Success

The indicators identified in this section can help program designers and evaluators frame some of the key areas for investigation in the assessment of education-technology projects. In practice, such indicators should be developed in relation to program design and objectives, the preexisting education environment, and other factors.[109]

Access indicators

Access to technology in schools can be a significant hurdle, limiting a project's impact in relation to student learning and other essential outcomes. Frequently used access indicators include:

- Availability of grid-based or mains electrical power (including, in low-infrastructure environments, hours per week of electrical power)
- Availability of alternative electrical power (e.g., diesel generator, solar power, pico-hydroelectric power)
- Number and type of devices (e.g., computers, printers, projectors, smart phones), number of functioning devices, and number of users per device (e.g., students per computer in a given class period)
- Type of Internet connection, bandwidth, and number of devices connected[110]
- Percentage of students using school computers per week, and hours of hands-on time per computer-using student

These and other access indicators will typically be considered inputs or input indicators for purposes of project evaluation.[111]

Credit: Edmond Gaible/The Natoma Group

Output indicators

Output indicators can valuably address changes in teaching practice and learning behavior that rely on technology or that meet objectives of technology-supported professional development. Examples of such indicators follow:

- Students use educational software resources[112]
- Students engage in technology-supported collaborative activities with other students in their class, with students in other classes, and with students in other schools or countries

109 In some instances, indicators in this section have been combined (e.g., type of Internet connection, bandwidth, number of devices connected) to streamline reading.

110 A more effective indicator is "bandwidth per user"; however, many organizations will not be able to provide this information.

111 Discussion of access indicators is based in part on *Technology in Schools: Education, ICT and the Knowledge Society,* by Pedro Hepp, Enrique J. Hinostroza, Ernesto Laval, and Lucio Rehbein (Washington, DC: World Bank; 2004; http://www1.worldbank.org/education/pdf/ICT_report_oct04a.pdf; accessed February 1, 2011).

112 Many educational software products include various forms of computer-assisted learning (CAI), which typically involve viewing, reading, or interacting with curriculum content; completing an assessment; and remediating poor competencies and then moving on to another instructional unit. Output indicators can in these instances be based on the completion of a given number of units. (Note that CAI-based resources vary *greatly* in their impact on student learning. No such product should be deployed without a close review of at least one independently conducted evaluation that demonstrates significant improvements in learning outcomes in comparison with a control group.)

Credit: Edmond Gaible/The Natoma Group

- Students conduct independent research, write reports, and make presentations
- Teachers display curriculum-related resources (e.g., videos, simulations) to their classes
- Teachers search for, find, and use lesson plans or other resources on DVD, a school server, or the Internet
- Teachers use technology (e.g., email, blog, SMS) to communicate with other teachers

Whether or not sample indicators require the use of technology—for writing a report or making a presentation, for example—should be determined in relation to the project design.

Programs that focus on deploying EMIS or using school report cards (see Figure 2: "School report card" from EMIS project in Georgia) can assess outputs in relation to participation in reporting activities and use of information for school improvement. Sample indicators follow:

- School heads complete monthly, quarterly, annual, or other reports (using technology).
- School heads share results of school report card with parents' committee (using technology).

Impact indicators

Impact indicators (or outcome indicators) in education-technology projects are often similar to impact indicators used to evaluate education projects that do not use technology: Did students develop the intended competencies? Did students perform better than students in classes that did not participate in the project? These questions can be answered by standardized assessments, such as national exams, or by dedicated assessments that are developed specifically as part of the project evaluation.[113]

Technology has been shown to have a positive impact on student motivation[114] (and on teacher motivation), with an indirect impact on attendance and school completion. These areas can also be addressed by impact indicators.

Impact indicators can also be designed to address the specific features of a given tool or intervention. For example, a project in which students use talking word processors (such as the NEO keyboard) might be evaluated using these indicators:

- Using the word processor, students write more (e.g., longer essays), and make fewer spelling errors
- Students make fewer mistakes on spelling quizzes or when writing with pencil and paper

Similarly, an evaluation of an IRI program in English-language instruction might include these impact indicators:

- Student pronunciation improves
- Student comprehension improves
- Student test scores improve

The first two of these three sample indicators would likely require dedicated assessments; in all instances, assessments of learning outcomes need to be conscientiously designed to eliminate confounding factors. (Improvements in students' test scores could, for example, improve if schools were open more days during the term, or if a separate initiative led teachers to come to school more regularly.)

School report-card projects might include impact indicators related to school resources and school heads' abilities to mobilize funding from outside sources:

- Improvements to school facilities (e.g., new room, Internet connection)
- Increased learning resources (e.g., mathematics manipulatives, science resources)
- Increased contributions from parents' committee

In addition to input, output, and impact indicators, evaluations must also account for the broader array of factors that have the potential to influence the outcome of education-technology projects. Those factors include national telecommunications infrastructure, levels of technology use (and literacy, among other factors) in relevant sectors of society, any costs to schools (to enable analysis of costs and benefits), and the relative costs and impacts of alternative approaches.

113 Discussion of impact indicators is informed by Wagner et al., op. cit.

114 *The Effects of Using Instructional Technology in Elementary and Secondary Schools: What Controlled Evaluation Studies Say,* by Kulik (Menlo Park, Calif.: SRI International; 2003, cited in *Monitoring and Evaluation of ICT in Education Projects: A Handbook for Developing Countries,* by Daniel Wagner, Bob Day, Tina James, Robert B. Kozma, Jonathan Miller, and Tim Unwin (Washington, DC: infoDev; 2005).

Conclusion

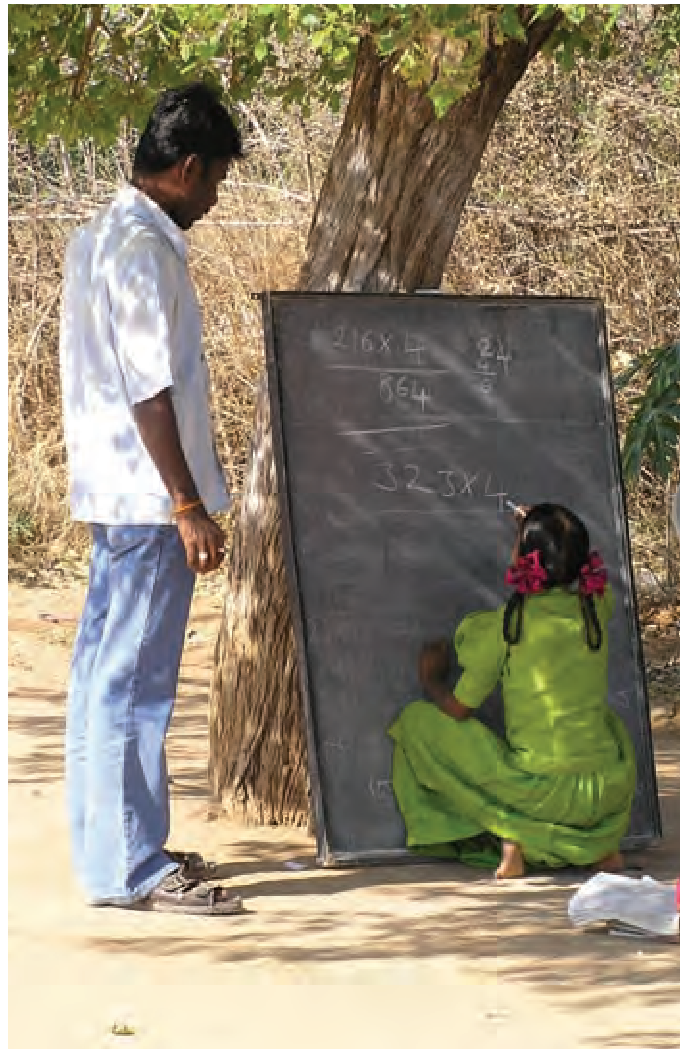
The introduction of technology into processes of education change carries risk and great potential benefit. In some instances, technology is the only feasible and cost-effective means of improving education across all of a nation's schools. Broadcast and networked communications and easily reproduced digital materials can help provide high-quality resources or direct instruction to students, information that school leaders and decision-makers can use, and opportunities for teachers to enhance their skills. However the skills and knowledge needed by the organizations charged with guiding technology projects in schools are often earned through difficult—and costly—experience.

The 10 principles that have been presented here are guideposts based on the more than two decades of history of ICT projects in schools in developing countries. Some principles focus on broad challenges and barriers that are common to all large-scale technology projects—matching tools to infrastructure, securing strong policies and partnerships, and accurately estimating costs. Other principles seek to ensure that investments in powerful and even eye-catching new tools pay off in terms of student learning and school management. Intense focus on education goals, on students' skills and knowledge, and on teachers' professionalism is essential if real impact is to be achieved. Without such focus, without such impact, the risks involved in education-technology projects will not outweigh the benefit.

Such pitfalls notwithstanding, the forces driving the adoption of technology in schools today will only intensify in the future. The relevance of traditional education will increasingly be called into question by dynamic economies placing new demands on each nation's workforce. The models for using technology to support the development of essential skills—reading, math, and job and life skills—will continue to be refined and improved. The skills and capacities with the highest value for all individuals, from small-hold farmers to globally focused professionals, will be less and less tied to mastery of specific bodies of knowledge; the new high-value skills and capacities will be in the use of technology to find and assess information, work effectively with groups of diverse people, solve new problems, and create new tools.

Today, few countries have mastered the use of technology to improve their education systems or to help today's students thrive when they leave school. However, these students will, over the course of their lives, confront challenges and

Credit: James MacNeil/World Education



encounter opportunities that demand new ways of thinking and acting that rely on their powers of communication and analysis, and on their ability to operate in environments that are dense with information. Deferring the decision to adopt technology can mean deferring the transformation of schools and school systems, whether the needed transformation is for equitable development of basic skills or for more radical transformation in the ways of thinking and knowing. Starting now on a path of change that makes use of new tools *and* acknowledges current capacities and existing challenges, lays the necessary groundwork for future improvements. First steps along this path, guided by first principles that have emerged out of years of practice, will lead to improvements that enable all individuals to flourish in their economic, social, and political lives.

Essential Reading

The reports, books, and websites that follow represent a very short list of essential resources on ICT in education.

Seminal works, surveys, and anthologies

These works provide solid overviews of progress to date in specific areas related to technology in education. Professor Cuban's book has shifted the discussion of the role and impact of technology in education worldwide.

Anzalone, S. and Bosch, A. 2005. Improving Educational Quality Through Interactive Radio Instruction. Washington DC: The World Bank. http://www-wds.worldbank.org/servlet/main?menuPK=64187510&pagePK=64193027&piPK=64187937&theSitePK=523679&entityID=000160016_20060410163243

Cuban, L. 2001. *Oversold and Underused: Computers in the Classroom*. Cambridge, Mass.: Harvard University Press.

Kozma, R. In press. *ICT Policies and Educational Transformation.* New York: UNESCO.

Perraton, H. and Lentell, H. 2004. *Policy for Open and Distance Learning: World Review for Open and Distance Learning,* vol. 4. London: Routledge.

Regional surveys

The series of regional surveys was started by UNESCO-Bangkok with the 2003 meta-survey.

Farrell, G., Isaacs, S., and Trucano, M., eds. 2007. *Survey of ICT in Education in Africa,* vols. 1 and 2. Washington, DC: infoDev. http://www.infodev.org/en/Publication.353.html

Farrell, G. and Waccholz, C., eds. 2003. *Meta-Survey on the Use of Technologies in Education in Asia and the Pacific*. Bangkok: UNESCO. http://www.unescobkk.org/education/ict/online-resources/e-library/key-resources/metasurvey/

Gaible, E. 2009. *Survey of ICT in Education in the Caribbean,* vols. 1 and 2: *Regional Trends and Analysis*. Washington DC: infoDev. http://www.infodev.org/en/publication.441.html

PriceWaterHouseCoopers. 2010. *Information and Communication Technology for Education in India and South Asia.* Washington DC: infoDev. http://www.infodev.org/en/Project.103.html

Key web resources

The EduTech blog and the EduTech Debates together provide updated coverage of issues, events, and publications about the use of technology for development education. The UNESCO ICT in Education focuses primarily on events in regions within Asia but also includes a large catalog of resources organized by six themes.

In the United Kingdom, Becta has compiled an extremely valuable catalog of research, standards, planning tools, and firsthand accounts for practitioners at many levels. Many Becta activities are to be discontinued by the UK government as the agency is closed down; Becta resources will continue to be available at the UK National Archives website.

Becta: Leading next-generation learning http://www.nationalarchives.gov.uk/webarchive/qualifications.htm

EduTech: A World Bank blog on the use of ICT in education http://blogs.worldbank.org/edutech/

EduTech Debates: Exploring ICT and learning in developing countries (Supported by infoDev and UNESCO) http://edutechdebate.org/

ICT in education: UNESCO Bangkok http://www.unescobkk.org/education/ict/

Annex A: Glossary

Active learning: A broad term for classroom or online processes, such as collaborative learning or project-based learning, in which students are engaged in guided activities that promote learning; related to "learning by doing," among other concepts.

Action research: A process of structured reflection and problem solving, typically conducted as part of a group (or "community of practice") to improve an individual's approach to a specific activity; a method of professional development for teachers.

ADSL (Asymmetric Digital Subscriber Line): A form of broadband connectivity provided by telecommunications companies using existing telephone lines, providing relatively fast transfer of information via the Internet.

Assessment: The act of measuring knowledge, skills, and performance, usually in the service of learning.

Bandwidth: The amount and rate of transmission capability of an electronic device. Typically measured in bits per second for *digital* devices (like computers) and in cycles per second for *analog* devices (such as radio). It is the range of frequencies that can be transmitted by phone line, fibre-optic cable, wireless, or T-1 line.

Blog (or Web Log): A publicly accessible journal available on the World Wide Web, often allowing visitors to the blog to comment on entries; group blogs may feature the blogs of several, hundreds, or thousands of individuals.

Broadband: A telecommunications signalling method with a wide range of frequencies, enabling faster transmission of data; often fibre-optic cable or ADSL.

Chat (or Instant Messaging): An informal online way of directly connecting people who are online at the same time. AOL Instant Messenger (AIM), ICQ, or iChat client software can be downloaded free.

CAI (Computer Assisted Instruction): A means of delivering educational content and related problem sets in which the learner's performance is assessed automatically and frequently, with assessment resulting in delivery of new content to address deficiencies.

Collaborative learning: Education that relies on any of several frameworks for activities in which students work together to solve problems, find and structure information, or create reports, playscripts, or other materials; often used interchangeably with "cooperative learning," although cooperative learning may be used to refer more specifically to pedagogical techniques involving structured assignments and assessment protocols.

Connectivity: The ability to access an electronic network to send and receive information between locations or devices; connectivity is typically provided using telephone lines, wireless signals, satellite communications, and other, similar means.

Cooperative learning: See "collaborative learning."

Curriculum: A fixed course of study in a particular subject area at a certain developmental point (e.g., age or grade), in which students address specific, related topics and skills and are assessed on those topics and skills.

Direct instruction: A teaching method involving demonstration, explanation and exercises or practice; used in connection with ICT, a use of a dedicated learning technology, such as educational software or instructional videos.

Distance Education (DE): Courses typically at the college-level (but also including agricultural extension and other non-formal forms of learning) in which students do not visit a school campus for every class; in developing countries, often relying on printed materials and the postal service, but increasingly making use of computers, the Internet, mobile telephony and other means.

E-book: Electronic book that can be viewed on a computer, e-book reader, or other device.

E-book reader: Lower-cost and low-power computing device dedicated for use with e-books.

E-learning: A style of learning in which students interact with digitally delivered content, services and support, often including a distant teacher; although most widely applied to Web-based learning, "e-learning" is also used to refer to learning via satellite TV, DVD, and/or CD-ROM, and is in many instances a sub-set of DE (see "Distance Education").

EMIS (Education Management Information System): A technological system for collecting, storing, retrieving, and analyzing information about an education system to support planning and administration; EMIS typically involves teachers and schools uploading data to a central system; information may include anything from student attendance and grades to the size and condition of school facilities.

E-waste: Discarded electronics equipment, including computers, mobile telephones, digital cameras and other hardware; e-waste can pose health risks for communities and for workers.

Formative evaluation: Several types of evaluation that are conducted to help shape or monitor projects before or during implementation.

Geographic Information System (GIS): Hardware and software used to store, retrieve, map and analyze geographic data, usually oriented in relation to Earth coordinates.

Indicator: A variable used in program evaluation to measure change in a process or condition.

Information and Communications Technology (ICT): Any technology (mainly digital but also analog) that allows users to create, store, display information in all its forms (text, images, video, audio) or communicate with others over a distance, such as computers, television, handheld computers, radio, audiocassettes, DVD and CD players, cell phones, networks, and the convergence of any of these technologies.

Internet: A network of networks with worldwide scale, in which millions of computers are interconnected through standardized protocols (TCP/IP).

ISP (Internet Service Provider): An entity that provides individuals and organizations access to the Internet.

LAN (Local Area Network): A network connecting computers that are in the same physical location, such as a school or classroom.

MP3 and MP4: Compression technologies for audio and video files, respectively; these techniques assist transmission of music and video files over the Internet by making the sizes of the files smaller.

Netbook: An inexpensive laptop-style portable computer that typically provides limited processing power, uses solid-state storage memory instead of a hard disk drive, and has long battery life.

One-to-one (or 1:1) computing: Classroom-, school-, district- or system-wide provision of computers, typically laptops, to students; laptops and other mobile devices enable students to use computers in all classes and at home.

Open Educational Resource (OER): Public-domain teaching and learning resources that can be freely used, re-purposed and adapted.

Open Source: Open source refers to any program whose source code is made freely available for use and modification as users or other developers see fit; also sometimes referred to as "Free and Open Source Software" (FOSS) and "Free/Libre and Open Source Software").

Credit: Edmond Gaible/The Natoma Group

Outcome: The effect of program or project activities on the beliefs, behaviors, skills, knowledge, attitudes or affect of the targeted population. Outcomes can also be non-personal: access to resources, changes in policies, improvements in environmental conditions, etc.

Pedagogy: The science of teaching and the methods used to teach.

Podcasting: A method of publishing audio broad- casts via the Internet, allowing users to subscribe to a feed of new MP3 files that can be downloaded to portable music players or to computers; podcasting uses a syndication model—such as RSS—to deliver an enclosed file automatically. Podcasting enables independent producers to create self-published, syndicated "radio shows," and gives broadcast radio programs a new distribution method.

Professional Development (PD) or Teacher Professional Development (TPD): The provision of learning opportunities to teachers intended to enable them to advance their knowledge of their subject areas, their teaching practices or other components of their careers in education; typically indicates learning opportunities that are both more broad and more focused on pedagogy than those provided in "training"; often qualified as "pre-service" and "in-service."

Smart phone: A mobile device that offers the features of a mobile telephone (voice calls, SMS) as well as the ability to run small software applications ("apps") and to connect to the Internet to provide email, web browsing and other data-communication services.

SMS (Short Message Service): A service that allows short text messages to be sent between mobile phones.

Summative evaluation: An assessment of the results of a project to determine the effect that the project had, typically in relation to its objectives.

Sustainability: The capacity of a program, project or other intervention to continue its activities over time.

Tablet PC: A computer contained in a single panel that typically is a touch-screen for inputting commands, keystrokes and other information.

Technology integration: The use of technology by teachers and students as a tool to support learning objectives, enhance instruction, and improve student learning in any subject in the school curriculum (exclusive of IT courses); technology integration may be designed to build students technology skills, but only in the course of improving their mastery of curriculum content.

Text-to-speech: The conversion of electronic text into voice output using speech-synthesis technology; a computer or other device "reads" the electronic text aloud; used to support visually impaired, low-literate and early readers.

Thin-client network: A LAN that links computer terminals ("thin clients" or "dumb terminals") to a server that provides them with software applications and information-processing services; the server may also be used to store users' data.

Total Cost of Ownership (TCO): A method of developing financial estimates of the cost of purchasing, maintaining and disposing of computer hardware, software and systems; TCO estimates may include installation, training, electricity or other costs associated with purchase and use.

Twenty-first century skills: A description of skills involving independent learning, problem solving, communication, collaboration, as well as many others, typically applied to the kinds of knowledge and capacities that individuals will need to thrive in a global knowledge society or knowledge economy.

Virtual Private Network (VPN): A secure (private) network, such as a network available only to schools, that is configured within a larger network, such as a commercial telecommunications network.

Voice Over Internet Protocol (VOIP): A means of using the Internet to support voice telephony.

VSAT (Very Small Aperture Transmission): A small, earth-based transceiver that transmits digitally to satellites at high speeds.

Wireless: The ability of one ICT device (computer, cell phone) to communicate with another without cables or wires.

World Wide Web: An information-representation method that operates via the Internet to enable users to access resources that may contain text, images and sounds, and that display in a standard fashion on many computers and software applications.

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- Early Childhood Development
- Gender
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- School Health
- Standards and Assessment
- Curriculum and Instructional Materials Development
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