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Complementary uses of Information Systems in Decision Making, Planning and Democracy: An Example in the Education Sector

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This paper describes the ongoing implementation of web intelligence tools in public education and other policy sectors in Guatemala. In the case described, software tools first developed for use in business were adopted for planning and decision making in public institutions. Easy online access to the outputs of these tools as web documents suggested their use to foster transparency, accountability and social oversight. This paper summarizes the salient aspects of the experience so far of implementing and expanding what has been called the “Platform for Integrated Social Information,” It discusses the issues this Platform raises as a resource for improved public decision making, policy analysis and especially, as a promising but challenging tool for democracy in the education sector.

KEYWORDS: Web intelligence, business intelligence, social development, democracy, education

I. Introduction

Can information systems and web intelligence applications contribute to democracy? Over the last two decades the Ministry of Education (MOE) in Guatemala has invested a considerable amount of time and effort to develop its information systems and infrastructure. Overall results have been positive, and the MOE now has continuous, relatively good quality and well-maintained records going back to 1992. Even though these efforts have increasingly fallen within the purview of a well-established IT department, generally the implementation of databases and information applications have been undertaken to serve the needs of specific organizational units, using diverse software and generating data in different formats. More recently efforts have focused on implementing web intelligence tools in the MOE and other public sector institutions to bring together information from many sources. These applications were developed initially as an effort to support public sector decision-making and later to enhance planning. However, their expression as web-enabled publications and their ease of use rapidly suggested applications beyond the MOE's limits, touching upon issues of transparency, accountability and social oversight (Joia 2007).

This paper examines the “Platform for Integrated Social Information” (PISI) that emerged from these efforts as a resource for improved public management and planning, and as a promising but challenging resource for democracy, considering that what began as an effort in increasing efficiency in data management has now expanded to touch upon critical issues of democracy and participation which will require further development. This document is based on: a) the author’s first-hand experience as the director of the project that has provided technical and financial assistance to the MOE and Ministry of Health (MOH), b) conversations with project specialists on web intelligence, MOE and donor agency counterparts in the context of the design and follow-up to the intervention,

\[1\] Beyond the use of a business intelligence tool, we understand the PISI as a combination of software, hardware, reports and institutional arrangements that lead to the transparent availability of manipulable non-aggregated data from the social sector (currently education, health, finance and demographics) that can be accessed and analyzed through a common interface, irrespective of the institution and technology on which these data are originally based.
and c) material from an external review of the PISI and two other technology interventions conducted in 2008 in preparation of a policy brief (Trujillo 2008). It is not intended as a final analysis, but rather to provoke further reflection as the intervention continues to evolve.

II. Three Complementary Uses of Information

A. Information and Management Decision-Making

The most obvious need for information in the public sector is management. Managers need information to improve decision making (Cf. Kemoni & Ngulube 2008). Together with IT specialists and vendors, these “clients” are the motor in introducing information systems in public institutions, and they behave much like their private sector peers. Governments frequently adopt technologies developed for business applications.

Though information systems have existed in the Guatemalan public sector for several decades, they have mostly been stand-alone tools developed specifically or bought off-the-shelf for use in a single unit (human resources and payroll, education statistics, finance, etc.) Even in small countries public networks are large and frequently public institutions such as the MOE. These are often among the largest organizations in the country. Effective decision making in such contexts requires information from multiple levels and locations. For example, a manager in a centralized school system needs information to manage the allocation of resources between districts, but the data reflecting enrollment and retention are produced locally, not at her level.

In day-to-day work, governments have tended to adopt networking applications from the private sector (Joia 2007) as the benefits of on-line integration become apparent. As in the private sector, operational control, efficiency and quality are seen as open to improvement through “Government-to-Government” (G2G) applications linking public data sources. For example, decisions about textbook and school material distribution logistics span multiple geographical and hierarchical levels, depending on timely combinations of information about suppliers, enrollment and geographical localization of facilities.

B. Information and Policy-Making

G2G applications, much as Business-to-Business (B2B), focus on improving services and processes. Is there more to these technologies when applied to government? Can they help policy-making? Reimers & McGinn (1997) have made strong arguments in favor of addressing policy questions through information. However, educational outcomes are not simply results of education sector actions. Poverty alleviation and conditional cash transfer policies, local public investment, migrations and health conditions and services, all affect educational outcomes in communities, families and individuals, but are not under exclusive control of the MOE. Policy decisions straddle institutions and sectors, and affect results according to how these are taken into account (Joia 2007).

2 G2G is understood as the online (electronic, Internet-mediated) mutual interaction between government organizations, departments, and authorities (See Backus 2001). Beyond the data connections between organizations, G2G may involve standards-setting, common “language” development, integrated processes and shared data management cultures (Realini 2004).

3 B2B similarly can be taken in a strict sense as “… the enabling technology and the necessary infrastructure (…) to make automated supply chain integration possible (…) in a peer-to-peer pattern to trading partners…” (Bussler 2003:3), or in a more extended sense covering the exchange of messages between business partners in a market.
Policy planning where educational activities fit in with other sectors requires integrating information between education and other sectors, as well as integrating national, regional and local information. For example, the World Bank's “country at a glance” tables and charts show data from various national sources in a compact format that rapidly induces a policy discussion. Similarly, an analyst in a central office in the MOH needs to integrate data about demographics, input and teacher allocation, services production and student performance, broken down by relevant jurisdictions and sex and age groups to produce useful policy suggestions and design relevant plans.

Relating government information across institutions through G2G applications helps see the objects of policy making beyond the limits of the institutions and better relates them to the substantive issues of human development, the economy and politics, for example. Furthermore, precise data move policy making from the realm of speculation into common agreement.

C. Information and Democracy

Public education is not only about services and management. It is about a citizens' right to education and the State's responsibility to guarantee this right. In this context, information is more than an input for decision making or planning. Information and Communication Technology (ICT) tools can help transparency, accountability, oversight and participation (Kemoni & Ngulube 2008). The political and cultural role of information has been recognized and is not problem-free. Morales-Gomez and Melesse (1998) warn against ICTs in participation without careful examination of their social and cultural implications. Telecommunications in the '90s expanded thanks to plummeting costs and innovation, but radically modified social relations. Arunachalam (1999) compares the significance of this to the role of movable print in facilitating the Protestant Reformation. As information systems now move from addressing specific unit’s needs to integrating data and providing access the question becomes: can we harness web intelligence as a tool for democracy, or will it remain an instrument for efficiency? In this respect, the implementation in Guatemala of a Platform for Integrated Social Information which brings together data from education, health, finance and demography using web intelligence tools shows a promising start, and underscores the challenges ahead. Will information strengthen democratic practice, or increase power differences based on information between central and local government, and between institutional officers and citizens? We should think pro-actively about what information is needed for democratic participation within the education sector, and what tools and practices address that need.

III. Case Description: The Integrated Information Platform

Almost two decades ago the Ministry of Education (MOE) in Guatemala began to modernize its information systems in an attempt to reduce the almost two years it took for educational statistics to be published. With initial support from the United States Agency for International Development (USAID) and later the World Bank, over the 1990s the MOE established a strong IT department and progressively expanded the application of database technologies and networking to its central headquarters and departmental directorates (the main decentralized management units in the MOE). Overall this led to the systematic storage of detailed enrollment, promotion, teacher payroll and other data over the period between 1992, when the first large-scale electronic data collection effort was conducted, and the present. Time to publication fell below one year and quality has steadily improved, but databases are designed, implemented and managed independently by each unit in the

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4 A first enrollment census was held in 1991 but the data were never published due to unresolved data quality issues.

5 Fernando Rubio, personal communication.
MOE. Data use is extensive, but staff capacity for analysis varies considerably across units and between administrations due to the significant staff turnover in the public administration.

The Guatemalan “Platform for Integrated Social Information” (PISI) initiative began in 2006, again as an MOE initiative with support from USAID, the World Bank, the Inter-American Development Bank and other donors. The USAID/Dialogue for Social Investment project (www.proyectodialogo.org) worked closely with the MOE to implement information resources to improve transparency and efficiency in management. Initial efforts were a response to the Minister of Education’s concern that indicators were inconsistent according to which MOE unit published them (it should be noted that she held a degree in systems engineering). Systems were slow in addressing her requests for information, especially as any query of the data needed IT specialists' involvement, as they were the only staff familiar with the structure of the various databases. A review of technologies led to identify web intelligence tools as an answer to the problems described. A specific tool - Business Objects® - was selected. Its object-oriented design, which avoids the need to learn a special program language to formulate queries, and flexible reports made it easy to use for non-experts, but any software of this type would have served the purpose.6 Though implementation was originally conceived as an information and communication technology (ICT) initiative to facilitate access to data, specialists leading the effort soon realized that this was better framed as a planning initiative, leading to improved access to data and information for planners and decision makers. Implementation followed roughly five steps (Alvarado & Somerville 2009).7 Following on the perceived success in the adoption of this initiative in the MOE (Trujillo 2008), late in 2007 the Ministry of Health adopted the same tool with USAID support, and linked its data with the MOE’s in an “Integrated Information Platform”, roughly along the lines described here.

A. Data identification

Through conversations with managers from the various units in the MOE, key information needs and available data sources and databases were identified for integration. Working with early adopters in the planning unit and upper management, other units were incorporated as they became less reticent to sharing information. Despite early resistance, increasing volumes of data have now been incorporated into the Platform. To date, for the MOE this includes data about enrollment and promotion, teacher allocation, human resources and payroll (from 1992 to date), and infrastructure (based on a 2005 census of facilities), as well as demographic and population projection data from the last national population census (2002), and socioeconomic information from the last two national household surveys. A key element for success has been letting each unit decide what data to share. For example, while the human resources (HR) unit in the MOE has loaded all its data onto the Platform and uses it on a day-to-day basis, no data about teacher salaries are made available except within the MOE. In this way, while all analysts can benefit from the data concerning numbers and distribution of teachers, the HR unit continues to feel comfortable in this partnership.

6 In recent years a class of software tools known as “business intelligence” or “web intelligence” has taken off. These are software applications that have the ability to pull together data from multiple databases into combined interfaces and “mine” the data with great flexibility. Business Objects® is a commercial product available “off-the-shelf.” Other examples of commercial products are Sharepoint Server (previously ProClarity and now owned by Microsoft), Panorama (www.panorama.com) and Cognos (www.cognos.com). Free, open source options are also available. Of these, Pentaho (www.pentaho.com) is an example.

7 Sergio Somerville, as Policy and Planning specialist in the USAID/Dialogue for Social Investment project first described these five stages for the Platform in a training manual for users.
B. Data linking
The second stage involved defining relations between variables and items across databases. While the first stage mostly involved IT specialists, this phase required close collaboration between IT and content specialists in defining relations. As mentioned above, previously IT staff received frequent requests from content specialists to run queries because only they knew the database structures. Now analysts could focus directly on the data. This went a long way to reduce tensions between subject-area specialists, who could focus on the analysis, and technology specialists, who could focus on the systems and infrastructure, and reduced suspicion about the project as a whole. For example, while the National Institute for Statistics codes the country's 22 departments individually, the MOE has divided the greater metropolitan department into two separate codes (rural and urban) resulting in 23 codes, which then have to be reconciled if queries are to be consistent.

C. Data unification
The third stage developed a unified presentation of the data on the Platform. A key aspect has been the integration of information using data from different units in the MOE and, more recently, between the MOE and other institutions. To date the Platform involves a broad range of integrated data, including the data described above, but also extensive data from the MOH (services provision, morbidity and mortality), the Ministry of Finance (approved, committed and spent budgets for both the MOE and MOH), specific research databases from the Presidential Secretariat for Planning and macroeconomic indicators from the Bank of Guatemala (the central bank). Unification does not involve manipulating or modifying the original source databases. Data from all sources are made directly available through a single integrated web interface. Data linking and unification has been completed for the Ministry of Education, but continues actively for the MOH and other sources.

D. User tool development
The fourth stage involves developing user reports in table, graphic and “dashboard” format, as well as links to geographical information applications. This continues to date, as more users learn about the Platform. At this stage work in the previous three stages comes to fruition, as decision makers, analysts and others realize the extent of data available. In the MOE the interface is used on a daily basis by analysts and planners in central and decentralized locations, who have developed a variety of reports to address their own needs. Significantly, these reports can then be published to public folders for use by others. Though an in-depth discussion of the tool itself is not intended here, it is to be noted that these reports are not static tables and charts, but rather dynamic templates that update with the latest data each time they are consulted by users. Some examples of reports published for the education sector include:

- A tool to track results in the school registration rapid survey, conducted yearly in the second quarter by the MOE. This lets authorities and managers understand trends in registration much faster than the official registration census, which only provides results at the end of the year;
- A report tracking the proportion of teachers, by education level, who are not allocated to classrooms;
- A school report bringing together information about infrastructure, teachers, and student registration, promotion rates and performance, for each school in the country;
- A set of indices relating education to social variables such as ethnicity, gender, poverty and rurality;
- A report on conditions and progress in girls' education; and
• A report on educational expenditures by program, activity and line item for tracking in the context of the Millenium Challenge Corporation targets.

More significantly, reports are now being developed for a broader public. In education this has included a “Municipal Education Advancement Index” showing progress in registration and termination results by municipality and year, simultaneously published in hard copy, published to foster dialogue about differences among municipalities. Another application currently under development is a national indicator system that will track education input, process, output and impact indicators as these become available for policy monitoring. Similar developments have begun to occur in the MOH.

E. Capacity building

The fifth and probably most challenging stage is building capacity in institutions and people. This includes training, developing manuals and establishing norms and systems for the use and maintenance of the data and information. Training has covered tool use, report preparation and statistical analysis and planning in public institutions, think tanks, NGOs, municipal governments, cooperation agencies and others. Beyond the obvious need to train people to use the tools and reports, a deliberate goal has been to establish a “critical mass” of inside and outside users and stakeholders for the platform who will support the initiative beyond the initial implementation and international funding. On the “inside”, i.e., the ministries, it has been relatively straightforward to conduct systematic training, but staff turnover is high. Users beyond the limits of the MOE, in NGOs and donor agencies and projects have tended to self-select and therefore are highly motivated and committed to training, but are less easy to reach. The project has established an agreement with a local university to deliver training directly and on-line to guarantee sustainability once the project has been completed.

These five steps, though presented sequentially, frequently overlap as additional data sources are identified: new databases are incorporated into the Platform while at the same time data continue to be linked and reports prepared for previously incorporated data. At the same time, the steps provide a guide for access and work with new units and institutions.

IV. Discussion

A. Issues

Implementation of the Guatemalan Platform for Integrated Social Information is a success in the eyes of those directly involved in the MOE and other government institutions, USAID and the USAID/Dialogue for Social Investment project (Trujillo 2008). Interest by other donors, municipal government officials and NGO representatives would suggest this perception is also shared by them. Heeks (2002) finds that not much more than a fifth of Information Systems initiatives are unambiguous successes. Though this initiative is now in its third full year of implementation, less than a year has so far been actively spent in the MOH, and lessons are only starting to be learnt from the implementation in the MOE. Some indicators that may help to understand what the current and future outcomes and impact of the PISI may be are: a) the nature and rate of incorporation of new data and databases into the Platform, b) the degree of institutional buy-in (shown by the growing number of institutions who actually consider themselves partners of the initiative), c) the adoption of the platform as a day-to-day tool by analysts, managers and citizen stakeholders, and d) the development of applications (such as online and printed reports) that actually use the data.
B. Incorporation of new data

The PISI has grown significantly since its inception. From including data from a few MOE units, it now comprises extensive data on educational statistics, teacher and administrative payroll and school infrastructure for the whole country and since 1992, but also the last two national population censuses (1994 and 2002), the last two national living conditions surveys (2000 and 2006), the two most recent school nutrition censuses, as well as all financial data for the ministries of health and education from 1998 to date, data on all primary health service provision since 2002, births, deaths and morbidity (including specifically HIV/AIDS) from 2001 to date, and data from the national public investment system for all the country (2008 and 2009). These data are fully integrated and analyzable, constituting a formidable body of information. As data become incorporated by sector the rate of growth has diminished. While health data are still actively growing and tertiary-care level data are still pending, most available data from the education sector have now been integrated.

C. Institutional buy-in

Institutional buy in can also be considered to show a positive trend. Based on the example of the MOE’s implementation of web intelligence tools, the Ministry of Health began tentative implementation in late 2007 and full implementation early in 2008. More recently the national secretariat for nutrition began adopting the platform in 2009, as did the presidential secretariat for planning. Much more cautious has been the approach by the national statistics institute, and this constitutes a significant challenge. “Mi Familia Progresa” an inter-ministerial initiative in charge of implementing a conditional cash transfer program fostering education and health for poor and rural families is also now considering its inclusion in the PISI.

D. Adoption of the platform for day-to-day operations

Although production is still incipient, Platform users have found answers to questions about data across sectors that would previously have been very difficult to answer. The MOE has now fully incorporated the PISI into its daily operations: staff in the planning unit regularly consult the PISI in preparing reports and as inputs for planning activities with the ministry’s higher authorities, as well as with other units. The MOE human resources unit also regularly consults the PISI and increasingly teacher and resources allocation planning is being fed by data and analyses built on the Platform. Researchers and analysts in some NGOs have started consulting the data on a regular basis as well.

E. Development of data applications

At this point the translation of data from the PISI into specific, accessible applications is still incipient and mostly driven by the USAID/Dialogue for Social Investment project, but shows promise in terms of what can be done. As mentioned previously, the MOE has published a Municipal Educational Progress Index for 2002 to 20068 and has used this extensively in negotiation and planning with municipalities. This experience is being replicated with the preparation of a Municipal Health Investment Guide. Both publications are direct applications of PISI reports. Similarly, an individualized Municipal Social Policy Status Report will be published in August, for use by municipal authorities and leaders, MOE and MOH analysts and donors to assess health, education and development conditions in municipalities they may wish to work with. The PISI has also been recently used to assess the rate of change in enrollment in municipalities served by the conditional

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8 Available at: www.mineduc.gob.gt, as well as on the project website: www.proyectodialogo.org (in Spanish)
cash transfer program. All three of these examples show the potential for applications at the micro-territorial level, making the data much more relevant for citizens and their representatives.

V. Challenges

The technology chosen for the Platform appears to induce positive behavioral changes. Although the tool was developed in industrialized countries and for business applications, implementation was not an imposition (Heeks 2002) or a “solution seeking a problem” (Cohen, March & Olsen 1972), but rather a choice by actively engaged decision-makers. Web intelligence is a technology that treads lightly: being non invasive and requiring no changes in data sources and institutional processes, it lets “owners” (given that these are public data it might be more appropriate to call them stewards) of the data decide what to share and under what conditions (Akrich 1992, cited in Heeks 2002:109, has called these “actuality-supporting” applications). Centered on the new technology, a “perfect storm”9 of five factors (Brown, Chervany & Reinicke 2007) came together in Guatemala: a) a committed and supportive leader while the system became established, b) knowledgeable managers, c) good communications between ministries, donors and projects supporting the initiative, d) well-developed hardware, software and data systems (especially in the MOE), and e) an effective approach to implementation on the project level.

On the latter point, the initiative has benefited from a clear vision – pulling together social sector data from a broad range of sources – and enough “design improvisation” (Heeks 2002) to keep the design close to what is actually happening in implementation. Restating the initiative as an effort in planning, rather than in IT, exemplified this approach, as did the decision to move from specialized analyst training to broad stakeholder development through training. Early involvement of non-technical users with technology and content experts at the data-linking phase also helped develop the system from a socio-technical perspective.

However, this effort is not exempted from challenges. Paradoxically, as more data are included, there is a tendency of users to blame the tool for the quality and timeliness of the data it presents; data which were previously not even available. This has translated into a threat in the MOE itself, as decision makers continue to commission their own, independent data collection efforts that are then not included in the PISI. Furthermore, as mentioned above, it has been something of a challenge to convince the National Institute of Statistics, as the traditional entity responsible for official data, to fully buy into the platform. Finally, extensive applications of the data to real-life situations will depend much more on the development of analytic capabilities in staff and citizen groups than on the deployment of sophisticated data-management tools.

VI. What Happens Next?

Although this initiative started three years ago, its full meaning is only just beginning to be evident, and there are more questions than answers at this point. How will information gatekeepers react to efforts to add value to information through oversight and participation, rather than just through management and policy decision making? What can we expect in expanding the Platform's user base? What will the project face in moving from management to fostering transparency, citizen's participation, and increased oversight? These important questions are only starting to be evident as the development of the Platform moves from implementation to use.

9 Thanks to Kurt Moses for the suggestion of this term.
Information can be conceptualized as a resource with mixed public and private qualities (Eaton & Bawden 1991). On the one hand, consumption by one user does not prevent consumption by others. On the other hand, unlike pure public goods, users can be excluded by system gatekeepers. In this sense, data in a shared but limited network can be defined as “club goods” (Aanestad, Monteiro & Nielsen 2006). For the Platform this appears to have had a positive effect on the “owners” of data, who are more willing to share within a known network. Cautious participants join as they see early adopters reap benefits of membership in this “data club” (Alvarado & Somerville 2009).

However, this introduces the challenge of defining limits to who is inside and who is outside (see Aanestad, Monteiro & Nielsen 2006:12). This issue is both cultural/attitudinal and political. Data sharing redefines the meaning of “information is power”: participants become comfortable with the notion that power in the network is based on distribution of data and influence, rather than on concentration. Power in gate-keeping now depends on controlling the “means of information” (where it is deposited, how it can be used), rather than information itself. Though information does not degrade in sharing (Arrow, referenced in Eaton & Bawden 1991:157), circulation can still be controlled, and what gatekeepers control is the means of making information valuable.

The project is promoting use of the Platform as a tool for democratic dialogue. In the education sector, an on-line, searchable report of municipal educational performance was prepared linking data from the MOE and the Presidential Secretariat for Planning to generate a thematic map highlighting municipalities with challenges and successes. Though this can be used for analysis, it is meant especially to foster dialogue at the local level and between central and local governments. Municipal authorities, local leaders and activists can consult this tool for management, policy planning and advocacy purposes. A printed version built with the same data has wider circulation, given the low access to computers in the country. Similarly, an online tool on the MOE website provides information about each school's enrollment, promotion and performance, but few users know it is available or can access it due to low access to the internet. However, if uncomfortable questions were raised based on the data shown, would the MOE be tempted to take these reports off-line or stop new experiments?

There is a need to develop more reports that make better sense to citizens. The limitations in technology and education suggest a role for NGOs and citizen groups that may bridge the gap between information and individuals without access to technology or without the education to understand the data. Will they take up this challenge? This could improve access to pertinent and timely information despite barriers to access due to poverty (Meneses-Gomez & Melesse 1998).

So far the development of the Platform has focused on publishing what is already available, recognizing that as data are made available, errors and limitations in the data will become more evident and pressure will mount to correct these. However, what will the channels be to establish feedback between civil society users and data sources? Whereas the path between data producers and users inside institutions is relatively straightforward, there are few mechanisms for users outside the institutions to comment on the data and information they may use through the platform, and no formal processes for these comments to have an impact on the data. This affects decisions surrounding the “politics of representation” (Aanestad, Monteiro and Nielsen 2006) involved in

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10 Democratic dialogue is a public conversation between policy stakeholders. It addresses conflict and builds consensus through the understanding of issues based on evidence, recognizing the role of participants in solutions, and as an ongoing learning process (Pruitt and Thomas 2008). Within this framework, the PISI is a resource that provides evidence (the data), shared and recognized as legitimate by all stakeholders, to build understanding.
defining who is counted (do citizens have a say in this or is it a task exclusively for analysts in the institutions?), and for the quality of the data (what happens when users identify problems with the data through the platform?)

Finally, issues of security in access to the data and in privacy are, as in all systems, an ongoing concern. Currently only the data for secondary school students are linked through a unique number to each individual student, but efforts are underway in the MOE to expand this to all levels. The widely networked and distributed nature of the Platform for Integrated Social Information implies a policy of open access, but underlines the need for novel solutions that might regulate legitimate use and guarantee privacy (Weitzner, Abelson, Berners-Lee, Feigenbaum, Hendler & Sussman 2007), without unduly burdening users (Joia 2007).

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Introducing Learning Technologies into Egyptian Schools: Where There is Demand There is a Way

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Little evidence demonstrates that the introduction of technology in schools can improve learning, unless it is accompanied by key educational conditions, including the ability to secure high quality teachers and improve teaching practice, and systems of accountability, competition, and local decision–making. The Technology for Improved Learning Outcomes project, funded by USAID and implemented by Creative Associates International, Inc., and its partners, Pal-Tech, Keys to Effective Learning, and Seward, Inc., is using approaches based on these conclusions to introduce computers in classrooms in Egypt. The article outlines several strategies which connect the introduction of technology to improved teaching practice, and which build capacity and demand through greater local decision making and competition between schools. The article highlights a study showing early changes in teaching behaviors and experience that demonstrate that competitive school and teacher selection processes can increase demand, local decision making, and longer term support for teacher professional development.

Key Words: computer technology, instructional technology, education quality, Egypt, learning outcomes

I. Introduction

After twenty years of experimentation with education technology in developing and middle income countries, few studies can demonstrate a direct link between technology and improvements in learning. Those studies that do also point to particular instructional methods, changes in larger instructional systems and the strategic ways in which technology leverages these priorities. They reinforce the mantra of a growing number of educators and researchers: it is not the technology itself, but how it is used to improve the educational environment that matters. Yet, far too many efforts still reveal a lack of understanding of what produces learning and what the technology can do to support a system focused upon education quality.

The dearth of evidence on hardware as catalyst has not slowed down the vigilance by which development organizations, governments, community organizations, and schools work to
acquire computers in the name of reducing the digital divide. Governments, principals, teachers and parents aim to introduce technology in schools for all the same reasons that we want new gadgets everywhere. They offer us the promise of a new era that is brighter, smarter, more informed and more connected, and which makes our lives easier due to the power of modern tools. Inside the box exists the hope that, upon opening, the school or community will be on a new path to success. Even with the fear of owning (and god forbid, breaking) new technology, the demand – and the potential – for technology to impact learning continues to grow. Still, the demand for the technology is not always coupled with a commitment to an instructional system where technology can improve learning.

This article highlights some of the early findings of the Technology for Improved Learning Outcomes (TILO) education technology project in Egypt as it works to build capacity and support the effective use of technology in schools to improve learning. TILO is a four year US Agency for International Development-funded project that works closely with the Egyptian Ministry of Education and Ministry of Communication and Information Technology, and is implemented by Creative Associates International, Inc. and its partners: Pal-Tech, Keys to Effective Learning, and Seward, Inc. In the TILO project, like many education technology projects around the world, the demand for technology is high: government officials want it, teachers want it, parents and students want it. But this article does not look at the demand for the technology. It reviews how the project used the demand for hardware to build a greater demand, capacity, and commitment to conditions within the system that are shown to improve educational quality, and how the unique attributes of technology can leverage them further.

II. So What Increases Education Quality?

Research specifically looking at technology as catalyst to improve education internationally has results as mixed as the products, contexts, and applications that are being tested (Kozma, 2007). There is no consistent evidence that the introduction of technology is sufficient to increase learning. However, studies that also look at other conditions in the school and how the technology is utilized reap more interesting results. In studies where teachers and others within the school work together to plan how to utilize technology use as a means to maximize particular teacher and student practices and content and support mechanisms are in place at the school, results are generally positive. In a long term study of the Project Explore program in Union City, New Jersey in the United States, for example, student performance improved results on standardized tests in writing and mathematics consistently as part of broad-based educational change that connected the use of educational technology to other prioritized elements in the system. Project Explore combined (a) the integration of technology with instruction, (b) extensive professional development for teachers, and (c) computer use with:

- school site leadership
- effective school improvement plans
- a strong emphasis on student creativity and expression of ideas in multiple formats
- an emphasis on different points of entry into a task for students working at different ability levels. (Honey, 1999).

Other recent studies are drawing similar conclusions about the necessary integration of technology with other prioritized elements at the school, such as teacher professional development and local planning (Metiri Group, 2009).
So, if technology introduced into a supportive environment with well-planned priorities can lead to positive results, what are the key factors that influence achievement? How can technology make a difference? Compelling research analyzing decades of studies on education quality suggests two sets of drivers are linked to high performing schools: (1) competent and well-supported teachers and (2) systems of accountability, competition, and local decision-making. A recent McKinsey Report (2007) concluded from an analysis of factors associated with school quality in top performing schools around the world that, while a number of factors could make a difference, there are three factors consistently related to the quality of instruction that have the greatest impact: “(1) getting the right people to become teachers, (2) developing them into effective teachers, and (3) ensuring that the system is able to deliver the best possible instruction to every child.” (p.1)

The Report states,

“The top-performing school systems recognize that the only way to improve outcomes is to improve instruction: learning occurs when students and teachers interact, and thus to improve learning implies improving the quality of that interaction. They have understood which interventions are effective in achieving this – coaching classroom practice, moving teacher training to the classroom, developing stronger school leaders, and enabling teachers to learn from each other – and have found ways to deliver these interventions throughout their school system” (p.35).

Other leading meta-research adds that, alongside ongoing attention to teacher quality, several key institutional characteristics are linked to high performing schools. In a recent analysis of international data and the factors linking schools to achievement, Hanuchek (2007) concludes,

“Evidence suggests that three institutional features may be part of a successful system of providing students with cognitive skills:

- Choice and competition
- Decentralization and autonomy of schools
- Accountability for outcomes” (p.16)

While researchers vary in the degree to which they emphasize teachers ability to instruct or local systems of accountability, decision making, and competition, there appears to be a growing consensus that these are the leading factors to producing high performing schools, and other inputs or efforts to produce change do not consistently pay off.

III. A Very Brief History of Education Technology and TILO in Egypt

Egypt is no stranger to education technology. Over the past decade Egypt has engaged in a variety of initiatives aimed at bringing Egyptian teachers and students into the 21st century through the introduction of technology for computer based skills. Egypt was one of the pioneers of the World Economic Forum’s public-private partnership program, the Egyptian Education Initiative (EEI), where invited technology companies in the private sector were invited to contribute their innovations and good thinking to the field of education. Implemented by the Ministry of Communication and Information Technology, with support from the Ministry of Education, EEI aimed to increase technology usage in schools and foster innovation in schools.

Egypt also developed the Smart School Initiative, a program designed to introduce computer technology and support into experimental preparatory (middle) schools. The Smart School Initiative...
in its original construction was a project with a closed school management system and a focus on computer literacy. Like EEI, it was not intended to reach across the massive education system of 44,000 public schools or to specifically increase achievement, but to test ways to use computers in schools and develop essential computer based skills. These and other technology-focused projects enabled Egypt to experiment with different models and types of interventions.

Supportive of the Egyptian government’s overall commitment to instructional technology, the U.S. Agency for International Development, the European Union and other funders worked with the government and contributed millions of dollars to introduce technology in schools and to build Ministry capacity to manage it and study its potential in different areas. In 2006, the Egyptian Ministry of Education (MOE) developed a new five-year Strategic Plan with education reform at its center. Reform included the introduction of national standards, more decentralized school and idara (district) level decision-making, a more systemic teacher professional development structure, and a plan to introduce education technology into schools. In 2007 the USAID-funded TILO project began implementation under the existing bilateral agreement between the governments of the United States and Egypt to complement other projects supporting education reform. Unlike the projects before it, the TILO project was created to increase learning gains, however, the initial project design still contained some of the trademarks of programs developed around the technology, not around education quality. The project was lean on teacher professional development and training, lean on content, and school selection and decision making were primarily top down. The timing of the project start was good, however, as TILO could work with the Ministry of Education through the new reform framework at a time when change was not only possible, it was expected. TILO could draw links to these new priorities as it began to study and recommend that the introduction and eventual role of technology be one that strengthens key educational elements in the system known to produce learning.

The four year TILO project developed a phased approach to the introduction of educational technology where clusters of six to twelve schools would be trained and practice with new digital resources and new governorates would be gradually brought into the program. The assumptions of the project were based generally on the research and included:

1. The quality of the instruction depends foremost on the quality of the teacher
2. The success of the teacher to use new strategies is dependent upon certain enabling conditions and people, all of which need to be taken into account
3. Technology use should be built upon and support a strong foundation of good pedagogical practice. Strengthening that foundation is the first step.
4. Technology use should be integrated in such a way to make teaching and learning easier and richer, and not as an additional long term burden.
5. Local decision making, choices, and accountability make people more engaged and motivated and systems more sustainable.

6. Demand and commitment to building an enabling institutional environment at the school level is a necessary prerequisite to taking part in the project.

By the end of the four years, TILO will work in approximately 275 schools across ten governorates in Egypt and with the national, governorate and idara levels of the Ministry of Education to negotiate and manage larger training and support programs.

IV. Introducing Technology as Tool in Support of Educational Quality in Egypt

If we learn nothing else from the international research on educational quality, we can surmise that technology can be a more effective tool to impact learning when it helps to build and strengthen an environment where teachers and their behaviors matter, decision making and accountability are experienced locally, and competition and incentives are used as motivators for quality. A year and a half into the project, the TILO team and its Ministry counterparts began to learn firsthand why these factors mattered. The local TILO training organization, Keys to Effective Learning, structured its training in ways that were consistent with the research. Training was delivered to teachers who went through a stringent teacher selection process, was school-based, included coaching and hands-on practice, and began with an introduction into pedagogical practice which led to ways that the technology could improve instructional quality. While TILO has not yet conducted studies of learning gains, an early study of changes in teacher and student practice in schools, as measured by a pre/post controlled study using the Standard-Based Classroom Observation Protocol for Egypt (SCOPE) instrument in a sample of TILO supported schools which received a partial TILO intervention, suggests that teacher and students practices are already improving, even with minimal exposure to technology tools. The SCOPE tool rates the quality of teacher student practice and interaction based on international criteria and the local Egyptian education standards.

Table 1: TILO Impact on Classroom Practice, Teacher Indicators, Comp IV, BL1, and M1

<table>
<thead>
<tr>
<th>Item</th>
<th>Comp IV</th>
<th>TILO BL1</th>
<th>TILO M1</th>
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</table>

Comp IV are a group of comparison schools in neighboring idaras. BL1 is a baseline conducted in October 2008 and M1 is the first midterm test conducted in May 2009 in the same classrooms. Source: Gabr, 2009.
We also began to study other elements of project implementation, such as the role and implications of competition and local decision making. While training modules were delivered equally to all schools, school selection, teacher support systems and local decision making were not experienced evenly. Early on, we could see that commitment, motivation and a demand for quality, even with encouragement from the MOE, were much higher in some schools than others.

The differences emerged slowly, but were hard to ignore. The TILO project serves two types of schools: (1) 85 experimental preparatory schools, which were selected by the central Ministry of Education and (2) approximately 190 “School Based Reform” schools, which were selected through a competitive school selection process that worked to identify and build demand and commit the school and idara administration to basic principles of local and joint decision making, teacher professional support, and collaboration and adherence to a set of overall methods that would be expanded at the idara level.

We implemented the following strategies in both sets of schools, all which were considered essential to TILO’s approach:

1. Stringent master teacher selection, based on observations of teacher – student interaction and a requirement to work closely and train other teachers in the school;
2. Introduction of a basic technology package, including (among other items) computer stations for 3-5 students on a computer in an Activity Room and floating IT suitcases with a laptop/projector to be used by a teacher in a classroom;
3. Introduction of a digital resource package, organized by use for grade and subject (largely free or open source);
4. Explicit connections between technology use and the Egyptian curriculum requirements, based on the need for teachers to understand how their jobs and teaching are improved through the use of technology;
5. Teacher professional development and school-based teacher training and practice for approximately one school year, first emphasizing good pedagogy and management, and then, technology and digital content as tools to practice it;
6. Administrator and supervisor level participation in school-based training, based on the concept that if good teacher practice is not recognized and supported by supervisors and others enabling them in the system, it will not be sustained;
7. Joint decision making and leadership support at the governorate level, based on aligning program ‘enablers’ and planning for institutionalization;
8. School-based Education Technology Management Plans as part of larger School Improvement Plans, as a way to create a local responsibility and accountability;
9. Full orientation of school principals; and
10. Support from higher levels in the MOE, as demonstrated by the TILO Steering Committee, led by the Deputy Minister of Education.

However, in the 190 School Based Reform schools, we also implemented the following strategies that emphasized competition and local decision making:

1. Competitive school selection, based on criteria including previous experience and commitment to joint local planning and decision making;
2. Joint decision making and leadership support at the idara (district) level, based on the need to constantly learn, plan, and troubleshoot at a local level for a large group of schools;
3. Idara level participation in school-based training, based on the concept that local decision making needs to be supported and the idara level will supervise and replicate training and management systems.

While the competitive process of school selection for the school based reform schools was time consuming, it generated and rewarded demand and rewarded commitment to the activities and approaches. Schools that could not make the commitment to the key elements of the program were allowed to opt out.

After schools were selected and training in the first phase of schools was underway major differences became clear. The principals in the schools that did not go through the demand-driven selection process complained more about the requirements of teacher training and were less apt to help develop solutions to problems or to develop locally acceptable systems. While the school based reform schools took great pride in their achievements and often offered praise for the success of the school-based training or the joint decision making, the experimental schools seemed to believe that TILO project staff were responsible for the inputs, and that school administrators were not. They did not express the same level of demand and commitment to cultivate the kind of educational environment needed for the technology interventions to be successful. While there were other distinctions between schools, after a few months, members of the Ministry of Education and Ministry of Communication and Information Technology also noticed differences in the commitment levels and dedication to teacher professional development in the different types of schools.

In the end, we agreed that we would go back and try to re-engage the leadership in the experimental schools and find ways to build greater demand and ownership among them. We have begun to plan future competitions to reward schools which have completed training, action plans for ongoing teacher professional development, management, and good practice with digital resources with small technology or training packages. Time will tell if these measures will increase ownership and commitment, but until then, valuable lessons have already been learned.

V. Conclusions So Far

Given current research on educational quality and increasing demand for education technology to play a role in education, can technology be introduced to maximize learning outcomes? There are some critics that maintain that technology in schools is irrelevant to learning outcomes based on the broad access to technology elsewhere and competing teacher responsibilities (Cuban, 2001). We believe that education technology has a significant role to play in many schools in developing and middle income countries, and in school environments willing and able to make a commitment to teacher professional development, local decision making, accountability and competitive practice, technology can play an even more meaningful role in improving instruction and increasing learning outcomes. While some of the identified drivers to educational quality in recent international comparison studies highlight factors that directly influence high quality instruction, such as teacher selection, professional development, and instructional support, other less tangible drivers of educational quality, such as competition, accountability, and local decision, making also play an important role. In Egypt, these less tangible factors helped the Ministry of Education and the TILO project recognize and build demand, and secure the commitment necessary to plan and problem solve through the challenges of growth and change associated with the effective use of technology for learning.
References


Emerging Trajectories and Sustainability of ICTs in Educational Reforms in Africa: Exploring the Prospects of the Teacher Laptop Policy in South Africa

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The integration of information communication technologies (ICTs) in education is part of the effort to ensure a better outcome in public education. Other sectors of the society have raised productivity by using technology to augment human labor. However, the teaching profession in Africa has become more labor-intensive due to lack of necessary resources. In line with the goal of raising teacher productivity, and given the shortage of qualified teachers in the system, the Teacher Laptop Initiative (TLI) policy in South Africa aims to bring innovation in the teaching profession by constantly improving the contents and pedagogical skills of teachers. Based on the technological, pedagogical and content knowledge theoretical framework, this study explores the prospects and challenges of the TLI program. As desirable as policy may be, this paper argues that a successful TLI in South African schools will go beyond providing teachers with laptop computers. The success will depend on how well the laptops are used by teachers for productive educational outcomes.

Key words: ICTs, Teacher Productivity, Educational, Development, South Africa

I. Introduction

The study examines the importance of Information and Communication Technologies (ICTs) in education reforms in Africa within the context of South Africa’s Teacher Laptop policy. Other sectors of the society have raised productivity by using technology to augment human labor. Contrarily, teaching in Africa has become more labor-intensive due to lack of necessary resources. The Teacher Laptop Initiative (TLI) is part of the effort to improve teaching and the overall educational system in South Africa. Helping the 350,000 teachers in South Africa to effectively integrate modern ICTs into teaching and learning processes is a major investment and a catalyst to support education reform in the country. Given that no educational system can rise above the quality of its teachers, the continuous development of teachers is crucial in South Africa, especially in an effort to reengineer the country’s social structure after many decades of a brutal apartheid system. Besides, training and updating the content and pedagogical skills of educators in South Africa is imperative for the realization of the goals of Education for All (EFA) espoused in the country. The integration of ICT has become a policy choice in educational development and reform in Africa. This emergent trajectory reinforces the belief that conventional approaches to teaching cannot cope with the high demand for education in the country.

In this study, ICTs are treated as tools, which can help to accomplish the complex task of educational improvement, rather than a subject of study for its own sake. With the case study of the TLI in South Africa, the study will explore the prospects and challenges of ICTs and teacher professional development in Africa. The goal of this study is to use Technological, Pedagogical and Content Knowledge (TPACK) conceptual framework to highlight how investment in the TLI program can bring maximum returns to education in South Africa. The TPACK theory provides a good framework which can be used to examine challenges facing ICT integration in education in
South Africa. This study argues that the success of the TLI initiative can be ensured through a continuous professional development for teachers in educational technology integration in teaching. However, the sustainability of such a large-scale teacher training effort will depend on public-private collaborative efforts. Based on the TPACK framework, this study explores three interrelated questions, namely: to what extent can educational technologies improve teacher productivity based on the TPACK model? What are the possible challenges of the teacher laptop initiative in South Africa? How can these possible challenges be resolved? The finding of this study informs research-based policy on TLI and other educational technology programs in the country.

II. TPACK Theoretical Framework

The Technological Pedagogical and Content Knowledge (TPACK) framework, addresses some of the challenges confronting ICT integration in education by teachers. TPACK theory highlights the necessary knowledge teachers and education policy makers need for a productive integration of ICTs in teaching. In developing the TPACK, Mishra and Koehler build on Shulman’s idea of pedagogical content knowledge (PCK). In this study Shulman (1987 cited in Mishra and Koehler, 2006) argues that contrary to many views, teachers’ subject knowledge and pedagogy are not mutually exclusive domains. Rather, they are interconnected. The TPACK theory is comprised of three different domains, namely: knowledge of content, pedagogy, and technology, and these elements interact for an effective integration of ICTs in teaching (Mishra and Koehler, 2008). The TPACK model puts forward two basic arguments: 1) thoughtful interweaving of technology, pedagogy and content knowledge is needed by teacher to ensure a productive application of ICTs in education; and 2) there is no single technological solution that applies for every teacher, every course, or every view of teaching (Mishra & Koehler, 2006).

The TPACK framework presents a holistic outlook of ICT integration in education. The theory recognizes the complex interrelationship among the different elements, which are contextually bound in a successful integration of ICTs in education. These core elements, which constitute the different components of the theory, are: technological knowledge, pedagogical skills/knowledge and the content knowledge (Mishra and Koehler, 2006). These three components overlap each other thereby creating three different intersections (See figure 1). Mishra and Koehler (2008, p.3) contend that: “It is the interactions, between and among these components, playing out differently across diverse contexts that account for the wide variations seen in educational technology integration.”

Technology Knowledge (TK) represents knowledge about the potential of basic technologies (example, books and chalkboard) and modern and advanced technologies (example, computers, internet and digital video) used in education (Mishra and Koehler, 2006; 2008). Teachers are required to be skilled in applying these technologies productively in their work Content Knowledge (C or CK) deals with teachers’ knowledge about the contents of the subject area they teach (example, Mathematics, English language and History). This relates to the contents, characteristics and practice in different disciplines. This element of knowledge underscores disciplinary differentials, which calls for application of different methodologies in teaching (Mishra and Koehler, 2006; 2008). The Pedagogical Knowledge (P or PK), which is the last component of the TPACK theory, deals with the processes and methods of teaching, students’ learning, educational purposes, values and aims (Mishra and Koehler, 2008). This component deals with lesson planning and implementation techniques, classroom management, and student evaluation. An enriched pedagogical knowledge enables teachers to understand and evaluate how learners construct knowledge and build skills.
As mentioned earlier, the three components in TPACK theory intersect with one another. The first intersection is created by the overlapping of Pedagogy and Content Knowledge, or Pedagogical Content Knowledge (Shulman, 1986 cited in Mishra & Koehler, 2008). This shows the strong relationship between content and pedagogy. It shows that each subject area (discipline) is different and should be presented and taught with different instructional strategies for utmost outcome. The second intersection is Technological Content Knowledge (TC), which comes from the overlap between technology and content. This demonstrates the importance of understanding the impact of technology on specific content or subject, or vice versa. In essence, certain contents can limit or enhance the type of technology the teacher can use, and some technologies can limit or enhance the content and subject teachers can teach (Mishra & Koehler, 2008). As Mishra and Koehler (2008, p. 9) put it “Teachers need to master more than the subject matter they teach, they must also have a deep understanding of the manner in which the subject matter …can be changed by the application of technology.” The third intersection between Technology and Pedagogy forms Technological Pedagogical Knowledge. This intersection shows how teaching and learning can change when certain technologies are used by the teacher (Mishra and Koehler, 2006, 2008). Different forms of technologies can enable the development and application of different forms of pedagogy. On the other hand, different pedagogical methods will require different forms of technology.

The simultaneous integration of technology, pedagogy and content in teaching makes a great difference in realizing the goals of investment in educational technology. The TPACK theory provides the necessary steps for the improvement of teacher performance and productivity through the TLI program in South Africa.

**Figure 1: Technological Pedagogical and Content Knowledge Framework**

Source: Mishra & Koehler, 2008, p. 3
III. ICTs and Teacher Productivity in South Africa

Educational technologies can be used to improve the performance of teachers and education quality in Africa. Economists identify technological innovation — the creation, distribution, and use of new knowledge — as one factor that leads to growth based on increased productivity (UNESCO, 2008). Unfortunately, the teaching profession in Africa has not been influenced much by modern technological innovations. This has affected the overall performance of teachers in the region. One of the major challenges of education in South Africa and Africa in general is the poor quality of the teaching force. The quality and quantity of education provision depend largely on the stock of teachers in the system. As Crouch and Perry (2003) observe, the combined impact of reduced educator training facilities, high rate of attrition and the HIV/AIDS pandemic will cause a severe shortage of teachers in South Africa in the next decade. The implication of this is that the available teacher workforce in the country will be stretched thin if no measures are taken to enrich it.

The TLI is an effort to use ICTs to shore up the quality and productivity of teacher workforce in South Africa. In essence, the TLI is geared toward offering quality education to learners in South Africa with fewer teachers. Based on the TPACK model, ICTs such as computers can improve the productivity of teachers. Despite the conceptual and practical difficulties of measuring educational productivity, it seems fair to observe that educational productivity lags behind productivity growth in other sectors in South Africa. However, there is ample evidence that suggests that a meaningful integration of old and new ICTs can improve teaching and learning outcomes (Dede, 1998; Kozma, n.d). The application of technology, pedagogy and content can help teachers “structure, organize, or enhance the activities that facilitate outcome –based education (OBE) in South Africa.” The emphasis of the OBE education philosophy is on results and not subject areas or on what Chisholm (2003) describes as “content-laden curriculum.” In an effort to undo the apartheid education, the OBE model provides a broad framework for an open and non-prescriptive teaching style. It relies on teachers to create their own learning programs and learning support materials (Chisholm, 2003). Unfortunately, teachers in the country are ill-prepared and ill-equipped to handle the subject contents they teach under the OBE system. As described above, the OBE system, which is orienting towards student-centered pedagogy, demands rich educational and instructional resources such as computers and updated text books. However, these resources are scarce in most schools in the country.

Computers and other ICTs have the potential to improve teachers’ productivity in many aspects of their work outside the classroom. (See Table 1 for a summary of the potential of ICTs for teacher productivity). In an information-driven world, teachers are expected to perform multiple tasks and amass huge volume of knowledge to improve the learning experience of students. At the center of this change in teaching and learning is ICT. To meet the expectation, teachers must not only keep pace with effective instructional technologies, but also with effective strategies to infuse pedagogy with appropriate technology.

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11 The concept of educational productivity is replete with a number of problems. First, there is the lack of identification and agreement on the goals of education. Second, there is no adequate ways to measure the attainment of complex academic skills and affective outcomes (Melmed, 1983).

2 Outcomes-based education model starts by designing the outcomes to be achieved by the end of the educational process. The OBE system describes the knowledge, skills and values learners should acquire and demonstrate during the learning experience (DoE, 1997).

3 On the other hand, the rapid growth of computers in schools has been criticized by many who see investment in ICT as a waste of time, efforts and money. For example, Oppenheimer (2003) puts forward the "failure of technology" in education argument. While Oppenheimer argues that the use of computers in teaching and learning has been almost "entirely wasteful," other critics think that computers have been “oversold and underused” for educational improvement (Cuban, 2002).
### Table 1: Potential of ICTs in Teaching

<table>
<thead>
<tr>
<th>Technology Potential</th>
<th>Method of Application by Teachers</th>
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<tr>
<td><strong>Improved Teaching Practice and Learning</strong></td>
<td>Resources for teaching abstract concepts, complex systems, problem solving—and basic skills</td>
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<td></td>
<td>Resources for group work and collaborative inquiry</td>
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<td></td>
<td>Building and maintaining a class or course Website</td>
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<td></td>
<td>Adaptable to various student learning styles and special needs</td>
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<td></td>
<td>Using ICT in preparing quizzes and exams for students</td>
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<tr>
<td></td>
<td>Improve teaching practice: Use ICT to improve teachers’ subject knowledge and improve pedagogical practices, and to assist teachers in planning objectives, structuring lessons.</td>
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<tr>
<td><strong>Assisting with Daily Tasks</strong></td>
<td>Preparing lesson plans: Online databases, CD-ROMs, videodiscs, and other electronic sources</td>
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<td></td>
<td>help teachers create, customize, and update lessons.</td>
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<td></td>
<td>Tracking student progress: Grade book programs and databases to update student profiles and maintain records.</td>
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<td></td>
<td>Familiarize teachers with basic and advanced 21st-century ICT usage skills including word processing, online collaboration, Internet research, multimedia production.</td>
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<td>ICTs will free teacher and administrator time and improve data storage and flow.</td>
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<td>Communicating: Telephone, voice mail, e-mail to contact parents, other teachers, or administrators to plan meetings, discuss student and administrative concerns</td>
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<tr>
<td><strong>Enhancing Professional Development and Mentorship</strong></td>
<td>Just-in-time training and support: Satellite, video, cable, or computer access to new ideas, master teachers, and other experts for training and follow-up</td>
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<td>Formal courses and advanced degrees:</td>
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<td>Distance learning technologies for courses not available locally.</td>
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<td></td>
<td>Using ICT in communication with colleagues: Online contact with teacher colleagues and other experts; exchanging materials and lesson plans</td>
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<tr>
<td><strong>Preparing New Teachers</strong></td>
<td>Models of effective teaching: Video can take prospective teachers into classrooms to watch effective teachers in action.</td>
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<td></td>
<td>Computer and video simulations and case studies:</td>
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<td>Give prospective teachers practice solving teaching challenges in a nonthreatening environment</td>
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<td>Electronic networks:</td>
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<td>Minimize violation during field experiences; provide support and interaction with college faculty or mentors.</td>
</tr>
</tbody>
</table>

Adapted from, U.S. Congress, Office of Technology Assessment (1995); Intel Corporation. (2007)

Different studies (Ertmer, 1999; Mishra and Koehler, 2006; Boakye and Banini, 2008) have identified various forms of implementation barriers facing educational technologies in the school system. Barriers to ICT integration range from personal fears among teachers, technical and logistical issues, to organizational and pedagogical concerns. Ertmer classified barriers to ICT integration into two groups, namely: first-order and second-order barriers to ICT integration in
schools. She described first-order barriers to technology integration in education as being intrinsic to teachers. Such constraints include lack of access to computer hardware/software, insufficient time to plan lessons with ICTs, and insufficient technical and administrative support for technology implementation (Ertmer, 1999). On the other hand, Ertmer contends that second-order barriers to ICT integration are also intrinsic to teachers; however, they are less tangible than the first-order barriers.

Notwithstanding the potential and value of modern ICTs for the enhancement of the teaching profession, educators in South Africa and other African countries lack access to basic technologies such as computers and Internet. Despite notable investment in educational technology infrastructures in many schools across South Africa, many teachers still lack the basic computer skills necessary for effective integration of such technologies into learning. One common reason for teachers’ lack of access to computers is the insufficient number of computers in schools. Inadequate computers in schools limit teachers’ access and ability to exploit the educational potential of computers. The question of limited access to computers by teachers in South African schools is directly connected to the question of cost. The cost of purchasing computers and other peripherals such as Internet connectivity are high in South Africa. Due to budgetary constraints, many provinces in the country have not been able to provide adequate numbers of computers in their schools. Thus, the level of computer procurement for schools varies from province to province. Some provinces had adopted more innovative solutions to this challenge. Again, despite the increasing rate of educational computing in South African schools, most of the machines do not have the necessary educational software and Internet connectivity to meet the professional needs of teachers. The inventory of technologies in many schools in the country limits the ability of teachers to use basic educational applications. In addition, some South African schools do not have the basic telecommunication infrastructures such as telephone, Internet connectivity and technical support needed for the integration of technologies in teaching and learning. Although, this challenge of access to basic ICT resources is acute in schools located in rural communities, many urban schools face similar challenges. Organizational arrangements in schools and lack of adequate resources are other challenges that limit teachers’ ability to use computers for professional enhancement. Learning new technologies takes time; unfortunately, due to increasing responsibility teachers in South Africa do not have sufficient time to learn, master and incorporate these new technologies in their profession.

The above challenges to the application of educational technology in teaching underscore the importance of the TLI in South Africa. Education policy makers in the country have recognized the imperative of using available and affordable ICTs to improve educational outcomes. As the World Bank (2005) notes, the quality and quantity of public education in Africa cannot be increased without innovative changes in teaching and education delivery. Thus, a combination of demand and supply-side factors underscores the need for using available and affordable ICTs to improve the performance of educators in South Africa. Such innovative approach to education development requires careful implementation.

While educational technologies have their potential for teaching and learning in different subject areas, it is teachers’ ability to skillfully bring together the content knowledge, pedagogical skills and the technological skills, which makes a huge contribution to how students learn. This is what UNESCO (2006) sees as a benchmark and measure of internal efficiency in the education system. On

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4 A good example is the Khanya Educational Technology Project in the department of education in the Western Cape Province. The Khanya project operates as a collaborative partnership between the government and the private sector for the use of modern ICTs to improve education in the province.
the other hand, any improvement on the efficiency of the education system may reduce the demand for more teachers (ibid). At the same time, improving the efficiency of teachers enhances education quality and cost effectiveness in the system. Therefore, the TLI is part of a larger framework of educational reform in post-apartheid South Africa, aimed at realizing the goals of teacher quality and efficiency.

IV. The Teacher Laptop Initiative Policy in South Africa

One of the biggest challenges facing education, particularly the OBE system in South Africa is how to improve education quality. One element of this challenge is the quality of the teaching force. As stated by the South African Department of Education (DoE, 2004), the introduction of ICTs in education represents an important part of the government's strategy to improve the quality of learning and teaching across the education and training system. In pursuit of these objectives, the DoE announced the Teacher Laptop Initiative in May, 2009 and implementation followed two months later. With the goal of improving the quality of teaching and learning in the country, the initiative aims to ensure that every teacher in the country owns and uses a laptop. To bring this to fruition, the national government will provide permanent teachers with a monthly allowance, which will cover the cost of purchase and the costs of internet connectivity (Republic of South Africa, Government Gazette, 2009). The DoE has earmarked R550-million per annum for the next five years for the provision of the laptops for permanent teachers in the nine provinces in the country (Gower and Hoffmann, 2009). The laptop is expected to assist the teachers in their learning and teaching experiences. As outlined in the government gazette, some of the conditions for teachers’ participation in the program include:

- Every school-based educator employed in terms of the Employment of Educators Act and who occupies a permanent post on the establishment would be eligible to participate in the initiative;
- Provincial Education Departments (PEDs) will implement the allowance on a preference list of educators based on their seniority;
- Participants will, on their own, source the laptop conforming to the minimum (technological) specifications from service providers approved and listed by the registered CTUs;
- The allowance will be extended for further periods of 5 years subject to the conditions as detailed in Schedule A2 (see below). (Republic of South Africa, Government Gazette, 2009, p. 4).

In addition, the policy outlined minimum technological (both hardware and software) specifications for the teacher laptop initiative package (See Table 2). The uniform technological specifications aim to ensure that every teacher in the system has access to educational and administrative software packages in a centralized system. Given that many teachers are ill-prepared in their subject areas and inadequately trained under the revised OBE, the TLI is considered as a cost-effective approach of retraining teachers and providing them with the necessary tools to ensure improved performance of learners.

Considering the challenges facing teachers in South Africa, the TLI will bring some relief to teachers in many ways. As a tool, the laptops will afford South African teachers the opportunity to work “anytime and anywhere” and enable them to implement an outcome-based curriculum. The aim is to develop, broaden and deepen pedagogical, content and professional competence of teachers. Thus, the laptops are expected to provide teachers with abundant educational resources and render administrative and school management responsibilities less laborious. As outlined on Table 1, the laptop will enhance the performance of teachers in different ways, this includes: networking and
exchange of contents, lesson plans and other ideas; collecting and analyzing data; access to books and other education materials online. At this junction, it is worth stressing that the provision of laptop computers is not a panacea to the challenges facing teachers in South Africa. As some scholars (Haddad, 2007; Dellit, 2002 cited in Boakye and Banini, 2008) have noted, wrong application of ICTs can bring more disservice to an education system. What matters most is how the laptops would be put to a productive use to enhance teacher performance in the system.

Table 2: Minimum specifications for the teacher laptop initiative package

1. Minimum Technological Requirements
   - Software and content image (see 3 below);
   - Access to Internet connectivity;
   - Use of a common domain e-mail address;
   - Insurance policy covering the laptop; and
   - Proof of purchase.

2. Hardware Specification
   - 160Gb Hard Drive
   - 1024 Mb RAM
   - DVD/RW Multi-Drive (internal/external)
   - 9” LCD screen
   - Integrated keyboard
   - Integrated 2-button pointing device (mouse)
   - Wireless LAN, Ethernet LAN, and Voice-Fax Modem
   - Built-in speakers and microphone
   - Windows XP or higher
   - 2 USB ports
   - Integrated rechargeable battery with a battery life of 2 hours per charge
   - Three-Year Carry-In Warranty (excluding battery)

3. Contents to be Loaded
   - School administration package of SA-SAMS
   - National Curriculum Materials
     - National Curriculum Statements
     - Learning Program Guidelines
     - Subject Assessment Guidelines
       - Qualifications and Assessment Policy Documents
         - Exemplars
     - Matric Exam Papers
       - Teacher Training Manuals and Teacher Guidelines
4. Teacher development materials to be Loaded:

- Microsoft Digital Literacy (teach and assess basic computer concepts and skills so that people can use computer technology in everyday life); and
- Microsoft Partners in learning:
  - ICT Skills for Teachers (introduce new users to ICT skills in the context of their roles as teachers)
  - One Step Further (develop the information skills and take teachers one step further in their developing ICT literacy)
  - ICT Integration (Web-Quests)
  - ICT Leadership for Education Managers
  - 21st Century School Leadership
  - Peer Coaching
  - Deploying Student Technical Support Solutions.

Source: Republic of South Africa, Government Gazette (2009, pp. 7-9)

V. The TPACK Model and the TLI Implementation

As demonstrated by the TPACK model, the integration of technology in teaching is a complex and challenging process. This raises the question about the level of preparations given to teachers in South Africa prior to the rollout of the TLI program. With regard to the level of preparation, some teachers have advantage over others. This is because there are schools in South Africa where laptops are already part of the educational experience. Teachers in such technology-rich schools such as those in Western Cape and Gauteng provinces may have the needed expertise and guidelines to facilitate a smooth application of laptops in their professional tasks. Besides, such schools will also be in the position to anticipate basic demands of laptops and prepare for them. However, while teachers in affluent provinces may be familiar with laptop technological platforms, those in less affluent provinces like Eastern Cape and Limpopo may not have such prior experiences with laptop computers. The DoE has no plans to prepare these teachers before the TLI program starts. This decision is based on the assumption that the existing ICT in education programs in the country have prepared South Africa teachers for the TLI program. Under existing ICT in education programs, teachers in some schools were provided some training on computer applications. According to Mr. Firoz Patel, the deputy director-general of system planning and monitoring, DoE, no further training is planned because, an estimated 60,000 teachers across the country have received some computer training (Ndlovu, 2009). This means that about 290,000 teachers will receive the laptops without the skills to exploit the educational potential of the technology.

This study argues that the “One-Time Training” or “No Training Policy” of the DoE is counter-productive to the goals of the TLI program. A closer look at the claim that teacher training in educational technology has reached a critical mass reveals that the 60,000 trained teachers are not evenly spread across the 9 provinces in South Africa. Most of the accomplished technology-using teachers and a larger number of teachers who have received some form of computer training in South Africa are in schools located in the more affluent provinces such as Western Cape and Gauteng. Obviously, the majority of teachers in the country do not have any formal training in computer application in teaching. Besides, the training provided for the 60,000 teachers was primarily on the
technical elements of the technology (i.e., the mechanics and dynamics of a hardware and software technology). For the most part, pedagogy was hardly infused into such training because teachers needed to master the basics of computer operations before learning how to use it as a teaching tool. Thus, such early training lacked what McGrail (2007) called “pedagogy-based technology preparation.” The TPACK model reinforces the importance of integrating pedagogical skills in ICT tools. This is because the acquisition of appropriate pedagogical practices is considered more important to educational outcomes than technical mastery of ICTs (Trucano, 2005).

Thus, devoting additional resources, providing technical support and creating more technology training opportunities for teachers, can address first-order barriers (Ertmer, 1999) to a meaningful implementation of the TLI by teachers in South Africa. To a large extent, most challenges that may face ICT integration through the TLI policy in South Africa can be classified under first-order barriers. Hence, the implementation of the TLI program in the country should be geared towards eliminating these barriers, starting with continuous teacher professional development.

The key to realizing the expected gains from the TLI is teacher training through pre- and post-rollout professional development for teachers. Given the unique characteristics of the teaching profession, and given that many teachers in the system do not have sufficient computer skills, the nation-wide computer professional development for teachers should be approached in phases. The first phase, which should be instituted prior to the procurement of the laptops will identify and establish a network of provincial Teacher Technology Integration Mentors (TTIM) in each school. This structure will require the selection of one teacher from each school to serve in the TTIM in each province. The provincial TTIMs will be charged with two main responsibilities: 1) to help in the development of guidelines for laptop use by teachers within the province; and 2) to assist in the development of a nationwide network of professional development for ICT integration and pedagogy in schools. Part of the first phase of the TLI under the auspices of TTIM in each province will entail basic technical training of teachers in beginner computer skills. This early training will be an opportunity for many teachers to familiarize themselves with the computer system before the procurement of the laptop computers. The second implementation phase of the TLI will entail the procurement and distribution of laptop computers to teachers in line with the policy. At this phase, the national department of education in conjunction with the provincial departments of education will continue the professional development network and new roles in schools across the country. Among such new roles are the Teacher Leader and the Technology Coordinator. This new personnel will be required to undergo basic training to enable them serve as contact and support personnel for teachers in their respective schools.

After close monitoring of ongoing professional development of teachers, the TTIM in each province should create an additional role of a Content Mentor in each school. Teachers appointed to serve as Content Mentors should be teachers who are not only proficient in technology integration but also in specific content subjects such as English language, social studies, Mathematics, Afrikaans and Economics. The Content Mentor in each school will facilitate the integration of content curriculum and technology. This is important because, in line with the TPACK model, teachers in different subject areas may use ICTs in qualitatively different ways for instructional purposes. With the TTIM mechanism in place, professional development for technology integration in South African schools will be an ongoing event together with the TLI in the country. This will include a departmental professional development scheme to meet the needs of teachers in different subject-areas and interests. Empirical research suggests that the levels of use of laptops among teachers are higher for those who participate in professional development workshops and activities (Silvernail & Lane, 2004; Cowie, et al, 2008). Given that more professional development activities for teachers will
require extra resources, it is important for the DoE to engage in a dialogue with the South African Democratic Teachers' Union and the National Professional Teachers' Organization of South Africa. This will enable all stakeholders to work out a practicable modality for professional development for teacher for the laptop technology.

In addition to professional development, teachers who are advanced in integrating technology in teaching can serve as mentors to lesser skilled teachers. As observed by Younie (2006), it is not just enough to offer a general ICT training for all teachers in all schools; in order to meet individual needs of teachers, it is important to contextualize staff development strategy to meet the needs of teachers in individual schools. In addition to a continuous teacher training in ICT integration, it is imperative to rethink pre-service teacher education in South Africa. Teacher training needs to be reviewed by including ICT integration as a core part of teacher education curriculum. This will improve the ICT competence among teachers and give them more innovative skills and pedagogy.

Lack of basic infrastructure such as electricity supply and shortage of technical personnel are other challenges the TLI policy may face. The availability of a reliable power supply will determine the extent teachers will utilize the laptops in teaching. Although the TLI laptops may come with solar laptop chargers, this device will have its early challenges for teachers in rural areas where there is no electricity grid. This will make frequent and productive use of the laptops difficult. The availability of timely technical support for participants of the TLI is another major concern. In a study conducted in South Africa in 2005, school administrators see the shortage of technical personnel as a major obstacle in the integration of ICT in education (Evoh, 2009). Fortunately, the TLI program in South Africa includes extended warranties, insurance, and some third-party support services. However, it remains to be seen how some of these services will be extended to teachers in rural communities. Moreover, it must be emphasized that a strategy for prompt technical support, particularly, for teachers in rural communities will help to ensure the realization of the goals of the TLI. Finally, the TLI may face the challenge of the continuity of political support. Given that the TLI policy was initiated under the former Education Minister, Mrs. Naledi Pandor, it remains to be seen if the present administration of President Jacob Zuma will fully implement the policy as he promised.

VI. Conclusion

The TLI is an acceptable element of education reform. The TLI is a welcome model of education reform initiative in South Africa, which promises to improve teachers’ productivity and professionalism. The program is an effort to do better with less. At the center of effective technology integration in education is the ability of teachers to bring together technology, pedagogy and subject content. The TPACK framework suggests that improving teacher performance through the TLI in South Africa will depend on factors such as the level of technological literacy among teachers and their proficiency in using the laptop as a pedagogical tool. This set of skills are functions of continuous professional development activities. The TLI should include professional development programs designed according to the TPACK model to meet educators’ needs before, during and after the rollout of the laptops. In essence, the success of the initiative will depend not necessarily on the procurement and distribution of laptop computers to teachers; rather, on how well the non-technical or logistical aspects of the initiative are managed. The success of the initiative will depend on a careful implementation across the country, drawing lessons from existing ICT education projects in South Africa and other developing countries. The TLI is a crucial element of education reform initiative in South Africa. A creative and strategic integration of laptop computers promises to augment teachers’ productivity and professionalism.
References


Tuned In To Student Success
Assessing the Impact of Interactive Radio Instruction for the Hardest-to-Reach

Jennifer Ho and Hetal Thukral

Introduction by Mike Laflin
Education Development Center, Inc.

A review of recent research was conducted to assemble evidence on the impact that Interactive Radio Instruction (IRI) may have on improving student learning outcomes. IRI is an instructional tool designed to deliver a family of active learning packages via radio broadcast using a dual-audience approach. IRI exposes students to regular, curriculum-based learning content while modeling effective learning activities and classroom organization techniques for teachers. As IRI continues to be called upon to improve teaching and learning in low-resource and hard-to-reach areas, a better understanding of the empirical data available is critical to guide the way forward. IRI has been implemented by Education Development Center, Inc. (EDC) in over 50 countries over the past 30 years. This paper is a review of existing student and teacher data collected by EDC’s IRI projects. Effect sizes are used to summarize what is known about the effect of IRI on student learning gains in Grades K-4 for English, Mathematics, Science, Social Studies, and Local Language. In all, student test results from 13 projects, ranging from Nicaragua in 1977 through Indonesia in 2008, are reviewed, as are teacher observation outcomes from Mali and Madagascar.

Keywords: Interactive Radio Instruction, Student Assessment, International

I. Introduction

A. What is Interactive Radio Instruction?
Interactive Radio Instruction (IRI) is an instructional tool designed to deliver active learning by radio. Audio lessons are developed to guide the teacher or facilitator and students through activities, games, and exercises that teach carefully organized knowledge and skills. During short pauses built into the radio scripts, teachers and students participate in the radio program during the course of an academic year, often more than 100 times in daily half-hour lessons, reacting verbally and physically to questions and exercises posed by radio characters. Actual formats vary according to the subject and grade level being taught. Learners also participate in group-work, experiments, and other activities suggested by the program. In this way, IRI exposes learners to regular, curriculum-based content and models effective teaching and activities for teachers.12

Based on the national curriculum and developed locally, IRI programs are designed to be part of a comprehensive, multichannel learning system. Multichannel learning is based on the belief that successful learning is more likely when more than one channel is used because people learn in various ways and through various means. The paths, or channels, that connect learners to knowledge and skills are numerous: teachers and facilitators, other learners, family and community members,

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educational materials, and media of all kinds. In addition to radio-delivered instruction, IRI enriches the learning environment by engaging resources already available (including, for example, teachers, local cultural artifacts such as songs, games and the environment, instructional materials in the classroom such as books and the blackboard, the expertise of local community members, and locally available materials (such as bottle tops and sticks) to create a blend of good teaching and learning practice.

IRI was first developed in the 1970s in Nicaragua by Stanford University, funded by the United States Agency for International Development (USAID). Evaluation data gathered between 1975 and 2000 demonstrated that IRI had improved learning outcomes in conventional classrooms when compared with control classrooms not using IRI (Tilson, et al, 1991; Leigh, 1995; Corrales, 1995; Bosch, 1997; Dock and Helwig, 1999). In addition, IRI was repeatedly found to narrow achievement gaps between boys and girls, as well as between urban and rural students (Tilson et al, 1991; Hartenberger et al, 1996; Bosch, 2001). Programs during this time period often had relatively well-funded evaluation components, often taught a single subject, and focused almost entirely on improving quality.

IRI projects of the last decade have focused more on addressing critical and urgent deficits in meeting Education For All (EFA) goals, and have had fewer resources to gather data about learning outcomes. This study focuses on results primarily achieved from 2000 to present and seeks to add to what has thus far been revealed about an important question: “What effect has IRI had on student learning when it has been applied in difficult environments and taken to national scale?” Pulling together student assessment results recently collected and published by various projects at Education Development Center, Inc. (EDC), the researchers have focused on the use of IRI in more taxing circumstances and the outcomes it achieved as well as children learning in conventional school settings.

Among the 37 records analyzed for this paper, average effect sizes ranged from -0.16 to +2.19 across a variety of subject areas, projects, and participant countries. This variation suggests that several factors affect the degree to which exposure to IRI can improve student achievement. The researchers believe these may include the availability of qualified local resources, the quality of project implementation and monitoring, and the extent to which students listen to and participate in IRI programs. While it is beyond the scope of this review to address these and other qualitative variables, they are suggested as areas for further research.

### B. Methodology

The analysis to follow is based upon learning outcomes data as it was reported by EDC’s projects. No raw data has been manipulated in the process of analysis. In an effort to build upon findings in prior studies, the researchers have, in some cases, included data from project reports preceding 2000. In all, this analysis covers data ranging from Nicaragua in 1977 through Indonesia in 2008. The following table provides a comprehensive list of the projects which provided the data for this study:
Table 1: Data Sources for Review of Research

<table>
<thead>
<tr>
<th>Country</th>
<th>Project Duration</th>
<th>Subjects and Grades Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Salvador</td>
<td>2003-2005</td>
<td>Pre-Primary – Early Childhood Development</td>
</tr>
<tr>
<td>Haiti</td>
<td>2002-2008</td>
<td>Math and Reading, Grades 2-4</td>
</tr>
<tr>
<td>Honduras</td>
<td>2003-2005</td>
<td>Pre-Primary – Early Childhood Development</td>
</tr>
<tr>
<td>India</td>
<td>2002-ongoing</td>
<td>English, Grades 1-3; Math, Science, and Social Studies, Grades 4 and 5</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2005–ongoing</td>
<td>Pre-Primary – Early Childhood Development</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>1975-1978</td>
<td>Math, Grade 1</td>
</tr>
<tr>
<td>Madagascar</td>
<td>2006-2008</td>
<td>Teacher Observations – Grades 1 and 2</td>
</tr>
<tr>
<td>Mali</td>
<td>2004-2007</td>
<td>Teacher Observations – Grades 1 and 2</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>1990</td>
<td>Science, Grade 4</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2006, 2007</td>
<td>English Grades 1 and 2</td>
</tr>
<tr>
<td>Somalia</td>
<td>2005-2008</td>
<td>Reading, Grade 1</td>
</tr>
<tr>
<td>Sudan</td>
<td>2004-2009</td>
<td>English, Literacy, and Math, Grade 1</td>
</tr>
<tr>
<td>South Africa</td>
<td>1995</td>
<td>English, Grade 2</td>
</tr>
<tr>
<td></td>
<td>2000 – 2004</td>
<td>English and Math, Grades 1 and 4</td>
</tr>
</tbody>
</table>

Throughout this analysis, reference is made to ‘records’. A record is a unique combination of a grade and year. For example, Pakistan provides three records to this study – grade 1 2006; grade 1 2007; grade 2 2007. In all, 15 projects supplied 37 records for analysis.

Criteria for Inclusion of Studies

The following criteria were applied to determine the final list of 15 projects that were considered in this study. For each study, more than one year of data was often available. In addition to data reported in previous studies (for Papua New Guinea, Nicaragua and South Africa), the researchers identified datasets that:

- had available a technical report that detailed results of IRI with some measure of student learning as an outcome variable; and
- included in the report results for a control group, including standard deviation, mean, and sample size (n). In instances where this data was not reported, efforts were made to obtain the
data files containing the raw data. In all instances, except for Somalia, all data were obtained and verified.

Study Methodology

The researchers attempt to summarize recent data on the effectiveness of IRI on the learning outcomes of students in the hardest-to-reach areas. To this end, the data are summarized across subjects, grade levels, countries, over time, and by target groups.

To address the varying nature of IRI across contexts, this study employs effect size comparisons as a common measure of student assessment results. Effect size is a term given to a set of indices that measure the magnitude of a treatment effect, without dependence on sample size. By using effect sizes, researchers since 1976 have been able to summarize results from studies to effectively compare findings in a specific area of research.¹³

In this study, effect sizes have been derived by comparing the results for IRI students (experimental) to those students who have not been exposed to IRI (control), and are derived from two types of results: those based on gain scores, and those based on post-only scores. Gain scores are computed by subtracting a pre-test measure (student achievement at the beginning of the treatment period) from the post-test measure (student achievement at the end of the treatment period). Where pre-test measures are not available, effect sizes are computed based on post-only scores.

Across both gain score and post-only comparisons, analyses by grade are based on an average of the effect sizes across countries. This assumes that subject content at grade level is relatively comparable on an international scale. Analyses by country illustrate effect sizes by grade level as well as by year of assessment, allowing for a fully detailed review of results.

Upon a review of the available data, the researchers selected several lenses through which to analyze and present the findings. The lenses, or perspectives, selected were based on a) the availability of data, b) some general assumptions about the types of questions stakeholders may ask regarding the impact of IRI, and c) the lenses through which IRI has historically been analyzed.

Based on the findings of earlier research, the underlying hypothesis was that learning outcomes for students would improve when learners were exposed to IRI, even in recent years where it is more often used as a means to reach learners in difficult circumstances.

Data Limitations

The researchers acknowledge limitations to this study that are either inherent in the data itself or in the IRI development and implementation process. The first data limitation of this study lies in the number of data points available in each study in a given year. For instance, some studies report both pre-test measures (before the beginning of IRI in the academic year) and post-test measures (immediately following the completion of the IRI programs), while others collect and report only post-test measures. To address this, the researchers have reported these results separately, and have indicated the nature of the data available.

¹³ The current practice of calculating effect size as a means to combine results from different studies was developed by Glass in 1976.
A second limitation is that different sets of variables are often available for analysis in each dataset. For instance, gender and urban/rural status were not consistently available from all 15 projects. For these analyses, only those project that provided the relevant variables were included.

A third limitation is the restricted amount of data available for analysis. This study is not intended to be a comprehensive record of all IRI activities at EDC or other agencies, but rather of those projects for which there is data of known reliability and is available. Where preliminary data has been included, it has been labeled as such. Furthermore, data was not available on supplementary programs that participants may have participated in.

Lastly, this report does not include data from non-EDC project, nor does it draw conclusions about their impact. Care must be taken when comparing educational activities that may have fundamental differences in their design. Experiences from other organizations are not included in this analysis because, without prior knowledge of the ways in which the methodology of developing radio programs differs at other organizations, the researchers cannot reasonably compare EDC’s results from these (possibly) divergent efforts.

II. Key Findings

A. Learning Outcomes by Subject Area

As an instructional delivery mechanism, Interactive Radio Instruction has been used to bring teaching and learning material into classrooms in a wide variety of subject areas. The following analysis reviews student learning outcomes as an assessment of IRI’s effectiveness in supporting the mastery of core subject content in the primary grades.

In mathematics, data have been analyzed from IRI projects implemented from 2003-2007 in four countries: Zambia, Sudan, Haiti, and India (see Figure 1). A summary review of these results illustrates an effect size of 0.41 in grade 1. This tells us that had the average control student participated in an IRI math program she would have been ranked at the 66th percentile of her class rather than at the 50th, representing a 16 percentile “boost” in rank attributable to the effectiveness of IRI instruction. Subsequent grade levels through grade 4 also demonstrate positive effects of IRI math programming.
In local language literacy, analysis incorporates data from four countries: Zambia, Sudan, Somalia, and Haiti, spanning 2003-2007 (see Figure 2). Positive effect sizes observed in grades 1-4 evidence IRI’s stimulation of favorable learning outcomes in primary literacy instruction. Of particular note is the effect size calculated for grade 1, wherein the control learner, had she participated in IRI programming, would have been ranked at the 68th percentile at the time of post-test administration rather than at the 50th.

Figure 2: Local Language Literacy Effect Sizes by Grade (Post-Test Only)
In English, data collected from 2003-2007 show that IRI has almost always improved English language competency in the cases examined in Zambia, Sudan, Pakistan, and India (as shown in Figure 3 below). Across grades 1-4, students participating in IRI have been observed to outperform their control school counterparts. Notably, summary results by grade show that, in grade 1, had the average control student participated in IRI, she would have been ranked in the 96th percentile at the time of year-end testing rather than the 50th; the 46 percentile “boost” in rank at year-end is attributed to the effectiveness of IRI instruction. In grade 2, the average control student would have been ranked in the 89th percentile had he participated in IRI English programming.

Figure 3: English Effect Size by Country, Grade and Year (Post-Test Only)

The rather impressive results in each grade 1 and grade 2 are primarily attributed to post-test scores obtained in Pakistan, as can be discerned from the figure below detailing English effect sizes by country. The magnitude of the impact IRI has had on English language instruction is evident, where 7 of the 11 records show moderate or large effect sizes. Strengths in grade 1 English IRI instruction...
are reinforced by data from Sudan, which suggest that the average IRI student outranked 76% of her colleagues not participating in IRI. Effect sizes from India in grades 1 and 2 combined are moderate in 2005, and even stronger in 2006, again substantiating a strong pattern supporting the positive impacts of IRI in English language instruction.

In social studies, the introduction of subject content using IRI is a recent development. Analyses draw upon a limited data set including student assessment results from India and Zambia in 2006 and 2007. Student learning outcomes in both countries show slight advantages for IRI learners in grade 4 programming as well as in grade 4 and 5 combination programming. Grade 3 results from Zambia are stronger and suggest that had the average control learner participated in the IRI social studies series, she would have been ranked at the 58th percentile rather than at the 50th. More data is certainly required to confirm early patterns observed in these results. However, the evidence in this review suggests, albeit inconclusively, that IRI is effective in this area.

**Figure 4: Social Studies Effect Size by Grade, Country and Year (Post-Test Only)**

B. **Student Learning Outcomes in Early Childhood Education**

In addition to delivering primary-level classroom content, IRI has also been applied at earlier stages of cognitive and social development as a tool to support early childhood development and education. In the cases examined below, IRI has proven to be an effective pre-primary intervention in terms of early childhood development. Results have shown to be positive in both urban and rural environments, as well as in alternative learning centers lacking trained teachers.

Results from tests that are administered to younger learners (generally between the ages of four and six years old) are usually summarized by levels of development rather than by a “percentage correct.” Since effect sizes cannot be calculated on this type of metric, the data below should not be directly compared across countries in an absolute sense. What the data does show is that the trend of change in the development of young learners suggests that IRI can be influential in the lives of such very young children.
In Bolivia, assessments measured learner levels of verbal communication, physical activity, positive affects and engagement, and skill levels in performing designated tasks. Caregivers in classrooms using IRI were consistently more positive in their reviews of children’s attention levels, skills, and general enjoyment of learning activities than caregivers in control classrooms. Complementing these observations, student assessment results show IRI learners had outperformed their control counterparts in each subcategory by an average margin of 27 percentage points (see Figure 5). These achievements are considerable, particularly given that target beneficiaries represented large, often remote audiences, and that caregivers required training materials and program tools not reliant on high-level reading skills or face-to-face instruction.

Figure 5: Comparison of Early Childhood Education Post-test Results (Bolivia)

In El Salvador, assessment results were drastically lower for IRI learners than for control learners at the time of pre-test evaluation. However, by post-test administration, the percentage of IRI learners categorized as “Needs Improvement” dropped by 23 points, while control schools saw a reduction of 5 percentage points. After only a few months of program participation, the percentage of IRI learners evaluated as “Excellent” jumped from 34% to 82% while control schools saw a rise in the percentage of students in this category from 67% to 80%.

In Honduras, the Juego y Aprendo project established 53 early childhood IRI centers with the objective of increasing access to pre-primary education. It was not expected that, following 12 months of intervention, the project’s alternative IRI centers—staffed with volunteer educators—would match student achievement levels attained by the control group comprised of existing, formal preschools. Despite this, post-test scores for IRI and control group learners were not seen to be significantly different. This was true for centers in both urban and rural regions.

In Indonesia, although assessment results favored control learners over IRI learners at the time of pre-test, the percentage of IRI kindergartners meeting “average” and “above average” criteria were seen to be equal to or greater than students from control kindergartens in every subcategory at post-test examination. Of note, this meant an increase in the percentage of IRI students meeting or
exceeding school readiness requirements in each Language and Cognitive Development categories by 21 points from pre- to post-test where control kindergartners increased by 13.

C. IRI and Teacher Professional Development

Though in most contexts IRI has followed a dual-audience approach, involving direct instruction to students while modeling teaching strategies and classroom organization techniques for teachers, it has also been used specifically for teacher professional development. In Mali and Madagascar, assessments were administered to measure changes in teachers’ instructional behavior and understanding of pedagogical techniques introduced by IRI programming. IRI-trained teachers were surveyed regularly during the life of each project, providing some longitudinal analyses data, although no control comparison data is available. A summary of the findings is presented below and illustrates that teachers, too, stand to benefit from IRI.

In Mali, teacher training was introduced via IRI as a delivery mechanism built to overcome long distances, reaching educators at the school and classroom level. Radio-based in-service training complemented school-based “communities of learning” and face-to-face trainings developed by the Ministry of Education.

Results from teacher observations indicate real improvements in instructional practice over the course of the project (see Figure 6). Each evaluation shows steady gains in teachers’ familiarity with, and use of, all key techniques emphasized by the program. Increases in teachers’ facility with brainstorming are particularly notable, with the percentage of participant teachers familiar with, and the percentage using brainstorming during non-IRI lessons escalating 59 percentage points from 2005 to 2007. Also of note is the percentage of teachers familiar with cooperative learning (93% in 2007 up from 36% in 2005), and the percentage of teachers observed using group work during non-IRI lessons (75% in 2007 up from 18% in 2005).

Figure 6: Percentage of Teachers Familiar With or Adopting IRI Instructional Methods (Mali)
In Madagascar, in-class IRI training took on a similar form in which radio teachers would model the different games, songs, and student-centered learning activities to their classroom counterparts, aimed at improving teaching in mathematics, French and Malagasy. Pauses in the radio programs allowed participating teachers time to try new activities with their students while listening to the program. The primary objective of both programs was to improve the quality of classroom instruction with an emphasis on active learning and student-centered methodologies.

For both grades 1 and 2 teachers in Madagascar, steady improvements are observed from baseline testing to final evaluation. Grade 1 observation results (shown in Figure 7) illustrate that teachers improved by a minimum of 31 percentage points in each of the six key areas evaluated, with a marked improvement by 51 percentage points in the area of gender equity (64% of observed teachers in 2008 used gender equitable practices more than minimally, up from 13% in 2007). Grade 2 teachers improved in all six areas by at least 29 percentage points, where again, the most dramatic gains appeared in the area of gender equity (69% of observed teachers in 2008 used gender equitable practices more than minimally, up from 14% in 2007).

Figure 7: Percentage of Grade 1 Teacher Using Domain of IRI Practices More Than Minimally (Madagascar)

D. Student Learning Outcomes for Marginalized Populations

The concern for marginalized learners is not new, nor are the efforts to bring quality, scalable education to them. As a result of the ubiquitous reach of radio, IRI has been looked upon as a means to reach marginalized children, and more so in recent years. This section highlights what is known of the impact of IRI on the learning outcomes of four key marginalized groups: girls, orphans and vulnerable children, learners in fragile states, and those in rural areas. While all IRI projects include some combination of one or more of these marginalized groups, limited data is available that looks at the learning outcomes for these students specifically. The following analyses are based on projects that provided the relevant demographic information.

Girls and Boys

The researchers were interested to see if IRI had a differential effect on boys and girls and whether current data upheld earlier findings of IRI as a mechanism for narrowing gender-based achievement
gaps (Hartenberger and Bosch, 1996). Recent findings by subject or grade level appear mixed, but overall, reveal a slight gap between boys’ and girls’ achievement (see Figure 8). While IRI boys enjoyed a larger boost over non-IRI boys than IRI girls did over non-IRI girls, the difference between IRI boys’ and IRI girls’ performance, on average, appears small. English results by country show that mean scores for females mirror the general trend of mean scores for males--when boys did better, so too did girls. In local language literacy (which includes both reading and writing), the data show more variability in achievement compared to English.

**Figure 8: Gender Effect Size Comparison by Subject and Grade  (Post-Test Only)**

![Graph showing effect size comparison by subject and grade](image)

**Rural and Urban Students**

Another group of students that tends to have poor access to quality education are those in rural areas (see Figure 9). Common obstacles facing rural schools in developing countries, such as remote school locations, poorly trained teachers, and high teacher turnover rates, have adversely affected learning outcomes for rural students compared to their urban peers. In response to this discrepancy in achievement, EDC has seen a steady growth in the number of projects that target this population in recent years.

Analyses of student assessment results reveal that rural IRI students enjoy approximately the same boost in achievement over their non-IRI peers as do urban IRI learners. Results show that learners in rural areas continue to benefit from IRI programming despite the fact that the distinction between ‘rural’ and ‘urban’ is messy, at best, and more so today than a decade ago. With an increased interest in IRI in recent years as a means to reach remote learners, the kinds of learners that comprise the dataset for rural learners are more varied than ever, and yet results remain promising. The data for English in grades 1 and 2 provide the most promising evidence that IRI is bridging the rural-urban achievement gap. Here, the mean English score for rural IRI students in grades 1 and 2 is at the 100th percentile of rural non-IRI English students. By comparison, the mean English score for urban IRI students in English (in the same countries, grades and years) is at the 94th percentile of urban non-IRI students.
In Pakistan, results for English grades 1 and 2 rural and urban students were further disaggregated into urban, rural and isolated schools (data are based on pre- and post-test student scores) (see Figure 10). Isolated schools were rural schools that were classified as difficult to reach because of the challenging terrain. As a result of their location, students in these schools tended to be even more isolated than those in rural schools, resulting in poorer access to technology, quality teachers, and the routine support functions provided by the central education offices to each school (these supportive measures could reasonably reach the urban and rural schools). The results for student achievement scores in isolated IRI classrooms (shown here) are impressive in an absolute sense (in both grades, isolated learners’ post-test effect sizes are significant and large), as well as in a relative sense (in both grades, isolated learners show learning gains that are between their rural and urban peers).
Students in Fragile States

While the quantity of available data is limited to experiences in Sudan and Somalia, student assessment results reviewed for IRI learners in fragile states are nonetheless encouraging. Those students who participated in IRI classes had a distinct advantage over their non-IRI peers, and this advantage was consistent across subjects. The greatest advantage was observed in English, where the average IRI student was seen to achieve a mean score that was 29 percentage points higher than that of her control school peers (effect size 0.8 in Sudan), followed by mathematics (effect size 0.6 in Sudan) and local language literacy (average effect size of 0.6 across both Somalia and Sudan).

These data present medium (0.3 to 0.5) to large (≥ 0.6) effect sizes for students in Sudan and Somalia. To put this in perspective, Sudanese and Somali students participating in IRI classes are benefiting from a 16-29% advantage over their peers in non-IRI classrooms. In light of the multitude of factors that children in these conditions are faced with (including hunger, poverty, lack of access to health care, water, and proper sanitation), it is quite probable that the impact that IRI can have on their learning is understated in these data. While the available results are extremely encouraging, additional data is needed to make more broad conclusions regarding the impact of IRI on student achievement in fragile states.

Figure 11: Fragile States Effect Size Comparison by Subject (Pre-Post Gain Scores)

Orphans and Vulnerable Children (OVCs)

UNICEF (2008) defines Orphans and Vulnerable Children (OVCs) as those children who have been separated from their parents due to a variety of reasons, and as a result, suffer from poorer overall well-being and development. Since 2000, IRI has been used to reach both in- and out-of-school orphans in Zambia. Orphans have largely been exposed to IRI either during their attendance in community schools or IRI centers. Community schools are those schools established and maintained by local communities and offering IRI programming in addition to other instruction, while IRI centers offer solely Interactive Radio Instruction. For the purposes of this report, results from community schools and IRI centers are used as a proxy for results for OVCs. This is consistent with project data evidencing larger percentages of orphans attending IRI centers and community schools in comparison to the population enrolled in formal primary schools.

Data from 2006 for grade 2 students show a small advantage for learners participating in IRI community schools and IRI centers in mathematics and lifeskills over their non-IRI peers, although
the impact of IRI in local language literacy and English is not as encouraging. In mathematics, the advantage enjoyed by IRI students in community schools and IRI centers is small when compared to the advantage IRI students in formal schools enjoyed. Conversely, in lifeskills instruction, IRI students in community schools and IRI centers demonstrate a mean that is at the 54th percentile of non-IRI students in community schools (effect size of 0.1).

When comparing the effect sizes for students in formal schools to those for students in community schools and IRI centers, there are distinct differences between these two populations that must be kept in mind. For example, students in community schools and IRI centers differ significantly from their peers in formal schools – economically, socially, and in terms of the resources available to them in school. As such, a direct comparison and conclusion cannot be made from the data available regarding the differential impact of IRI on the two populations. Instead, the data available provide some initial indication of the potential impact of IRI on OVCs. While more data is required for more conclusive evidence, additional variables, such as the quality of teacher training in formal schools versus that in community schools and IRI centers, would also be necessary.

Figure 12: Conventional vs. Non-Conventional Schools Effect Size Comparison by Subject (Post-Test Only)

III. Summary and Overall Conclusions

In this study, the researchers set out to review recent EDC experiences with Interactive Radio Instruction and its impact on student learning outcomes, especially when applied in difficult circumstances. Based on previous analyses, the hypothesis was that learning outcomes for students would improve when learners were exposed to IRI. The researchers found this supposition to be tenable, albeit in some specific grade levels and specific subjects more than in others. As discussed in the preceding sections, at times the lack of sufficient data prohibited the researchers from reaching broad conclusions regarding the impact of IRI on student learning outcomes. This was the case for some subjects, for upper primary grades, and for some marginalized populations. At other times, the data provides a collage of convincing evidence. This was seen in the analysis for early grades and in English and mathematics, and for specific marginalized populations.
It is recognized that the effect sizes presented in this study are smaller in comparison to those cited in earlier IRI literature. While explanations for such differences are left to speculation, one of these may be that local resources and expertise available to both develop and evaluate high-quality IRI programming vary significantly between countries, and may have even more variability when developed in difficult contexts. Another possibility for these smaller effect sizes may be the degrees to which IRI projects have been implemented. More so than ever, IRI is being applied at national scales, posing a significant challenge for assessments attempting to capture impacts in student learning within whole countries and finite project timelines.

Additional factors should be taken into account in the evaluation of program effectiveness, such as the quality of project implementation and the extent to which students and teachers regularly listen to programming. Overall, however, the present library of data do uphold earlier findings and suggest that learners continue to benefit from exposure to IRI programming, including those in hard-to-reach areas.
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The Role of ICT in Enhancing Education in Developing Countries: Findings from an Evaluation of The Intel Teach Essentials Course in India, Turkey, and Chile

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This paper presents findings from case studies of the introduction of the Intel® Teach Essentials Course—a professional development program focused on integrating information and communication technologies (ICT) into project-based learning—into six schools in Chile, India, and Turkey. We describe four common dimensions of change in learning environments that emerged across the countries: changes in teachers’ knowledge, beliefs, and attitudes; changes in how students engage with content; changes in relationships among students, teachers, and parents; and changes in the use of ICT tools to promote students’ learning. Three of these dimensions relate to shifts in pedagogical paradigms that appear to be prerequisites to effectively using ICT to support students’ learning. Our findings indicate that these shifts must not just occur at the teacher level, but must take hold throughout the educational system and must accompany sustained investment in infrastructure, human resources, curricular frameworks, and assessment.

Key Words: ICT, developing countries, education reform

I. Introduction

Understanding how technology fits into the complex realities of classrooms has been a critical factor in creating real change in schools in the industrialized nations (Cuban, 1993; Honey, McMillan Culp, & Carrigg, 2000; Somekh et al., 2003), yet little is known about educational technology projects in the classrooms of the developing world. This paper examines the influence of an information and communication technologies (ICT)-focused professional development program—the Intel® Teach Essentials Course—on classroom learning environments in six schools in Chile, India, and Turkey. Over the years, program evaluations have found that teachers across a variety of countries value their experience in the Essentials Course and report using ICT and/or making changes in their teaching practice following the program (Light, McMillan Culp, Menon, & Shulman, 2006; Light, Menon, & Shulman, 2007). However, the evaluations have also suggested that the ways in which teachers in different countries follow up vary, depending largely on factors in their school contexts. The research presented in this paper sought to examine more deeply the nature of the changes that schools in different contexts have made to integrate ICT and student-centered practices and how these changes affect the classroom (Light, Polin, & Strother, 2009). In all three countries, we found that the educators we interviewed and observed felt they had been able to implement new ICT activities and teaching approaches with their students after the Course. We also identified a consistent set of programs and policies that, combined with the motivation and skills of educators, enabled these schools to innovate.

We selected the six schools in the study (two from each country) which key local stakeholders—the training agencies, the ministries of education, and the Intel Education Managers—considered to
be “good examples” of using the Essentials Course to create school-level change within their national contexts. In pursuit of the ideals established by their ministries, the teachers and administrators in these schools are attempting to transform the instructional strategies and the educational tools they use. Although each country is unique and each school is at a different starting place, all are moving toward more student-centered, project-based, and ICT-rich classroom learning activities. Across the diversity of their situations, educators in each school connected the ideas and tools offered in the Essentials Course with their own needs. From our case studies of the six schools, we identified four common dimensions of changes that are emerging to support more project-based and ICT-rich activities in the classroom: changes in teachers’ knowledge, beliefs, and attitudes; changes in how students engage with content; changes in relationships among students, teachers, and parents; and changes in the use of ICT tools to promote students’ learning. Three of these dimensions of change that emerged across schools are pedagogical in nature, supporting the idea that an appropriate pedagogical context is key to successful ICT integration.

II. Theoretical Perspective

When effectively integrated into a high-quality learning environment, researchers have demonstrated that ICT can help deepen students’ content knowledge, engage them in constructing their own knowledge, and support the development of complex thinking skills (Kozma, 2005; Kulik, 2003; Webb & Cox, 2004). However, ICT alone cannot create this kind of teaching and learning environment. Teachers must know how to structure lessons, select resources, guide activities, and support this learning process; many traditionally-trained teachers are not prepared to take on these tasks. As Bransford, Brown, and Cocking (2000) point out, to use technology effectively, the pedagogical paradigm needs to shift toward more student-centered learning. This shift is not trivial or easily accomplished, particularly in countries with teacher-centered educational traditions. The literature suggests that four broad sets of changes should accompany the integration of ICT and the move toward a constructivist model of teaching and learning.

1. Changes in teachers’ knowledge, beliefs, and attitudes: The literature on education reform highlights the importance of changing teachers’ beliefs and attitudes to create long-term sustainable change (Fullan, 1993). Many studies on ICT integration find that projects fall short of expectations because the educators continue working within a traditional vision of rote learning (Gersten, Chard, & Baker, 2000; Honey & Moeller, 1990; Teacher Foundation, 2005). Teachers need to believe that new approaches to teaching are effective and will make a difference for their students in order for them to continue using new approaches. Teachers’ understanding and commitment are particularly important to sustain changes in areas such as project-based learning or student-centered techniques, which require core changes to a teacher’s instructional practice (Gersten et al., 2000).

2. Changes in how students engage with content: Research in the learning sciences has established that constructivist theories of learning provide a more reliable understanding of how humans learn than previous behaviorist frameworks (Bransford et al., 2000). Studies have identified a variety of constructivist learning strategies (e.g., students work in collaborative groups or students create products that represent what they are learning) that can change the way students interact with the content (Windschitl, 2002). The introduction of ICT into schools and project-based approaches should change how students interact with the content through new types of learning activities.
3. **Changes in relationships among teachers, students, and parents:** Recent studies suggest that, specifically, a supportive and cooperative relationship with the teacher can be very important for learning (Marzano, 2007). Research in many different countries has found that the introduction of technology into learning environments changes teachers’ and students’ roles and relationships (Hennessy, Deaney, & Ruthven, 2003; Kozma & McGhee, 2003).

4. **Changes in the use of ICT tools to promote students’ learning:** The ICT integration in developing country classrooms is challenging (Akbaba-Altun, 2006; Comenius, 2008; Grant, Ross, Weiping, & Potter, 2005; Light & Rockman, 2008; Somekh et al., 2003; Vyasulu Reddi & Sinha, 2003). A number of factors—such as teacher knowledge, time, access to ICT tools, and the alignment of ICT use with pedagogical goals—appear to help teachers integrate ICT and to support students’ increased use of ICT tools for learning (Light & Manso, 2006; Pérez et al., 2003).

III. **Overview of the Three National Contexts**

A. **India**

Of the three countries, India is perhaps the country that has most recently begun reforms to promote new teaching approaches and ICT. Across India’s decentralized education system, national and state leaders face big challenges in their efforts to support an education system that must reach so many students (Cheney, Ruzzi, & Muralidharan, 2005; PROBE Team, 1999). Efforts to shift curricula from behaviorist approaches to learning to a constructivist approach that emphasizes the personal experiences of learners are recent (India—National Council of Educational Research and Training, 2006; Pandley, 2007). A growing number of policies support ICT integration, but one expert review (Vyasulu & Sinha, 2003) found that there is still great variation in implementation of these policies and access to ICT is still limited for most students.

Although there is variation by state, the duration of the standard school day is five hours, divided into 35-minute lessons. The class sizes tend to be large; the classes we visited ranged from 45 to 60 students. Indian teachers are expected to cover a lot of content, and the textbook often becomes the center of the learning process (PROBE Team, 1999; Rampal, 2002). The state curriculum varies, but in Maharashtra State, for example, the students have a very full schedule by the upper grades and study 11 compulsory subjects.

B. **Chile**

Since 1990, successive Chilean governments have pursued a consistent reform effort to modernize teaching and learning, improve and expand school infrastructure, promote student-centered curricula, institute full-day schooling, develop a national examination, invest heavily in teacher professional development, and integrate ICT into schools (Cox, 2004; Ferrer, 2004; Valenzuela, Labarrera, & Rodríguez, 2008). The Chilean school day is eight hours, with the amount of time students spend in core areas (math, language, and science) twice that spent on other disciplines, and there is reserved time for students to engage in enrichment activities or project-based learning experiences. Class periods are typically 50 minutes, with two-hour classes in core content areas. Every school is required to have a Unidad Técnica Pedagógica (UTP—the Technical Pedagogical Unit) that provides pedagogical support to improve teachers’ practice.

Chile also has an ICT program, Enlaces (Links) that, by 2007, had provided hardware, software, and connectivity to 94% of schools in Chile and trained 110,000 teachers (Cancino & Donoso Díaz, 2007).
Thus, most schools have a certain level of ICT infrastructure available in computer labs.

C. Turkey

Turkey has been instituting educational reforms to modernize and expand its school system and align it with European Union norms since the late 1990s (Baki & Gokçek, 2005). The reforms include the expansion of compulsory education, efforts to decrease class size, introduction of a new curricular approach and materials, the use of ICT, and efforts to provide teachers with professional development. Announced in 2005, the new curriculum draws upon constructivist pedagogical principles and the theory of multiple intelligences and promotes more student-centered techniques—such as individual and group work—to encourage students to explore and develop skills (Gomleksiz, 2005). As Phase 1 of the Basic Education Program, 1998–2003, the government distributed thousands of computers to schools (Akbaba-Altun, 2006), and many schools now have labs.

Turkey is moving toward full-day schooling, but many schools—including the two we visited—still have two, five-hour shifts because they cannot otherwise meet their communities’ demand. The demand for schools also means that Turkey has not yet reduced class size to 30 students. Nationally, the average primary school class size is 38.6 students (Otaran, Sayn, Güven, Gürkaynak, & Satakul, 2003) but in the schools we observed classes ranged from 50 to 60 students.

IV. Overview of the Essentials Course

The core goal of the Essentials Course is to prepare teachers to integrate ICT across the curricula as a tool for learning and to design and implement inquiry-driven, project-based learning activities. The Essentials Course involves teachers in a process of developing a complete unit plan that utilizes a project-based approach, engages students in a variety of ICT activities, and organizes learning around an “essential question” that guides students’ inquiry and exploration of a given topic. Teachers are encouraged to designate time in their unit plans for students to use ICT to conduct research and to create a final product to share their research findings. The Essentials Course also discusses crucial factors for creating high-quality, issues in student-centered learning environments (e.g., classroom management issues with technology), and approaches to assessing students’ technology products. During the unit plan development process, teachers expand their technical skills and prepare to implement their units back in the classroom. This is a vital feature of the Essentials Course, as it allows teachers to experience and evaluate the new teaching approaches (Guskey, 2002). In addition to Web resources, the Essentials Course uses commonly available software, primarily word processing software and presentation software, to support students in creating presentations, Web pages, brochures, reports, and newsletters.

Figure 1: Core Components of the Intel Teach Essentials Course

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<th>Content</th>
<th>Structural Features</th>
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Intel, in collaboration with ministries of education worldwide, has offered the Essentials Course to more than 6 million teachers in 45 countries. The collaborative approach to course delivery is important. Although the core messages and goals of the program do not change, Intel works with the ministries and local educational experts to adapt Essentials Course materials to fit local needs; a local agency in each country implements the Course. In Chile, the ministry created a network of universities throughout the country that offers the Course in their regions, and the Pontificia Universidad Católica de Chile in Santiago oversees the network. In India, the non-profit Learning Links Foundation oversees the program in the participating states. In Turkey, the Ministry of National Education (MNE) oversees the program, and trainers are based at the provincial education directorates and in larger towns.

In this study, we used an instrumental case study approach (Stake, 1995) to examine how successful schools and teachers have been able to integrate ICT and new teaching strategies into their classrooms. This approach allowed us to work directly with schools that have been making changes, talk with teachers about the aspects of the Essentials Course that are useful to their practice, and develop an understanding of what teachers are actually able to do in typical schools in each country. During a two- to four-day site visit at each of the six schools, we interviewed school leaders, the Essentials Senior Trainer (ST) or Master Teacher (MT), technology-using teachers, students, and representatives of students’ parents whenever possible. As shown in Table 1, classroom observations of both typical classrooms and students engaged in the computer lab or ICT activities complemented the interviews.

Table 1: Data Collected

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<th>Interviews</th>
<th>Focus groups</th>
<th>Observations</th>
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<td><strong>India</strong></td>
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<tr>
<td>Mumbai School</td>
<td>2 school leaders; 5 teachers</td>
<td>14 parents; 37 students; 12 teachers</td>
<td>5 classes</td>
<td></td>
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<tr>
<td>Village School</td>
<td>4 school leaders; 3 teachers</td>
<td>3 parents; 5 students</td>
<td>5 classes</td>
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<tr>
<td><strong>Chile</strong></td>
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<tr>
<td>Santiago School</td>
<td>2 school leaders; 3 teachers</td>
<td>7 students</td>
<td>4 classes</td>
<td></td>
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<tr>
<td>Village</td>
<td>3 school leaders; 2 teachers</td>
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As noted, to identify a sample of exemplary schools, we gained input from local stakeholders. We requested that the local training agency, the ministries, and the Intel Education Managers in each country compile a list of schools. We asked that they exclude schools with privileged access to resources, technology, or funds. Success was defined by the local stakeholders to represent what they felt would be reasonable expectations for schools and teachers in their country. From the list of schools, the research team made a final selection of two schools in each country.

To carry out the fieldwork, we collaborated with local partners. In Chile, we worked with researchers from the Centro Costadigital at the Pontificia Universidad Católica de Valparaiso, and in Turkey, we teamed with GLOKAL Research Consulting. Unfortunately, the arrangements for a local research partner in India fell through.

V. Sites

A. India

We selected a private school in a middle-class neighborhood of Mumbai and a government school in a Gujarati village. The Mumbai school, with 2,000 students, is an English-medium private school from pre-K to Grade 10 and the village school is a Grade 1 to 8 Gujarati-medium public school with 309 students. In the Mumbai school, every classroom has a computer connected to a TV, there are two computer laboratories each with 60 computers, and there is a computer in the library. The labs have broadband Internet. The Gujarati village school has a lab with 14 computers and a computer on a wheeled table with an LCD projector. The lab is connected to the Internet through a dial-up modem.

B. Chile

We selected a government-subsidized private school in a lower middle class neighborhood of Santiago Chile and a small municipal school in a rural town. The private school has 2,500 students from pre-K to Grade 12, and the municipal school serves 97 students from pre-K to Grade 8. The private school has five ICT labs, some with as many as 20 computers. The municipal school has a lab with 15 computers, plus four laptops, a digital camera, a TV, a printer, two LCD projectors, and a wireless network.

C. Turkey

We selected two public schools that serve students from K to Grade 8. One school, in an outlying neighborhood of Ankara, serves 2,300 students. The second school, located in a small provincial capital on the Anatolian Plateau, serves 1,410 neighborhood children and has a population of female
boarding students from villages in the province. The school in Ankara has one computer laboratory with 21 computers, 15 classrooms have a computer, and there are 350 Classmate PCs donated by Intel. The lab has broadband Internet and a wireless hub. The Anatolian school has three computer labs with 15 computers each, and five or six teachers also have a computer in their classrooms. The labs have wireless connectivity.

VI. Findings: Three Common Themes

The Essentials Course was not the only source of information or support for the new student-centered practices and ICT-based activities we observed in these schools, as all three ministries of education are engaged in reform with various changes such as new curricula, new standards, and new in-service training programs. Education reform is a long and complex process that needs to be supported with multiple strategies, and our findings suggest that the Essentials Course can be one part of that puzzle.

A. Changes in Teachers’ Knowledge, Beliefs, and Attitudes

Because all schools in the study were considered successful, we explored what teachers had changed in their own practice. In the interviews, we asked teachers to discuss what they had learned from the Essentials Course that was useful for their classroom practice. Three themes emerged across all six schools as the teachers spoke about what they found to be valuable for their teaching: (a) their beliefs about how students learn were shifting; (b) they had a deeper understanding of new teaching strategies; and (c) they had improved their knowledge of how to use ICT as a learning tool, as well as strengthening their ICT skills.

a. Teachers’ beliefs shifted to a constructivist paradigm of teaching and learning. Teachers expressed a growing belief that students can learn through exploration and discovery. The Essentials Course and, more importantly, the experience of implementing a project-based or ICT-rich learning activity appear to influence teachers’ understanding of how children learn. The interviews suggested the teachers began to value learning as different from memorization and to see that students can learn by exploring content, conducting research, and applying knowledge to real problems. For example, a Chilean history teacher remarked upon the difference from the traditional approaches of having students memorize information: “By following a question, the students acquire a lot of content through research.”

In all six schools, teachers also expressed their belief that students learn more than just content with projects and Internet research. Many teachers recounted what they did “before” and “after Intel,” and their descriptions consistently included how students “learn more deeply,” “have more confidence,” and “are more motivated” by the new ways of learning. They reported that students were developing skills and attitudes such as self-assurance, curiosity, collaboration and teamwork skills, presentation skills, and organizational skills. In appreciating how effective group work had been, a teacher in Turkey reported that, “Before Intel, students did not do teamwork. [...] In Turkey—kids want to learn from teachers, now they have to do research on their own and can learn more deeply. Otherwise students aren’t motivated to learn.” A second Turkish teacher commented that students “were sharing ideas and thoughts with each other” and learning to “trust themselves.”

B. Teachers deepened their understanding of student-centered practices.

Teachers reported improving their skills with innovative teaching practices. Although some countries had more experience than others, across the board, nearly all the teachers we interviewed valued project-based approaches and reported doing projects with their students. Teachers had very clear
ideas about how project-based approaches can support student learning by allowing students to explore content as they respond to a research question or problem posed by the teacher. They felt the project approaches made the content more relevant to students and required greater intellectual effort for students to find and synthesize information, which led to students learning and retaining more information.

At schools in Turkey and India, principals and teachers credited the Essentials Course with helping them learn how to do projects for the first time. In Turkey, teachers told us the Course helped them better utilize the project ideas offered in their new national curricula. One school in India had been experimenting with projects prior to participation in the Essentials Course, but the teachers reported that this professional development experience gave them a solid template and a set of strategies for project-based approaches. In Chile, teachers told us that the Course helped them learn about inquiry-driven project-based strategies in addition to the problem-based approach supported by their ministry.

While teachers from all three countries agreed that the Essentials Course supported their use of student-centered practices, each country’s context and educational goals influenced which topics were of most interest to teachers. For example, while all the teachers spoke about using group work and collaborative learning, the teachers in Turkey were very excited about the collaboration strategies presented in the Essentials Course. Turkey’s traditional approach to teaching is lecture-based and emphasizes individual student activities, and teachers reported that they did not have any previous experience with collaborative learning. Group work and collaboration are, however, part of the new Turkish curriculum and reform efforts and teachers expressed appreciation for how the two programs supported each other. The curriculum contains many group activities, and the Essentials Course offers strategies to facilitate group work, as well as follow-up support to practice these strategies with coaching from their MT.

In India, teachers found the “Essential Questions” strategy to be compelling. Essential Questions (e.g., “Why do we need others?”) are intriguing, open-ended questions that organize a project and are an effective way to encourage students to think deeply and to provide them with a meaningful context for learning (Wiggins & McTighe, 2001). The Indian curriculum is very demanding and the school day is crowded, so teachers felt that they could not easily integrate project work into every class. While they could not do projects during the class period, they were, however, exploring the use of questioning strategies to push students’ critical thinking and to allow students to share their perspectives and formulate their own conceptual understandings of the content. For example, one teacher asked her students what they thought the impacts of British Colonial policies were on the farmers, and a social studies teacher asked students what they valued about their community. Teachers felt that asking for student input was a significant change. As one teacher commented, they no longer just “stand and teach,” but facilitate discussions and encourage children to share their knowledge. The teachers we visited felt the open-ended questions and ensuing dialogue between teachers and students might be the foundation of a new relationship between teachers and students.

One of the schools in Chile, which already had a lot of experience with ICT and projects, focused on the use of rubric assessments presented in the Essentials Course. The principal noted that teachers were facing increasing challenges in assessing students’ work as the school moved toward complex, technology-rich student products such as presentations and websites. Through these products, students master more than just content and teachers wanted to value all aspects of students’ learning. They considered the rubrics—designed to capture the range of skills, attitudes, and content that students develop—as a key way to address these challenges. The teachers were also using rubrics to
put students more directly in control of their learning process; students know from the beginning which aspects of the content teachers will evaluate.

C. Teachers improved their ICT knowledge and skills.

Teachers reported that they had developed the skills needed to initiate or increase the use of ICT with students. Most of the teachers in India and Turkey reported little ICT experience before Essentials, whereas most Chilean teachers had previous trainings and experience using ICT. Regardless of their experience with ICT, all teachers we interviewed who took the Essentials Course reported they increased their knowledge of how to use ICT as an educational tool. For teachers with no prior experience, the Course helped them acquire basic skills. However, all of the teachers commented on how the Course helped them see ICT as a pedagogical tool. The strategy of having teachers design a model unit of their own choice appears to allow teachers to work on skills and areas that are new and challenging for them.

VII. Changes in How Students Engage with Content

The introduction of ICT into schools and the use of project-based approaches and Internet research have changed how students interact with the content in a number of ways. In the site visits, teachers and students spoke about three types of new learning activities that would, according to the literature, contribute to a constructivist learning environment: (a) learning through projects; (b) conducting Internet research; and (c) connecting school content to students’ lives (Windschitl, 2002).

A. Project-based work gave students a chance to collaborate, use multiple resources, and direct their own learning.

In all the schools, student projects were fundamental to bringing student-centered instructional strategies into the classrooms. The Essentials-trained teachers we interviewed spoke of doing projects with their students. Despite variations among project designs, a few core features emerged. In almost every site, projects gave students chances to work collaboratively and challenged them to take on new roles and responsibilities; students worked in groups and often had to coordinate efforts to complete the projects. Also, all of the projects described included research and culminated in a final product that required students to synthesize and share what they learned. For example, in the Gujarati village, the students did a project about water use and irrigation. They visited local experts, surveyed the community, collected data, and researched solutions. As a result of the students’ examination of drip irrigation, and their proposal of how farmers could use this new strategy, the village converted to drip irrigation. Again, the teachers in India could not fit the project into the class time, so students did a lot of the work before and after school. The municipal school in Chile did a multi-grade project on insects in which the younger grades collected bugs and wrote reports and the older grades helped them create a website.

B. Independent Internet research gave students autonomy and a chance to develop and share their own perspectives.

Internet research was a constant theme in these schools. Teachers, students, and parents all spoke about having students do Internet research for homework and as part of the projects. Teachers often asked students to bring in additional information on topics in the textbook (e.g., in a Turkish project students researched systems of the human body). Or, teachers asked students to research additional topics or themes (e.g., after a lesson on farmers under the British Empire, a history teacher in India asked students to research the condition of Indian farmers today).
C. Connecting school content to students’ lives made learning more meaningful to students.

We found that many of the projects teachers designed connected students’ school work to their home life and the community more broadly. In a very simple sense, the increased use of practices such as open-ended questions and group work allowed students to share the perspectives and knowledge they bring from home. For example, a teacher in India asked her students what they had eaten for breakfast and then used this as the start of a nutrition lesson, and a Turkish teacher had his first grade students discuss how an animated story related to their own families and lives.

Yet many of the project topics also engaged students in examining real-world issues or concerns that gave them an opportunity to connect “school learning” with the real world and allowed them to develop their own opinions and perspectives about the issues. For example, the Indian village that did the irrigation project mentioned above also did projects on clean water and public health. Other projects were less ambitious, but still meaningful, such as the Chilean school where students collected stories and images from the community to publish in a booklet for their families.

Our interviews with parents in the Indian and Turkish sites also supported the perception that students were becoming a source of new information for their families. Parents credited their children’s increased use of Internet research with providing them with current information to which they would not otherwise have had access. Students are generally more excited by information they find themselves than the contents of a textbook, and parents reported that their children were rushing home, eager to share what they had discovered.

VIII. Changes in Relationships among Teachers, Students, and Parents

In keeping with the new activities and roles for students, the teachers and students in the schools we visited reported that they were transforming how they interact. The changes in teaching practices in these schools are part of a broader change in relationships within the school and between the school and the community. The educators and students described changes in the ways they collaborate with each other that grew out of the new teaching practices (e.g., project-based approaches, open-ended questions), integrating ICT into the schools (e.g., Internet research or presentations), or both. We noticed that teachers, students, and parents reported changes in three sets of relationships: (a) among the students; (b) between students and teachers; and (c) between the school, the parents, and sometimes the community.

A. Projects and ICT activities fostered collaborative relationships among students.

Many of the teachers and parents interviewed said that students were developing a range of social and interpersonal skills that they attributed to the projects and the new roles that students were taking on. As noted, students in every school were taking on new responsibilities as they worked on projects—leading teams, conducting research, writing reports, debating with peers, and making presentations to peers, teachers, and parents. A Chilean fifth grade teacher explained how her students were developing the skills and maturity to work as a team, even across grade levels, because of the collaborative techniques she learned in the Essentials Course. Some of the parents also commented on their children’s maturity and responsibility. A Turkish father noticed a change in his daughter’s attitudes since doing the “Intel projects.” He observed that before teachers participated in the Essentials Course, his daughter did not share her things with anyone. After her teachers participated in the Course, his daughter began to share more with friends and she enjoyed working in
teams. The father also said that, as a result of her involvement in projects and team work, his daughter completed her school assignments independently at home and no longer asked him for help.

B. **New teaching strategies allowed teachers to develop more collaborative and interactive relationships with their students.**

The teachers reported that, as their teaching practices changed, their relationships with their students also became more open and supportive. Teachers began to allow more intellectual discussions between themselves and their students, and students were more willing to approach teachers and share concerns and opinions. The teachers and parents in Mumbai were, perhaps, the most eloquent. One group of teachers commented that, as children, they had been afraid of their teachers and they were happy that their students no longer “fear the teacher” but gladly ask questions and give opinions.

The students we interviewed echoed these sentiments. A group of high school students from the school in Santiago, Chile explained that a good teacher is one who encourages students to disagree when they have a well-reasoned argument. A student from Mumbai shared a similar perspective: “I like that whenever I do a report I can include my own critical opinion—it is not just cut and paste. And I can learn many things outside of the textbook.”

C. **Innovating with projects and ICT strengthened the relationships between the school, parents, and the community.**

The parents we interviewed were excited by the introduction of community-focused projects and student research, and they expressed pride in what the schools were doing for their children with technology. A group of parents in India praised their school “because of the new technology, [the school] is innovative. They have very high performance, but it is not just academics-oriented.” In the four public schools we visited, parents and the community had also initiated efforts to bring additional ICT resources to the schools by donating equipment or paying for improved Internet connections. However, the parents also remarked on the new teaching practices and what these changes mean for their children. All of the parents we interviewed commented on how the school was developing the whole child since the project work was supporting teamwork, independence, and self-confidence. Parents in India and Turkey highlighted their children’s growing confidence and independence to do research or make public presentations, and they also noted the caring relationships between students and teachers.

IX. **Changes in the Use of ICT Tools to Promote Students’ Learning**

A core aim of the Essentials Course and a central objective for the ministries in Chile, Turkey, and India is to encourage the use of ICT as a learning aid for students. Although the administrators and teachers we interviewed in all six schools told us they wished they could do more, to the extent permitted by resources, space, and time, students were using ICT for learning activities. PowerPoint presentations and Internet research were, by far, the most common ICT tools that students used.

All six schools promoted student use of ICT, but each adopted different strategies to realize its goals. In Turkey and India, with short school days and tight schedules, the teachers had to strategically make time—either by working outside of class, or rationing access—for students to complete their ICT projects. For example, the teachers at the Anatolian school in Turkey told us that they meet as a team each semester to decide which classes will do long-term projects to ensure every student gets a chance each year. The Chilean teachers had more flexibility to schedule lab time during school hours,
although they also did afterschool activities. Perhaps the clearest change is that, in all six schools, teachers gave students Internet research activities for homework. For instance, a math teacher in India assigned students to calculate average rainfall in different parts of the world using online databases, and a Chilean history teacher had students analyze online photos for life conditions in 1900s Chile.

X. Conclusion

This paper presents the findings from our fieldwork that describe the nature of the changes taking place in the classrooms in these six schools as they integrate ICT activities. Since the governments point to these schools as positive examples, their experiences can help contribute to an understanding of the process of integrating ICT into the schools of developing countries. While some educators we observed are more skilled than others, and some changes in practice are just emerging, all six schools are making changes beyond just the use of new tools. They are developing: new beliefs about learning and new practices, new ways to engage with content, changing relationships, and new ICT tools for learning. That three of the four common dimensions of change are pedagogical shifts, and that they are changes in pedagogy that are supported by the ICT, illustrate the paradigm shift required for effective ICT integration (Bransford et al., 1999; Hepp et al., 2004). These findings illustrate the complex sets of changes that have to occur for ICT to be deeply and meaningfully used to support student learning. This would explain why technology integration is so difficult to achieve but also points the way forward.

Our findings suggest that necessary changes are much broader than just the introduction of a new tool or one new practice. Instead, change begins by deeply reshaping life in the classrooms—from educators’ beliefs about learning to the relationships that make up the school community. In each context, the teachers found points of engagement between the model of ICT use and teaching in the Essentials Course and the possibilities and limits of their context. For Indian teachers, it was most feasible to integrate aspects of the teaching model (i.e., open-ended questions) into their classroom and the ICT into after-class time. In Turkey, schools brought ICT activities into scheduled lab time and group work into their class activities. And, Chilean teachers used holistic assessment strategies and inquiry-based projects in class because their school day provides a block of time for projects.

But, the responsibility for change cannot rest solely on the shoulders of the teachers; bringing about these changes is a long-term, incremental process. Effective reform requires sustained investment and support along multiple dimensions of the educational system, including physical and technical infrastructure, human resources, curricular frameworks, standards, and assessment. For example, the teachers in Chile and Turkey spoke of how things like new national curricula, national computerization efforts, and professional development opportunities helped them use ICT in their classrooms and apply what they learned from the Essentials Course to their practice.
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Providing ICT Skills to Teacher Trainers in Cambodia: Summary of Project Outputs and Achievements

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This study presents data on the outputs of an international development project called Establishing the Effective Use of ICTs in Education for All in Cambodia. A main component of this project was to teach all teacher trainers how to use basic ICTs. This article presents the achievements of the project juxtaposed with a study of the factors that either inhibited or motivated the teacher trainers’ choice to adopt use of these ICT skills. This project was implemented by both UNESCO and the Cambodian Ministry of Education. Analyses were conducted on 379 surveys, 17 interviews, UNESCO project documents, and Cambodian Ministry of Education documents.

Key words: ICT, teacher training, Cambodia, case study

I. Introduction

Less developed nations not able to address their standing in the global digital divide may face political instability (Afele; 2003; Wilson, 2004), increased poverty (Servon, 2002; Wong, 2001), increased marginalization (Servon, 2002; Tiene, 2002), and decreased democratic participation (Cullen, 2001; Lau, Aboulhoson, Lin, & Atkin, 2008). As less developed nations attempt to close their digital divide and shift to participate in the knowledge and innovation economy, international development project managers and international development policy makers would be served by gaining an understanding of both the motivators and inhibitors to adopting the use of information and communication technologies (ICTs). To better facilitate sustainability, scalability, and spread of technological innovations in less developed nations, there is a need to better understand why stakeholders choose to adopt or not adopt these innovations. The present study presents data on the outputs of an ICT in education project as well as the perceptions of the end users about factors that either motivated or inhibited their continued use of ICT skills.

II. Review of the Literature

The global digital divide separates individuals, communities, states, and nations with regard to information access, knowledge sharing, and general use of digital technologies to connect and make meaning of information (Fink & Kenny, 2003; Hachigian & Wu, 2003; James, 1999, 2007; Lau et al., 2008; Mossberger, Tolbert, & Stansbury, 2003; Rodriguez & Wilson, 2000; Servon, 2002; Tiene, 2002; Tinio, 2003; Wilson, 2004; Wong, 2001; Xiaoming & Kay, 2004). The digital divide is important to understand globally at the macro level, but it is arguably more useful to understand the digital divide at the grassroots level. This is because the digital divide is not simply about access to the internet, but involves access to information and the ability of the end users to apply that information to create new knowledge. Afele (2003) and Wilson (2004) posited this understanding under the umbrella of peace, security, and prosperity. Afele stated that ICTs can empower local groups by allowing marginalized communities to contribute to “global knowledge and foster global peace and security” (p. 5). Afele claimed that processing and using information to create knowledge,
share lessons learned, and innovate at the local level can give marginalized societies opportunities to become empowered and to contribute to the “wealth of global knowledge” thus fostering peace and security (p. 5). Wilson (2004) supported this claim by linking marginalization at the local level with conflicts of politics, economics, nationalism, and even terrorism.

Gaining an understanding about how ICT innovations are diffused at the grassroots level will allow policymakers, governments, and funding agencies in less developed countries to construct more effective and efficient responses to social problems such as poverty, inequality, and empowerment where ICTs can play a pivotal role (Servon, 2002). Wilson (2004) found it is important to understand and address how ICT innovations are diffused at the local level to avoid repeating mistakes of the past. “Leaders who fail to seize ICT opportunities may produce the same results as leaders who failed to build factories or railroads in the early stages of the industrial revolution” (p. 5). The United Nations Development Programme (2001) claimed that “today’s technological transformations hinge on each country’s ability to unleash the creativity of its people, enabling them to master technology, to innovate and to adapt technology to their own needs and opportunities” (p. 79). Therefore, for future prosperity it is important that researchers, program managers, and international policy makers achieve a greater understanding of what motivates and what inhibits end users' choice to adopt ICT innovations in less developed nations.

III. Project Summary

The Establishing Effective Use of ICT in Education for All in Cambodia project was “based on the premise that the innovation and appropriate use of ICT can help reach those excluded from learning and improve the quality of learning and quality of life for all” (UNESCO, 2006a, p. 1). The project was a joint venture between the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Cambodian Ministry of Education, Youth and Sport (MoEYS), and the Japanese government through the Japanese Funds-in-Trust. The goals of this project were to:

- provide ICT training to teacher trainers and lecturers in all teacher training colleges (TTCs) and the Royal University of Phnom Penh, curriculum specialists, and book editors;
- provide ICT access to 1,000 primary and secondary school teachers;
- provide ICT access to a minimum of 5,000 children and youth in both formal and non-formal programs; and
- create a national ICT-based resource repository.

A. Project Outputs

Through the Establishing the Effective Use of ICT in Education for All in Cambodia project, UNESCO and the MoEYS conducted various levels of training that reached a variety of stakeholders. The project was scaled up by building awareness, developing master teacher trainers, and increasing institutional capacity at the teacher trainer level while at the same time improving the carrying capacity of the infrastructure. Table 1 contrasts the original project objectives with the achieved results.

Through this project teacher trainers were taught how to use hardware such as computers, printers, scanners, digital cameras, and digital recorders as well as software such as Word, Excel, PowerPoint, the internet, and internet-based email. The training was primarily focused on the functionality of software and hardware. The training nonetheless included components of how these ICTs could be used in the field of education. Training included creating electronic lesson plans, electronic grade books, and educational PowerPoint presentations as well as locating digital resources to use in the
classroom. What follows is an analysis of the factors that either motivated or inhibited teacher trainers’ choice to continue use of the ICT skills gained through the training. The continued use of the ICT skills is referred to as adoption of the ICT skills.

Table 1: UNESCO Project Objectives Compared to Achieved Results

<table>
<thead>
<tr>
<th>Project Objective</th>
<th>Results Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish the ICT in education network among all TTCs in the country.</td>
<td>Trained one master teacher trainers from each TTC as well as educational professionals within the MoEYS.</td>
</tr>
</tbody>
</table>
| Improve ICT capacity for 600 teacher trainers, 50 curriculum specialists and curriculum developers, and 2,000 primary and secondary school teachers. | - Trained 526 teacher trainers.  
- Trained 28 teachers of English.  
- Trained teachers in 24 pilot secondary schools.  
- Facilitated the donation of 838 secondhand laptops and desktops.  
- Purchased 33 new desktop servers for the TTCs.  
- Published and printed 1,000 copies of *Guidebook on ICT in Teaching and Learning* for teacher trainees (UNESCO, 2006c). Distributed these to 26 TTCs and 24 pilot secondary schools.  
- Distributed 637 educational DVDs, VCDs, software programs, and CD-ROMs to 51 educational institutions in the country. |
| Establish the national clearinghouse and promote the production of local education content online. | - Created the virtual library that hosts more than 1,000 web pages.  
- Trained 25 teacher trainers on how to create their own institution's web page.  
- Trained 13 teacher trainers on computer maintenance and repair. |
| Provide access to ICT in education to thousands of deprived children and youth.   | - Gave access to 5,030 deprived children via a mobile learning van. The van was equipped with 22 secondhand laptops, one new desktop, internet connectivity, four digital cameras, one television, one digital sound recorder, one generator, and a wide range of educational resources.  
- This mobile learning van was donated to the MoEYS in January 2006. |

Source: UNESCO (2006b)
B. Conceptual Framework

Analysis of the teacher trainers' choice to adopt use of the ICT skills was based on the diffusion of innovations model developed by Rogers (2003). The adoption categories are based on this model. Rogers noted “instead of simply accepting or rejecting an innovation, potential adopters are on many occasions active participants in the adoption and diffusion process, struggling to give meaning to the new idea as the innovation is applied to their local context” (p. 187). Based on Rogers’ model, the adoption categories include: early adopters, late adopters, teacher trainers who reinvented the innovation, teacher trainers who experienced discontinuance, and teacher trainers who rejected the innovation.

Motivating factors were based by Rogers' (2003) model of the diffusion of innovation as measured using a survey developed by Moore and Benbasat (1991). Table 2 describes the motivational factors measured in the survey.

Table 2: Description of Motivational Factors Measured

<table>
<thead>
<tr>
<th>Motivational Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Advantage</td>
<td>Degree to which an innovation is perceived to be better than what is currently used</td>
</tr>
<tr>
<td>Image</td>
<td>Degree to which using the innovation increases one 's reputation</td>
</tr>
<tr>
<td>Compatibility</td>
<td>Degree of perceived consistency with “existing values, past experiences, and needs of potential adopters” (Rogers, 2003, p. 15)</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>Perceived degree of difficulty with using the innovation</td>
</tr>
<tr>
<td>Visibility</td>
<td>Degree to which the innovation is visible</td>
</tr>
<tr>
<td>Results Demonstratability</td>
<td>Degree to which one can see results of using the innovation</td>
</tr>
<tr>
<td>Trialability</td>
<td>Degree to which the innovation can be practiced</td>
</tr>
<tr>
<td>Voluntariness</td>
<td>Degree to which using the innovation is voluntary</td>
</tr>
</tbody>
</table>


IV. Methods

A. Document Analysis

The researcher served as an intern at UNESCO in the Phnom Penh, Cambodia office on the Effective Use of ICTs in Education for All in Cambodia project. Through this internship the researcher had the opportunity to analyze project documents, formal reports, informal evaluations, and anecdotal evidence provided by project staff.

B. Survey

The survey used in the current study was a slightly altered version of a four-point scale, 25-item instrument developed by Moore and Benbasat (1991). This survey measures perceptions of users about adopting a given ICT innovation. Moore and Benbasat noted that although the questions for the instrument were tested for reliability and validity and were developed with respect to a particular ICT innovation (i.e., personal work stations) for a particular audience (i.e., U.S. university professionals)
it was nonetheless “believed that they could be easily reworded by substituting the names of different... innovations” (p. 211). The current study substituted the phrase ‘ICT skills’ for ‘personal work stations.’ This survey was selected for two reasons. First it was an instrument that has proven to be reliable and valid and applicable across fields. Second this instrument was developed to measure the characteristics of innovation adoption as described by Rogers (2003) and thus fits well into the conceptual framework of the current study.

Using Rogers (2003) framework, an ICT skill adoption category was determined for each teacher trainer based on responses from a set of five behavioral questions. Two additional open-ended questions were added to the survey. These questions were ‘Please describe in detail an experience when you felt you used the ICT skills successfully’ and ‘Please describe in detail an experience when you have not been successful using the ICT skills.’ The open-ended questions were used to better understand these adoption categories.

The original survey was translated into Khmer by a UNESCO staff member who served as the Khmer translator for the ICT in education project as well as on other development projects within the country. A second Khmer UNESCO coworker edited the translated survey. The first and second translators collaborated to create a third version of the translated survey. A third translator read the edited survey and made final grammar and spelling corrections without changing the meaning. The fourth translated survey was back translated into English by the original Khmer translator. The Khmer translator for the ICT in education project translated and helped code all returned surveys.

At the close of the project, the survey was disseminated to every teacher trainer in the country who participated in the ICT training (N=526). The return rate was 72% where 379 teacher trainers returned surveys. No incentives were given in the current study. It is however believed that the high return rate was achieved due to the request by the MoEYS representatives to complete and return the surveys.

C. Interviews

The researcher interviewed 17 teacher trainers at their respective TTCs. Questions asked dealt with further describing the motivators and inhibitors to adopting use of the ICT skills. The interviews were conducted with the assistance of a MoEYS representative as well as a hired Khmer translator. These teacher trainers were selected through convenience sampling.

D. Validity and Reliability

Reliability and validity were maximized by triangulating data from various sources: a quantitative survey; open-ended questions attached to the survey; interviews; document analyses; and onsite experiences. Content validity of the survey was addressed by the survey's original developers who noted “the method of developing the scales provides a high degree of confidence in their content and construct validity” (Moore & Benbasat, 1991, p. 210). Using three translators and multiple survey iterations as described above addressed the face validity of the translated survey. Inter-rater reliability was addressed by using the first Khmer translator to confirm and refine coding through an iterative process.

V. Results

It is important to note that Cambodia has 26 TTCs. Six Regional Teacher Training Centers (RTTCs) that trains lower secondary teachers; one National Institute of Education that trains upper secondary
school teachers; 18 Provincial Teacher Training Colleges (PTTCs) that trains primary school teachers; and one National Pre-School Teacher College that trains pre-school teachers. Through the Establishing Effective Use of ICT in Education for All in Cambodia project, ICT training was provided to nine groups of educators. What follows is a brief description of each of these groups and their respective training.

**Group 1:** ICT training was extended to 100 TTC representatives. One group of 50 people included 14 teaching and non-teaching staff from five TTCs and 36 people from departments within the MoEYS. The second group of 50 included representatives from various TTCs including directors, deputy directors, and teacher trainers from Takeo RTTC and Takeo PTTC in addition to local school heads in the Takeo area. Both groups attended a four-day training workshop on teaching and learning methodologies in primary schools and a one-day workshop on ICT awareness. The training workshops were intended to create an understanding of ICTs and interactive learning.

**Group 2:** Trained were 28 master teacher trainers who attended 96 hours of training on how to use Word, Excel, PowerPoint, the internet, and internet-based email. The training was based on training modules produced by UNESCO (2003). One master teacher trainer was chosen from each of the TTCs based on three criteria being that they had to: (1) be a teacher trainer; (2) have a good command of the English language; and (3) have a commitment to teaching and learning. The 28 master teacher trainers represented all of the TTCs in Cambodia. Thus, 18 teacher trainers were from the 18 PTTCs, six teacher trainers were from the six RTTCs, one teacher trainer was from the National Pre-School Training College, and one teacher trainer was from the National Institute of Education. The final two master teacher trainers were representatives from within the MoEYS. Of these 28 master teacher trainers, 18 remained at their respective TTC to instruct and guide pre-service teachers and support teacher trainers in ICT-based pedagogy. The ten best master teacher trainers traveled throughout Cambodia and through a cascade training model became trainers of other teacher trainers in addition to trainers of the pilot upper secondary school teachers and the pilot lower secondary school teachers.

**Group 3:** Through a 5-day hands-on course, 28 teacher trainers were trained on basic website design. This group included: one teacher trainer from each of the 18 PTTCs; one teacher trainer from the six RTTCs; one teacher trainer from the National Institute of Education; one teacher trainer from the Pedagogical Research Department; and two teacher trainers from the MoEYS. Two of these teacher trainers were master teacher trainers. The other teacher trainers were chosen by the directors of the TTCs.

**Groups 4 & 5:** The ICT training was extended to 55 administrative staff members in various TTCs. Excluding the two MoEYS master trainers, 526 teacher trainers were trained on ICTs through this project. Teacher trainers at the National Institute of Education were excluded from this ICT training because this institution had an effective ICT curriculum in place and therefore the teacher trainers were not in need of additional ICT training. The ICT training was also extended to 13 secondary school teachers. Teachers at these secondary schools received the same 96 hours of training as the teacher trainers.

Training provided to the teacher trainers was based on an UNESCO (2003) produced training manual. Based on this training manual, UNESCO (2006c) published a textbook titled Guidebook on ICT in Teaching and Learning. UNESCO printed 1000 copies which were disseminated to the TTCs and the pilot secondary schools.
Group 6: Training on how to repair and maintain computers was provided to 13 teacher trainers through 56 hours of training. This group included the ten field master trainers in addition to two teacher trainers from the National Institute of Education and one person from the MoEYS. Group 7. A 5-day, hands-on training course on basic website design was provided to 28 teacher trainers. One teacher trainer from each of the 18 PTTCs, one teacher trainer from each of the six RTTCs, one teacher trainer from the National Institute of Education, three teacher trainer from the MoEYS were trained through this course. These 28 teacher trainers were selected by their respective TTC directors. Two of the teacher trainers in this group were master teacher trainers.

Group 8: Trained also were 28 teacher trainers of English. This group included 19 teacher trainers from the six RTTCs and nine teacher trainers of English from the National Institute of Education. This group did not include any master teacher trainers. The goal of this training was to familiarize the teacher trainers of English with the concept of using ICTs in their English language classrooms. The training was provided in partnership with the University Women’s Association of Singapore.

Group 9: The final group trained on ICTs included 24 secondary school teachers. The secondary school teachers were trained by the ten field master teacher trainers. This training was conducted in three phases and was based on the 96-hour training manual used by the master teacher trainers as well as teacher trainers. Phase I training involved the integration of ICT skills in teaching and learning and focused on the use of Microsoft Office. Phase II training focused on how to use email and the internet for teaching and learning in addition to developing ICT-based achievement indicators. A Refresher Phase involved training on e-communication skills and e-library skills.

The first set of teachers trained included 12 teachers from 12 rural lower secondary schools. This set received 16 days of Phase I and Phase II training. The second set of teachers consisted of the six upper secondary school teachers mentioned above from six rural schools and six lower secondary school teachers from six rural schools. These 12 teachers attended seven days of Phase 1 training. All 24 teachers attended a 5-day refresher course. The 18 lower secondary school teachers attended an additional two days of training on survey implementation which immediately followed the 5-day Refresher Phase.

VI. Teacher Training Adoption Rates

Determining the adoption category was based on responses to the survey's five behavioral questions. Table 3 details the categorization of all teacher trainers in the study.

- Master trainers were the only teachers who could have adopted use of the ICT skills early. These trainers were the first to be introduced to this new innovation and where the first to be trained on how to use this innovation. These trainers were also the only teacher trainers who reported any prior use of ICT skills. All but six master teacher trainers reported adopting use of all ICT skills.
- Teacher trainers who reported using the ICT skills without change to how they were taught were labeled late adopters of the ICT skills. These teacher trainers were labeled as late adopters because they adopted use of the ICT skills later than the early adopters.
- Teacher trainers who reported that they currently used the ICT skills differently from how they were taught at the training were labeled as reinventors of the ICT skills. Examples of teacher trainers reinventing the skills included using different email services, finding shortcuts to Microsoft tools, using different internet browsers such as Mozilla Firefox versus Internet Explorer, and using the skills to earn university degrees.
Teacher trainers who reported that they used the skills initially, but no longer used the ICT skills were labeled as had experienced discontinuance.

Teacher trainers who reported they never used the ICT skills outside of the training were labeled as rejecters of the ICT skills.

In total 360 teacher trainers were placed in the five decision categories. Of the returned surveys, data from 19 were unusable. The survey results indicated that 7 out of 10 teacher trainers adopted use of the ICT skills to some degree.

Table 3: Total Respondents by Each Adoption Category

<table>
<thead>
<tr>
<th>Adoption Category</th>
<th>Number of Surveys</th>
<th>Percentage of Teacher Trainers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>21</td>
<td>5.8%</td>
</tr>
<tr>
<td>Late</td>
<td>185</td>
<td>51.4%</td>
</tr>
<tr>
<td>Reinvent</td>
<td>46</td>
<td>12.8%</td>
</tr>
<tr>
<td>Discontinuance</td>
<td>58</td>
<td>16.1%</td>
</tr>
<tr>
<td>Reject</td>
<td>50</td>
<td>13.9%</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>100%</td>
</tr>
</tbody>
</table>

VII. Motivators to Adopting the ICT Skills

Table 4 reports the means and standard deviations of each motivating factor compared across adopter groups. It was determined that the eight tested motivating factors did impact adoption. That is, teacher trainers were motivated to use the ICT skills if use of the skills were perceived to:

- be mandatory;
- offer advantages over previously used methods (e.g., grades were easier to compute in Excel versus by hand, lesson plans could be saved and used again in the future, lessons could include engaging digital resources; teachers could find applicable lesson plans and resources on the internet);
- increase one's image and reputation with one's peers (e.g., earn advanced degrees, earn money helping others with technology skills, viewed as being a better instructor by students);
- be compatible with how the individual liked to work (e.g., recording and submitting electronic grade reports, storing and submitting lesson plans);
- be easy to understand and use;
- produce results and outputs (e.g., lesson plans, Excel grade books, create engaging PowerPoint presentations, locate teaching resources on the internet);
- be observable by seeing others using the ICT skills (e.g., seeing peers using the ICTs); and
- be coupled with ongoing opportunities to practice using the skills (e.g., guided practice).

In general, early adopters reported the most agreement with these factors followed by late adopters and reinvent adopters. Teacher trainers who discontinued using the ICT skills or who totally rejected use of the ICT skills tended to report the least agreement with these factors. Richardson (2009a) provides a more elaborate discussion about this set of findings.
Table 4: Means and Standard Deviation of Adoption Categories Compared by Each Motivating Factor

<table>
<thead>
<tr>
<th>Adoption Category</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Voluntariness</th>
<th>Relative Advantage</th>
<th>Image</th>
<th>Compatibility</th>
<th>Ease of Use</th>
<th>Results Demonstratability</th>
<th>Visibility</th>
<th>Trialability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>21</td>
<td>Mean 1.48</td>
<td>.49</td>
<td>3.69</td>
<td>3.05</td>
<td>3.24</td>
<td>3.30</td>
<td>3.36</td>
<td>2.79</td>
<td>3.10</td>
<td></td>
</tr>
<tr>
<td>Late</td>
<td>181</td>
<td>Mean 1.73</td>
<td>.55</td>
<td>3.39</td>
<td>3.13</td>
<td>3.06</td>
<td>2.85</td>
<td>2.85</td>
<td>2.55</td>
<td>2.93</td>
<td></td>
</tr>
<tr>
<td>Reinvent</td>
<td>46</td>
<td>Mean 1.62</td>
<td>.68</td>
<td>3.27</td>
<td>3.21</td>
<td>3.04</td>
<td>2.85</td>
<td>2.95</td>
<td>2.75</td>
<td>3.04</td>
<td></td>
</tr>
<tr>
<td>Discontinuance</td>
<td>55</td>
<td>Mean 2.08</td>
<td>.64</td>
<td>3.24</td>
<td>2.87</td>
<td>2.83</td>
<td>2.56</td>
<td>2.75</td>
<td>2.46</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>Reject</td>
<td>48</td>
<td>Mean 2.03</td>
<td>.70</td>
<td>3.30</td>
<td>3.01</td>
<td>2.96</td>
<td>2.60</td>
<td>2.74</td>
<td>2.40</td>
<td>2.74</td>
<td></td>
</tr>
</tbody>
</table>

(VIII.) Inhibitors to Adopting the ICT Skills

Inhibitors to adopting use of the ICT skills were measured through interviews and open ended survey questions. Table 5 details the seven main inhibitors. Across all adoption groups, the lack of an adequate number of computers was the most pervasive inhibitor. Early adopters reported that broken computer and a lack of electricity in the TTCs were powerful inhibitors to adopting use of the ICT skills. Teacher trainers who rejected adoption or discontinued use of the ICT skills often reported that using the skills was too difficult and they were not given adequate guided practice opportunities to master the skills.

Table 5: Inhibitors to Adopting Use of the ICT Skills

<table>
<thead>
<tr>
<th>Inhibitor</th>
<th>Early</th>
<th>Late</th>
<th>Reinvent</th>
<th>Discontinue</th>
<th>Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair</td>
<td>36.8%</td>
<td>12.7%</td>
<td>12.5%</td>
<td>14.3%</td>
<td>16.7%</td>
</tr>
<tr>
<td>Language barriers</td>
<td>5.3%</td>
<td>8.2%</td>
<td>3.1%</td>
<td>0%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Lack of electricity</td>
<td>36.8%</td>
<td>9.0%</td>
<td>0%</td>
<td>5.7%</td>
<td>13.9%</td>
</tr>
<tr>
<td>Lack of computers</td>
<td>57.9%</td>
<td>27.6%</td>
<td>21.9%</td>
<td>22.9%</td>
<td>22.2%</td>
</tr>
<tr>
<td>Limited internet</td>
<td>10.5%</td>
<td>8.2%</td>
<td>12.5%</td>
<td>2.9%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Difficult to use</td>
<td>26.3%</td>
<td>36.6%</td>
<td>40.6%</td>
<td>40.0%</td>
<td>36.1%</td>
</tr>
<tr>
<td>Lack of guided practice</td>
<td>21.1%</td>
<td>22.4%</td>
<td>12.5%</td>
<td>37.1%</td>
<td>41.7%</td>
</tr>
</tbody>
</table>

(Adapted from Richardson (2009b))

IX. Conclusion

The current study presented an overview of data collected from a completed ICT in education project in Cambodia. It was found that the Establishing the Effective Use of ICTs in Education for All in Cambodia achieved more than originally intended and thus exceeded many of its original goals and objectives. By this measure, the project was a great success.
The current study measured perceptions to understand what motivates or inhibits the end user's choice to adopt a given ICT innovation. It was found that three out of ten teacher trainers did not adopt use of these ICT skills. Non-adoption in the current project was attributed to not being able to overcome challenges such as broken computers, language issues, limited internet access, the complexity of using the skills, and a lack of ongoing support. Teacher trainers in the current study were more motivated to adopt the ICT skills if they thought use of these skills was mandated, increased their reputation, was compatible with the demands of their current job, was compatible with how they liked to get things done, was easy, if they could see tangible results, if they saw others using the skills, and if they were given opportunities to practice using the skills. The data about adoption rates demonstrated the project was equally successful.

The intent of the present study was to report on the achievements of this ICT in education project and to analyze the outputs based on end user adoption rates. Through systematically analyzing and triangulating the data, funders and project implementers are better informed about ICT adoption rates at the grassroots level. By analyzing the project outputs and triangulating the data with end user adoption rates, reporting results of development projects can give voice to an often silenced stakeholder. By robustly measuring success of ICT in education projects, we are better informed of inputs, processes, as well as outputs. Together these data increase the likelihood projects can be sustained, replicated, and scaled up. The data and method presented in the current article will be useful to policy makers, international development educators, and educational researchers as they continue to improve ICT in education initiatives in Cambodia specifically, and in less developed nations generally.
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An Analysis of the Research and Impact of ICT in Education in Developing Country Contexts

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American Institutes for Research (AIR), International Development Division

Despite evidence of increased usage of information and communication technology (ICT) in educational programming, extant evaluations on the impact of ICT on educational child outcomes are sparse and often lack the methodological rigor necessary to guide policymakers towards sound, evidence-based practices. The American Institutes for Research (AIR) has conducted a global analysis of research undertaken to date on the deployment of ICT solutions to support education goals in developing countries. The present study is comprised of two phases. First, a series of in-depth, structured interviews were conducted with a range of stakeholders, including policymakers and academicians, researchers, users and developers of ICT solutions. These interviews touched upon the challenges associated with developing, implementing and evaluating ICT solutions within educational settings, perceptions on the utility and future of ICT solutions and extant gaps in the usage of ICT solutions within developing countries. Second, AIR conducted a detailed literature review of published and unpublished evaluations on the educational impacts of ICT solutions. This paper reports on the demonstrated and measurable impacts of ICT on students and generates an innovative and rigorous research agenda addressing salient issues such as impact and effectiveness, return on investment, and total cost of ownership.

Key Words: ICT/Technology; Evaluation

I. Introduction

The purpose of this article is to examine what conclusive research has been conducted to determine the impact that information and communication technologies (ICT) in education has had on student learning in developing country contexts. The current evidence base assessing the impacts of ICTs on student learning outcomes in developing countries consists primarily of qualitative studies. Very few true experiments have been conducted in this arena, leaving unanswered important questions regarding the educational benefits of ICT interventions on beneficiaries. Extensive descriptive information on and evaluations of projects incorporating ICTs in educational settings in advanced economies (and even some developing countries) does exist. However, the context for studies in North America and Europe is very different from the social, economic and cultural realities often found within communities in developing countries.

II. Necessity of Monitoring and Evaluation (M&E)

The primary impetus behind this desk study is to address the hypothesis that many ICT-based reforms are approved based on intuition or anecdotal evidence rather than research or science. This study will demonstrate that many ICT efforts, while well intentioned, have been launched with limited amounts of empirical research to support programmatic choices.

Unfortunately, much of the existing research demonstrating the impacts of interventions employing ICTs with students and adults are from advanced economies. Studies conducted in developed
countries have demonstrated that the relationship between ICTs and student outcomes is a relatively complex one. Clear consensus has not emerged on the direction or the magnitude of ICTs’ effects on students, due in part to the design of program evaluations. Moreover, conclusive evidence on factors that mediate or moderate the relationship between ICTs and educational outcomes has not been demonstrated. Taking the availability of computers and student achievement as an example, Fuchs and Woessman (2004) found a negative relationship between computer availability in the home and achievement scores for students in the U.S., while several other large-scale studies also conducted within the United States found a positive relationship between computer availability in homes and test scores (e.g. Blackmore et al., 2005; National Center for Educational Statistics, 2001). Such conflicting results within the developed world point to the need for rigorous research in both advanced and developing countries as many important questions on the impact of ICTs on student learning outcomes remain unanswered.

Many evaluations (e.g. Kozma et al., 2004; Light et al., 2008; Linden et al., 2003; 2008) of ICTs in developing countries rely on correlational designs to test whether variables are associated with each other and utilize a qualitative or case study approach. Such an approach provides a detailed look into why and how ICTs may be used within educational settings to boost learning outcomes, but not whether their usage leads to desired outcomes over time. Moreover, there exists an ongoing discussion on how to define and measure impact in this field, creating a substantial barrier to conducting rigorous research and developing comparable evaluation designs. Challenges also exist at the program implementation level. Competition for scarce funding often detracts from the importance of measuring impact for policymakers and practitioners. M&E is often trivialized or given short shrift either due to the complexity of M&E tasks or a preferred focus on program activities.

III. Methodology and Structure of Report

This study is unique in its focus on studies conducted within developing countries to better understand benefits and challenges to implementation in those contexts. In this study, both qualitative and more rigorous experimental techniques are discussed. The findings presented in this article are based on two sets of activities:

E. Literature review

The literature for this report was identified through several mechanisms, including web-based searches of educational and other special interest databases, a call for papers and recommendations resulting from in-depth qualitative interviews conducted with experts in the field including practitioners, developers and users of ICTs. Extant literature on the impacts of interventions employing ICTs can be divided into five groups: (1) empirical and qualitative research on ICT interventions in the US and other advanced economies (e.g. Angrist & Lavy, 2002; Cox & Marshall, 2007); (2) empirical and qualitative research on ICT interventions in developing countries; (3) theoretical reviews on the importance and utility of ICT in the education sector (e.g. Hepp et al., 2004); (4) studies examining the cost effectiveness of ICT interventions (e.g. Bakia, 2001; Potashnik & Adkins, 1996; Wolff, 1999); and (5) policy-level reviews or “educational technology master plans, that provide a vision for the use of technology in education and institute programs that support this vision” (Commonwealth of Learning, date unknown; Kozma et al., 2004; Light & Manson, 2007; Powell, 2006) conducted by Ministries of Education in developing countries. The focus of this article is solely on extant evaluations of ICTs on student learning outcomes within developing countries.
F. Qualitative interviews

In preparation for this article, the authors also contacted 40 experts in this field, including researchers, academicians, policy makers and practitioners, working both within the United States and Europe and in developing countries such as India, Nepal, Zambia and Afghanistan. Both users and developers of ICT solutions were contacted. Of these 40 individuals, 25 agreed to in-depth telephone interviews. This is a unique component not found in traditional desk studies. The goal of this effort was to request unpublished reports on the educational impacts of ICT in the developing world and to obtain a more detailed first-hand account of the challenges associated with developing, implementing and evaluating ICT interventions in developing countries. Interview questions depended upon the expertise of the individual, but generally included:

- In your opinion what is the future of low-cost and other ICT devices in educational sector in developing country contexts?
- Is there a widespread need for these types of solutions?
- What changes should be made, if any, to the use and development of ICT in education?
- What, in your opinion, are the two or three most important considerations when planning and deploying ICT for education?
- What are the challenges to implementing these solutions in developing/emerging countries?
- (For users of ICT solutions) What resources are available and what do you still need? What are the challenges to using these types of devices? What solutions are you most excited about?

In the full length version of this report, we present and discuss existing literature (divided into experimental evaluations and qualitative case studies) on the impacts of educational interventions with ICT components on student learning outcomes in developing countries. We divide the research into two categories: experimental evaluations and qualitative evaluations that use a case study approach. In this abridged version of the report, we summarize the challenges that exist to conducting evaluations of these types of interventions in the developing world and conclude with a review of the lessons learned from investment and activities witnessed during the past decade, including successes and failures, related to ICT use in education, and recommendations on how these lessons can inform policy dialogues and intervention development within the education sector in future years, focusing on the areas we believe are most salient for practitioners and policymakers.

IV. Experimental Evaluations Assessing Impact

Few experimental evaluations have been conducted on the impact of ICTs on student outcomes in the developing world. Advocates frequently propose ICTs in the classroom, but often do so with little rigorous evidence to support their claims (F. Barrera, personal communication, August 25, 2008). Additionally, very few randomized controlled trials (RCTs) have been conducted and as a result, important questions remain unanswered, such as whether differential effects across subgroups exist, whether certain ICT interventions are more successful than others, and what factors mitigate and enhance the success of ICT interventions.

Studies employing rigorous methodologies, such as RCTs, allow researchers to generalize study findings beyond the study participants, an important design consideration when funding for evaluation is limited. By conducting experiments, researchers can attempt to construct cause-and-effect relationships and subsequently determine what types of interventions “work” and what do not. But even with the careful control of variables, causal relationships can be difficult to establish within complex social phenomena (Mertons, 2005). Ethical concerns can also surface when applying a...
“treatment” to one group but not to another, especially when the “treatment” is a possibly beneficial intervention for children in the developing world where resources are scarce. In the full length report, we review a series of experiments conducted by Linden and his colleagues (2003; 2008) estimating the effects of computer assisted learning on student achievement in India. Second, we discuss an evaluation of the World Links Initiative, designed to establish global, educational on-line communities for secondary school students and teachers (Kozma et al., 2004). We conclude with a review of an evaluation of the Jordan Education Initiative (JEI), a set of educational reforms designed to improve the quality of education in Jordan through ICTs (Light et al., 2008). While drawn from a limited pool, these studies represent a diverse set of approaches and methodological rigor. While the studies demonstrate mixed findings (i.e. both positive and negative effects on student learning outcomes), they also consistently point to the need for more focused and rigorous monitoring throughout the life of an intervention and comprehensive impact evaluation at the conclusion of the intervention. For example, Light et al. (2008) indicate that an additional weakness in the evaluation of the JEI program was a lack of internal capacity for M&E and formative research techniques to continually measure the impacts of the ICT interventions. This is a serious and pervasive challenge facing researchers and will continue to be addressed throughout this study.

V. Qualitative Evaluations Assessing Impact

Quantitative data helps analysts and policy makers understand progress towards achieving targets or pre-defined objectives (Powell, 2006). However, quantitative data does not explain why difficulties were experienced in achieving a particular target or exploring the context in which learning takes place (Powell, 2006). Qualitative analysis can provide data that is policy-relevant and informative. Moreover, qualitative analysis provides richer descriptive data and enables a rich, in-depth exploration of complex phenomena in a way that quantitative data cannot.

As discussed earlier, our literature review uncovered a limited pool of evaluations utilizing quantitative and mixed-methods techniques to assess the impacts of ICT interventions on students’ educational outcomes in developing countries. Excluded were evaluations that examined the impacts of ICTs on teacher outcomes (e.g. Burns, 2006a; Burns, 2006b), education information management systems (including communication between networks of schools) and policy-level reviews on the “state of ICT” within countries. The number of purely qualitative evaluations, or case studies, available for review was even smaller, but included a short-term field study of a radio program designed to increase access to primary education for children in Zambia (Hollow, 2006); an evaluation of promising models of ICT integration in rural and remote areas of Mongolia (Strigel, Ariunaa & Enkhjargal, 2007); a policy-level evaluation of the conditions under which Open Educational Resources (OER), digitized materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning and research education, improve dissemination of knowledge in sub-Saharan Africa (Mulder, 2008); and a field study exploring the role of ICT in the lives of low-literate youth in Ethiopia and Malawi (Geldof, 2008), among others.

In the full length report, we present and discuss three qualitative evaluations of educational interventions implementing ICTs; these studies were selected because they represent a diverse set of approaches and methodological rigor within the qualitative arena. First, we discuss an evaluation of a project that integrated handheld technologies in science and mathematics enrichment courses in Thailand; second, we discuss a unique comparative evaluation of computer-based education programs in Chile and Costa Rica; finally, we discuss an evaluation of a pilot implementation of One Laptop Per Child’s initiative in Ethiopia.
The results of these qualitative studies are mixed, pointing to both positive and negative effects on student learning outcomes, but without quantitative verification of these results, it is difficult to ascertain the significance of these findings. Case studies alone do not provide a rigorous enough base from which to draw policy-relevant or programmatic conclusions. Studies employing both quantitative and qualitative techniques will likely offer the most comprehensive assessment of impact given that researchers can use statistical techniques to identify specific factors that enhance or dilute an intervention’s effectiveness and also explore, through interviews and observations, why and how these factors operate.

VI. Challenges Facing Evaluation of ICT for Education in Developing Country Contexts

Educational interventions that seek to integrate ICTs into the classroom or other learning environments will face a different set of challenges in developing country contexts compared to interventions taking place in developed countries, such as economic (including infrastructural), cultural, and social factors that impact on how an intervention program is implemented and the differing resultant outcomes (Horton & Mackay, 1999). Reliable and high quality evaluations to assess if and when ICT solutions work in educational settings is of the utmost importance given competition for scarce resources that occurs within most developing countries.

G. Challenge: Absence of Standardized Evaluation Framework for Educational Interventions using ICTs

As reviewed in this article, a comprehensive and rigorous body of evidence of the educational impacts of ICT interventions in developing countries does not yet exist and is needed to better understand if and how particular interventions will prove effective, and to guide local and national decision making and spending of scarce donor resources. Program evaluation is an essential component to the implementation of effective educational interventions, especially those that employ innovative technologies. Creating a standardized evaluation framework that is flexible enough to allow for the multitude of resource constraints, as well as other economic and socio-cultural factors often found in developing countries, is a necessary precursor to establishing a cohesive body of evidence demonstrating the impacts of ICTs.

H. Challenge: Limited Local Capacity for Evaluation

Researchers and evaluators in developed countries have extensive experience in empirical—both quantitative and qualitative—techniques and evaluation design. Often, local researchers within developing countries need to be trained in modern data collection methodologies, monitoring and analysis.

I. Challenge: Limited Funding and Resource Constraints for M&E

Many projects in the education sector have specific monies set aside for M&E activities. However, additional monies often need to be allocated in order to conduct a comprehensive impact evaluation which is very difficult when resources are scarce to begin with and existing funds for M&E are diverted to program activities (B. Spielvogel, personal communication, September 16, 2008).

J. Challenge: Lack of Demand and Ownership of Evaluations

The most basic requirement for developing a results-based M&E system, either project-based or within an overall government-sponsored framework, and for a culture of M&E to truly take root, is
the commitment and enthusiasm of project stakeholders and funders. For example, Schacter (2000) found that “the key constraint to successful M&E capacity development in sub-Saharan Africa is lack of demand” (Schacter, 2000, p. 15; see also Hollow, 2008; Kusek & Rist, 2004).

K. **Challenge: Confusing Updating with Upgrading**

Given the dearth of evidence that correlates ICT with improved student learning, why then are so many developing countries headed down this path? Clearly, the research shows that many stakeholders and decision-makers in developing countries are driven by their intuition, that by modernizing learning environments with computers and other ICTs they believe they will be improving the learning and teaching that occurs in classrooms. Social and political pressures may also influence where scarce resources are allocated, hoping to realize the biggest and quickest impact towards reaching goals of improved student learning. However, by simply updating materials, infrastructure and resources, schools and education systems are not likely to accomplish the desired upgrades to classroom instruction and student learning.

VII. **Lessons Learned and Future Trends**

A summary of the lessons learned and future trends reported in the full-length version of this article are:

- Extant evaluations using qualitative methodologies often rely on self-reported data, without validation or triangulation across multiple sources. This can lead to an **inflation, or positive bias, of the effectiveness of ICTs in educational settings**.
- Several resources exist detailing the elements of a rigorous, comprehensive and well-designed evaluative strategy (e.g. Ripsey et al., 2004; Trucano, 2005; Wagner et al., 2005) and suggest a second lesson learned - that **evaluation can and should inform each phase of a project**.
- In order to establish the scope and intended objectives of a project and finalize its design, future evaluations of ICTs in the educational sector should include **a formative evaluation during the intervention’s developmental phase**.
- Relatedly, **process evaluations are a necessary component to comprehensive program evaluation** that should occur on an ongoing basis throughout the life of the project.
- An **impact evaluation to assess the overall effects of the intervention on beneficiaries, including cost benefit and effectiveness analyses**, and whether intended goals were achieved is also crucial to understanding if and why an educational intervention is effective and relevant.
- **Wide dissemination of findings to relevant stakeholders** is also critical after a project has finished ensuring its accountability to donors and the sustainability of effects for beneficiaries.
- **ICTs and their evaluations must be context-sensitive.** A uniform approach to implementation and evaluation cannot be universally applied. For each intervention, researchers must consider national-level educational goals and the fit of ICT solutions within this policy framework.
- The **impact of ICT is also dependent upon exogenous factors**, such as teacher training and support, classroom management techniques, and support from school leadership. Successful school integration depends heavily on effective and integrated leadership at the school, regional and national levels; support systems across sectors (including professional...
development, infrastructure maintenance, etc.); and curricular content that is relevant to needs and interests of teachers and students.

- Finally, an important lesson learned is that it is equally important to know about the “failures” of ICT use in education. Important data can be gleaned from these stories to inform planning and roll out of ICT interventions in other countries within developing regions in the future.

VIII. Suggestions for Future Evaluations

The design of future evaluations should capitalize on the lessons we have learned from evaluations of ICTs over the past few decades. Several suggestions are summarized below:

- Assess impacts longitudinally: Generally the uptake of ICTs in schools is a long process. It can take years for teachers to fully appropriate the technology and even longer to be able to effectively integrate ICT into their teaching routines. Therefore studies should look at the impact on students over a period of years.

- Be comprehensive in scope: Trucano (2005) found that the quantitative monitoring or impact data that has been collected in these evaluations focuses primarily on infrastructure (i.e. “the presence and functionality of ICT-related hardware and software”) as that is the most straightforward and easiest to collect (p. 13). Using quantitative techniques and qualitative techniques can help inform researchers and practitioners on the array of possible effects and explanations for observed effects.

- Employ mixed methodologies: In recent years, a mixed-methods approach has become a popular alternative to selecting a purely quantitative or purely qualitative design (Day, Sammons & Gu, 2008). There is a reciprocal synergy between quantitative and qualitative approaches—for example, one may find compelling descriptions in qualitative interviews with stakeholders that can be further explored on a larger scale with survey or assessment data. On the other hand, one may want to delve into interesting patterns or trends found in survey or assessment data with in-depth interviews with relevant stakeholders.

- Explore innovative research questions: Future research should extend beyond the descriptive to inform development of effective and relevant interventions that truly capitalize upon the strengths of ICTs in educational settings for learners.

IX. Conclusion

The role of and potential for ICTs in the education sector is not an issue separate from educational reform efforts, but rather inextricably intertwined. ICTs are important tools to meet Millennium Development Goals of access to and quality improvements of educational programming for all children. This paper has reviewed relevant literature that investigates the impacts of ICT interventions on student learning outcomes and has highlighted the challenges that hinder rigorous evaluation of such interventions. Evaluation is a crucial process to assess how and when to use ICTs to achieve desired outcomes and to what degree perception and reality align. However, the number of reliable and methodologically rigorous studies that have been conducted on the impacts of ICTs in educational settings within developing countries is small. From this small pool, our review suggests that the impacts of ICTs on learner outcomes vary, whether positive, negative, or no impact at all. The perception of ICT impacts however among stakeholders is mostly positive and whether ICTs can meet these expectations is dependent upon how such solutions are implemented.
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iThe American Institutes for Research (AIR) announced a Call for Input at the convening of the World Summit on the Information Society (WSIS) in May of 2008 in Geneva, Switzerland. The announcement invited policymakers, academicians, researchers and practitioners in the field of ICT to submit reliable and rigorous research undertaken to date on the deployment of ICTs to support education goals around the world with an emphasis on the developing world. Further, these studies were to contribute towards discussions of ICTs’ impact, efficacy, return on investment, and total cost of ownership. A project website was developed: www.ictimpact.org for this purpose.

iiThis literature review uncovered several experimental evaluations that investigate the impacts of ICTs on learning outcomes. As mentioned earlier, given this article’s focus on developing country contexts, evaluations that focused on advanced economies were excluded (e.g. Angrist & Lavy, 2002; Cox & Marshall, 2007). Other studies, such as the Mitra et al (2005) evaluation of children engaging in unsupervised group learning with computers, were innovative yet only tangentially related to our focus on student learning outcomes. Additionally, Maclay et al.’s evaluation (2005) of the Global Networked Readiness for Education project presents valuable findings on possible measurements of ICT success, but its broad scope precludes detailed attention in our study. While also not within the scope of this article, of importance are Potashnik and Adkins’ (1996) cost-benefit analysis of ICT projects in education and Tinio’s (2003) outline of uses and challenges in ICT in education interventions. Such articles are illustrative of the range of methodologies used to measure the impacts of ICTs on learners.

iiiIn 2004, The Partnership on Measuring ICT for Development, an international, multi-stakeholder initiative was launched with two goals: to achieve a common, core set of international indicators that can be enhanced and expanded over time and to enhance the technical capacities of statistical offices in developing countries. In 2007, the working list of indicators was endorsed by the UN Statistical Commission and the Partnership’s Task Group on Capacity-Building (TGCB) was formed to begin capacity building work at the international, national and regional levels.