

An Analysis of the Research and Impact of ICT in Education in Developing Country Contexts

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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 Second, AIR conducted a detailed literature review of published and unpublished evaluations on the educational impacts of ICT solutions.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:

A. 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 papers¹ 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.

B. 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.ⁱⁱ 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.

A. 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.ⁱⁱⁱ

B. 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.

C. 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).

D. 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).

E. 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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¹ Tolani-Brown, N., McCormac, M. & Zimmermann, R. (2008). *An analysis of the research and impact of ICT in education in developing country contexts*. In (Ed. J. Steyn) *ICTs and Sustainability for Global Development: Theory, Practice and the Digital Divide* (Vol. 1 of series entitled *Development Informatics and Regional Information Technologies: Theory, Practice and the Digital Divide*). Monash, South Africa: IGI Global.

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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.

ⁱⁱ This 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.

ⁱⁱⁱ In 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.