Global Networked Readiness for Education

Preliminary findings from a Pilot Project to Evaluate the Impact of Computers and the Internet on Learning in Eleven Developing Countries

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Executive Summary
While the ultimate impact of information and communications technologies (ICTs) on society can still be disputed, there is no doubt that the introduction of these tools has changed lives, organizations, strategies and discourse in communities around the world. Private sector organizations have led the adoption of new technologies in many respects, but government, and the education sector in particular, are becoming increasingly active participants in the knowledge society. While developed nations have invested massive sums of money and institutional resources in ICT over the last decades, developing nations by and large have addressed other priorities including the preconditions necessary for successful ICT integration.

With the introduction of ICTs, developing nations envision the elimination or improvement of age-old barriers they face such as geography, high cost of and limited access to quality information, communication limitations, non-transparent governance and, of course, education deficits. In the education sphere, enthusiasm abounds over how computers and the Internet can bring improvement in numerous ways, with technology applications that range from administration to new materials, from distance learning to project-based learning, and from pedagogical re-invention to virtual communities of practice.

In schools and countries around the globe, diverse educational ICT programs have been initiated, strategies have been developed, hardware has been procured and software has been coded. However, there has been far less attention to and understanding of the monitoring and evaluation of these new ICT efforts. Very few communities in either the developed or developing world seem to understand how to assess how ICTs are working, what their impact is, and what drives their efficacy or lack thereof. Now, as developing world communities are increasingly moving towards the institutionalization of ICTs, policymakers, educators and donors are asking themselves whether ICTs are worth their high cost and the challenges they bring. More specifically, they want to know, whether and how ICTs are changing education, and what they need to do to achieve their goals for education.

The Global Networked Readiness for Education project seeks to support the evaluation and assessment of ICTs for education in the developing world by creating tools, metrics and measurements that can help to examine these areas, and the understanding necessary to use them to realize successful educational ICT outcomes. Specifically, the GNRE project goals are to:

- Develop surveys geared toward students, teachers, heads-of-school and computer lab administrators in schools in developing countries;
- Deploy survey pilots in 11 developing world countries;
- Create online toolkits, geared toward policymakers, researchers and others, that provide opportunities to participate in subsequent phases of survey deployment as well as provide resources for planning around ICTs and education;
- Build an initial database of ICT/Education indicators based on the survey results; and
- Discern preliminary findings and observations about the current situation vis-à-vis computers and Internet in schools in the project's 11 pilot countries,

especially with regard to learning what characteristics are associated with which outcomes, and identifying elements that can be essential in determining best practices for policy and decision making.

The report highlights the findings from the Global Networked Readiness for Education surveys, deployed between August and November 2003 in schools in Brazil, Costa Rica, El Salvador, The Gambia, India (Karnataka), Jordan, Mexico, Panama, the Philippines, South Africa and Uganda. In total, over 3,700 students, 1,000 teachers, 120 heads-of-school and 115 computer lab administrators were surveyed in 126 schools. The challenge of identifying the appropriate measures, capturing the data accurately, and analyzing it effectively are great, and these preliminary results from the study should be interpreted as the beginning of our understanding rather than its end. The survey and resources toolkits are available online at http://cyber.law.harvard.edu/gnre.

The most basic finding of the first round of surveys is that ICTs are still new to education in the developing world, a reality that affects all use and impact of computers and the Internet in all schools surveyed. While computers are available in one form or another in the schools surveyed, they are still not well-integrated into most core learning processes. The sample schools were selected to be broadly representative of the leading edge of ICT implementation within state-sponsored secondary level education within each nation in terms of their access to and experience with ICTs for education. In general, the schools had low levels of ICT use and integration – with no significant differences between private and state schools. Indeed, most students and their teachers do not access the Internet in school, and use computers only on a weekly basis. As much as anything, this suggests the incipient state of ICTs in education efforts in the developing world, even in the most technologically advanced schools, and underscores both the importance of understanding its impacts and the difficulty in doing so.

Strikingly, despite their limited exposure to ICTs, students', teachers' and administrators' attitudes and perceptions of computers and the Internet were overwhelmingly positive. While this disconnect may cause some concern that ICTs are over-hyped, it also suggests the tremendous enthusiasm over the new tools and their power to instill a willingness to accept related changes.

A brief summary of select preliminary results follows. These results should not be treated as final truths, but rather, as condensed insights into areas that merit focused attention and deeper consideration. Highlights of survey results are presented in conjunction with select abbreviated policy recommendations, which stem not only from the survey results, but also from existing literature on ICTs in education and the field experience of the World Bank Institute and Berkman Center teams. These summary observations are organized along major topic areas as follows:

School demographics
The survey sample is representative of schools using technology in the participant nations. Schools are primarily state-sponsored, located in both urban and rural areas, focused mainly on secondary education, and represent a range of socio-economic circumstances.

Infrastructure

Perhaps unsurprisingly, schools with better electrical and telecommunications infrastructure have higher degrees of computer-mediated learning and computer use, and their students, teachers and administrators exhibit more positive attitudes towards computers. Virtually all the schools surveyed were on the electrical grid and did not deem reliable power to be a major problem. Most teachers have a mobile phone.

Moving forward, it will be important to undertake a deeper exploration of other infrastructure indicators, looking more closely at the school setting and introducing alternative quality and reach measures for national level infrastructure such as electricity transmission loss, radio availability and cable television penetration. The preponderance of electric grid access may suggest that ICT for education programs are not yet reaching the most rural schools, since in many of the survey countries the most rural areas have significantly less access to electricity (and telecommunications).

ICT and Network Infrastructure

More than half of all schools have had computers for less than four years and Internet for less than two years. Most computers are located in libraries or computer labs, although they are frequently sited in administrators' offices. Computers are rarely found in classrooms. They tend to arrive new, nearly all run Microsoft Windows, and almost half of schools use a dial-up connection. Respondents find Internet reliability to be more important than speed.

Policymakers will want to investigate ways in which to make actual classroom infrastructure more robust and flexible. They may want to encourage the adoption of technologies such as wireless networks and mobile laptop computers to allow computer and/or Internet access from any classroom, while also addressing other challenges such as inconsistent power supply and physical security. Since most schools equip new computers with Microsoft Windows, a proprietary (and expensive - if the appropriate licenses are purchased) software, it appears that little attention has been given to alternative, cheaper sources of hardware and software, despite notable promise. In order to keep costs down, policymakers should consider acquiring used and refurbished computers as well as open source software and platforms.

Computer Access

Computer access for students remains a challenge, with an average of over three students per computer – although it is unclear whether this harms some forms of learning. Nearly half of the students surveyed who want access to computers outside school hours do not have it. Similarly, over half of the teachers do not use computers outside class hours. Along these same lines, half the schools surveyed do not keep their computer laboratories open after hours.

When computers sit idle, and a broadband connection goes unused in the evenings, over weekends and during holidays, ICT infrastructure and Internet bandwidth are unnecessarily wasted. Future monitoring and evaluation is needed to determine how these untapped resources can be best used, and whether they can be better harnessed to increase use, learning and impact of ICTs on education or otherwise benefit the surrounding community. One possibility that schools can consider is to retain a mentor, lab administrator or teacher who can stay after school hours to allow students better access. Other solutions include creative scheduling and opening labs to the broader community.

Attitudes and Perceptions
Students, teachers and administrators all report strongly liking computers. They indicate that their peers and colleagues also like them, and that they are useful and important for learning. Familiarity and confidence with technology, as well as trust in content were powerful indicators of teacher attitudes and student use and learning.

If students, teachers and headmasters have largely positive attitudes toward computers and these are matched by positive experiences with them, they tend to be more receptive to some of the administrative, curricular, and pedagogical reforms that computers may facilitate at the school level. Policymakers can directly address teachers' anxiety through constructive professional development that emphasizes the teachers' central role in the teaching and learning process, as well as strategies that directly address perceived deficits in information quality. Resources such as training programs, websites, and communities of practice that support the identification and communication of the trustworthiness and usefulness of content and applications are important for both teachers' and students' perceptions.

Teacher Training and Professional Development
While training is generally available in most schools, and valued by teachers and administrators, it reaches less than two thirds of teachers. Self-trained teachers tend to have more positive attitudes towards computers, although formally trained teachers report greater improvements in learning, verbal and written skills among their students. Teachers depend on peer support networks for much of their knowledge and continued learning.

In general, there may be too much dependence on ad-hoc teaching and technical support structures, requiring a reexamination of how this support is prioritized vis-à-vis hardware and software procurement. Experience and the literature both suggest the importance of formal professional development, including how available (in terms of cost, frequency, access) and appealing the program is to teachers (in terms of factors such as release time, effectiveness and direct incentives). But this should extend beyond technical training and support to pedagogical issues of integrating technology with teaching and learning. While formal training programs are the most highly rated by teachers, the surveys revealed little about their content or effectiveness, including whether they cover topics such as: demonstration of successful teaching practices enhanced by the use of ICTs; management of learning sessions; monitoring student performance and learning outcomes; classroom organization; and creation of the communities of practice and support networks to connect the teachers to each other.

Educational Content and Software
Old tools still dominate the educational landscape, with teachers calling textbooks the most useful tool for teaching, and e-mail the least important among common tools. While heads-of-school consider software and CD-ROMs to be essential tools, teacher and student attitudes show that the quality of educational content is important. Most schools do not have websites.

As overall use of ICTs (especially the Internet) remains limited, it is unsurprising that teachers appear to not yet be fully utilizing the potential of the Internet as an educational tool. One important finding for policymakers is that teachers are less positive about the Internet when they doubt the quality of online information. Educational portals, training, and communities of practice could be valuable for helping teachers identify trusted information. Furthermore, helping schools to develop their own websites and other content could develop local cultures of creation and publishing that would contribute to the overall body of knowledge and information in school networks.

Teaching Pedagogy and Computer Use

The introduction of computers and Internet has not diminished the central role of teachers in learning; students learning about computers from teachers have more positive attitudes towards the new technologies. These tools also empower teachers, leading to more positive attitudes among educators who value creating their own course materials. According to teachers, computers and the Internet also lead to a positive overall effect on their schools.

It is important for teachers to have positive attitudes toward computers and to believe that computers facilitate the development of higher order thinking skills such as problem solving and creativity. When this is the case, there is a greater likelihood that they will introduce pedagogical and curricular innovations that emphasize a more interactive and constructivist approach to teaching and learning. Despite rhetoric (and fears of some teachers) to the contrary, educators are as central to the learning process as ever. Professional development programs need to ensure that teachers do not simply "get by" in this new environment, but rather take advantage of the opportunity it offers. Professional development should continue to emphasize the key role that teachers play in the effective integration of technology in the school, including how they can facilitate a more student-centered, interactive classroom. As part of that dynamic, teachers and students should also be encouraged to become content creators as well as content consumers.

Gender

The results suggest that girls use computers less frequently than boys, although girls are still benefiting from ICTs. Girls' use of computers is associated with improvements in learning, writing skills and verbal skills, and Internet use is likewise beneficial for girls who trust online content. There is also evidence of specific ways in which the Internet could be particularly important to girls, with about half of the teachers reporting that the Internet helps girls to access health information.

School-level equitable use policies should be considered to ensure equal ICT access by girls. In many countries, girls are often disadvantaged by limited free time for computer use outside school and inhibiting cultural mores. To combat this, schools may explore policies of providing girls more access during or immediately before or after school, or designating certain computers for girls. A better understanding is also needed of how schools can work with the community and parents to create effective and appropriate training programs for girls, as well as what materials are most valuable for girls' intellectual growth and educational development.

Community Involvement
Because of the costs and complexities of introducing technologies into schools, only a few schools and education systems have actively reached out to a broader set of stakeholders to help them accomplish their ICT in education goals. Schools do very little to share their facilities with their communities. Nearly half of schools report that their labs are never opened to the public and less than two percent of schools report that they generate revenue from telecenter fees.

However, there are many potential benefits to extending computer access to those outside the school. Building a larger base of support for costly and innovative programs can not only reduce cost burdens and resistance to innovation, but also insulate against political change, and support effective use, upkeep and acceptance of the new computers and online resources.

Policy Issues
One-third of administrators are frustrated by the lack of clear policies to integrate ICT in education, but almost all feel ICT integration is part of broader educational policy reforms. Most schools report that computers are covered in national exams. While many actors have participated in the planning process and in the decision to bring ICTs to schools, the heads-of-school feel that they had the greatest impact, and about half the teachers feel that they also had an important role in the ICT planning process. Specific ICT use policies (that govern how students can use the Internet and computers) are common, but have mixed effects: they are associated with both decreased student use and improved teachers' perceptions of their students' literacy and learning. Students play a major role in running computer labs in two-thirds of the schools surveyed.

Existing ICT policies should be reviewed to ensure that they promote effective use of technology across the curriculum as well as support any broader educational reforms. Policymakers should ensure that they engage the school community (heads-of-school and teachers, in particular) in the planning and implementation process, as well as the broader community. Since headmasters seem to be cognizant of existing educational reforms, policymakers should be clear about how computers contribute to the reform process, and how they can measure their impact. A re-examination of use policies is important to ensure that when students are protected from questionable content, that they are not excessively limited in free exploration of information, knowledge and communication. Monitoring and evaluation programs are essential, but the target outcomes must be clearly defined so that testing provides the incentive for appropriate skill development. Systematic examination of student involvement in ICT management could yield effective, educational and economical solutions to technical challenges.

Costs
Capital costs for hardware and software were cited as the greatest challenge for two-thirds of the schools, but were rarely passed on to students. Schools tend to use traditional sources of funds – school budget and government support -- to pay for Internet access, with little revenue coming from donations or telecenter revenues.

ICT in education programs are under great pressure to identify sustainable financial strategies and undertake long-term planning. As a result, comprehensive information on upfront and ongoing costs is essential for effective management of ICT in education efforts, including not just hardware but training, maintenance, equipment replacement, software updates, Internet access, and other unforeseen expenses.

Other Challenges
The surveys indicate that the lack of local and same language content and fear of technology are not major challenges, although hardware problems and computer viruses are problematic.

Heads-of-school, teachers, and students all want both more hardware and greater technology support. In the face of this clear finding, policymakers should not overemphasize the hardware challenges at the expense of support (or professional development, for that matter). While hardware issues are easy to discern and easier to remedy than other concerns, they must be addressed in a measured way in relation to the other challenges.

ICT Use
Computer and Internet use by students is incipient across the board. About half of all students never use the Internet at school, while one-third use the Internet only weekly. About half use computers weekly and a one-fourth use them several times per week. More than half of all students never use school computers outside school hours. Students with computers in their classrooms tend to use them more, although their classes do not. Almost half of teachers surveyed use computers once per month or less, and slightly fewer never use the Internet in school. More than half of teachers rarely or never use ICTs in class. Teachers who have formal training and experience with ICTs however are more likely to use them in class. School administrators report fairly heavy computer use, with three-quarters using them at least several times per week.

As key drivers of learning and skill development, the main priorities of any ICT in education program should be: breaking down the barriers that deter use; supporting the factors that facilitate use; and monitoring use as an output indicator of progress in integrating ICT in education. In hardware access terms, schools should increase overall numbers of computers, ensure that computers are used more efficiently, and maintain their computer stock to maximize reliability. Policymakers may also wish to explore attempts to provide teachers free or concessionary-priced computers, along with associated extra training and support. Until technologies are used more widely, it will be difficult to determine their impact on learning. Indeed, until computers are more widely used, their impact should not be expected to be significant. A better understanding of the factors that motivate student use would also provide valuable insight with respect to curriculum design. Experience suggests that content that is rich in media and interactive, and active learning through exploration, discovery of knowledge and exchange with others (including educational games) are engaging for many students.

Effective Use/Perception of Impact
Statistically, the survey results indicate that the use of computers is associated with improved skills and learning. Particular gains are correlated with using computers in science/programming, word-processing and games, and having a policy that governs games. E-mail and other electronic educational resources are associated with perceived decreases in skills and learning. Improvements in teaching are associated

with in-class computer use, school computer use, perceived reliability of Web content and use, and higher ratios of students per computer. Teachers find basic computer use more valuable than Internet use for student learning. Heads-of-school are overwhelmingly positive on the impact of computers in their schools in terms of teaching, learning and administration.

These results suggest both the real and the perceived power of ICTs to develop the essential new economy skills and learning that schools around the world are working to develop in their students. Schools still need to get the tools closer to the classroom, and the teachers and students who work and learn there. They also need to advance genuine curricular integration of ICTs to bolster their effective in-class use. Word processing, science and programming are highly valued uses of the computer due to clear benefits for enhancing the curriculum, while e-mail and educational software and content are often valued and integrated less within the curriculum. It seems that schools can use e-mail effectively for educational benefit only by embracing it as a collaborative tool, something that is currently rare. Finally, although the ultimate impact is unknown, getting computers to administrators appears to have been positive, primarily based on their support for ICTs. There should be lessons from the experience of administrators that will help with the diffusion of ICT usage and acceptance among teachers.

I. Introduction

Over the past decade, the goal of preparing the citizenry for the global "knowledge economy," "information society" or to be a "workforce for the 21st century" has become increasingly prominent on public agendas throughout the world. One of the main strategies adopted by the governments to achieve these objectives is an incorporation of information and communication technologies (ICTs) into learning systems. In practice this has focused more on the purchase and installation of desktop computers and Internet connections in schools all over the world, than on improving curricula, pedagogy, teacher training or support. Many believe that in order for learning to be relevant and "modern," computers must be part of the formal education system. There are, however, many critics who question the impact of ICTs, whether based on the initial investment required, or on the limited evidence about the efficacy or efficiency of these programs.

Particularly in the developing world, where there has been increasing pressure to "catch up" to the more developed countries, integrating ICTs into schools has become an increasingly common element of national and sub-national education policy – although still largely implemented at the pilot level. Ministries of Education, national and municipal school authorities and private organizations have invested a significant amount of resources, time and effort to incorporate ICTs in education. Their goals range from lofty attempts to reinvent their education systems and prepare their youth to compete and participate effectively in an increasingly technology-savvy and globalized workforce, to more straightforward attempts to modernize education by adding new materials, or more socio-politically motivated efforts to signal systemic change and new opportunity.

Yet in spite of the effort to put computers in schools, there is still a very poor understanding of how these computers are being used, let alone what impact the use of computers and Internet is having on learning. In more developed nations such as the United States, Australia, Canada, and the member states of the European Union, there were attempts to design and implement rigorous evaluations of school technology programs that yielded a mixed picture of effectiveness of approach and implementation.[1] However, in the developing world, where education-related data collection mechanisms are often very limited, there are very few commonly accepted indicators or reliable sources of statistical data on the status of ICT for Education programs. As a result, there is no clear sense of how efforts to introduce technology in developing world schools are faring, individually, collectively or in relative terms.

In order to address some of these shortcomings of monitoring, evaluation and data collection, and to provide insight for policymakers into rationale for and successful patterns of incorporation of ICTs into learning systems, the ICT for Education Program of the World Bank Institute (WBI) and the Berkman Center for Internet & Society at Harvard Law School, with support from the UK's Department for International Development (DFID) and the Education Development Center (EDC), launched a pilot research project in 2003 to directly survey user experiences of ICTs in developing

[1] For example, see http://crpit.com/confpapers/CRPITV23Kennewell.pdf or Boston College's Technology and Assessment Study Collaborative at http://www.bc.edu/research/intasc/.

world schools. The first phase of the Global Networked Readiness for Education Project[2] has five specific goals:

- Develop surveys geared toward students, teachers, heads-of-school and computer lab administrators in schools in developing countries;
- Deploy survey pilots in 11 developing world countries;
- Create online toolkits, geared toward policymakers, researchers and others, that provide opportunities to participate in subsequent phases of survey deployment as well as provide resources for planning around ICTs and education;
- Build an initial database of ICT/Education indicators based on the survey results; and
- Discern preliminary findings and observations about the current situation vis-à-vis computers and Internet in schools in the project's 11 pilot countries, especially with regard to learning what characteristics are associated with which outcomes, elements that can be essential in determining best practices for policy and decision making.

These goals supported larger and more global programmatic objectives to:

- Instill stronger values for monitoring and evaluation around issues of ICTs and education, and to encourage others at a variety of bureaucratic and educational levels to do the same;
- improve our collective understanding of the factors associated with success; and
- Develop metrics and measurements that can help us examine these areas.

This report highlights the findings from the Global Networked Readiness for Education surveys, deployed between August and November 2003 in schools in Brazil, Costa Rica, El Salvador, The Gambia, India, Jordan, Mexico, Panama, the Philippines, South Africa and Uganda. In total, over 3,700 students, 1,000 teachers, 120 heads-of-school and 115 computer lab administrators were surveyed in 126 schools.

In the discussion of the results of the pilot project that follows, we refer to the concept of "Global Networked Readiness for Education." In a prior study done by the Harvard team, the term "Networked Readiness", has been defined as "the ability of a community to realize the benefits of the Networked World."[3] We have extended this Networked Readiness concept to the school environment, and have sought in our work to understand better the ability of schools or learning communities to integrate ICTs within their learning environment. This has increased our understanding of how the enabling environment in each school affects the nature of the use of the technologies, and ultimately leads us closer to understanding their impact.

It is our hope that this modest pilot project makes a valuable contribution towards a better understanding of how ICTs are being used in the school environment as well as towards methodologies that researchers, policymakers and others can use as they try

[2] All components and materials are online at http://cyber.law.harvard.edu/gnre
[3] See *The Global Information Technology Report 2001-2002: Readiness for the Networked World,* Geoffrey Kirkman et. al. editors, Oxford University Press, 2002.

to interpret and evaluate the global experience with ICTs and education. Finally, it is hoped that the study will assist policymakers to evaluate ICT programs in their own countries and help identify ways in which ICT in Education policies and programs can be better designed and implemented to maximize the positive impact that technology can have on learning.[4]

II. Experience to Date

Globally, both attention to and funding of ICT programs for education have increased tremendously over the past decade or so, with Turkey, Thailand, China and Russia all investing in ambitious ICT and Education programs. As the price and level of difficulty in accessing ICTs has dropped and their sophistication and power have increased, computers and the Internet have become much more central to the core functioning of economy and society, and positive linkages between ICTs, enhanced learning, economic competitiveness and productivity have been firmly cemented in the mindset of decision makers around the world.

While figures are hard to come by, rough estimates indicate that globally, computers have been deployed in schools in some measure in over 140 countries, implying that hundreds of millions of dollars have been spent on ICTs for schools and millions of students have used them at school.[5] To be sure, the 126 school sample in these eleven countries represents only a small portion of the overall global experience of computers in schools. Projects take diverse approaches with varying foci on the types of technology used, delivery of training and support, users and uses targeted, and community involvement among other factors.

There is little doubt that information and communication technologies are, and will continue to be, a powerful and driving force of change in the global economy. For instance, despite the uncertain environment of recent years, the IT industry remains India's fastest growing sector and is estimated to represent USD 28 billion,[6] while India's software exports had a compounded annual growth rate of over 60 percent between 1995 and 2000.[7] Whether within the context of specific industry applications of technology, or applications such as electronic government, grass roots entrepreneurship, or basic communications, many developing nations are looking to technology to improve social and economic opportunities, and indeed, quality of life for their citizens. In many countries, significant responsibility for bringing about this change is placed within education systems that are expected at least to provide a capable workforce and citizenry.

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[4] For other recent and related materials, please see the excellent work undertaken by UNESCO Bangkok, available online at http://www.unescobkk.org/ips/ea/ea-E_Learning.htm

[5] As in other aspects of educational technology implementation and use, there are very few data available on technology expenditures. The literature suggests that on average investments in technology account for roughly 10 percent of educational spending, though this figure varies from over 20 percent to negligible amounts. Additional investment often comes from multinational, non-governmental and private sources. While the costs of ICT in education are high (especially in developing world contexts), many observers have posited that the economic returns they generate greatly outweigh the required investment (Bakia 2002).

[6] http://www.nasscom.org/download/IndianITIndustryFactsheet.pdff Last accessed March 15, 2005.

[7] http://www.nasscom.org/artdisplay.asp?cat_id=314#IT Last accessed on September 15, 2004.

Past research has examined many ingredients of ICT and development; studies frequently focused on aspects which were more easily quantified. For instance, limited statistics can be found on computer availability, Internet access points, Internet Protocol addresses and investment in ICTs, but few attempts have been made to assess how such technologies are employed and perceived by different stakeholders or their social, economic and cultural impact.

Further complicating the inherent difficulties of any ICT impact evaluation, other challenges common to education systems (including chronic resource shortages, political disincentives, systematic treatment of diverse educational challenges across widely varied settings) and limited collective understanding of ICT in education have left policymakers with insufficient information to make informed decisions for employing ICT in learning. In many cases, they have been left to rely upon measurable inputs and outputs, including teacher-student ratios, infrastructure investment, rates of enrollment, graduation, and literacy, with little opportunity to track specific use or impact of educational technologies. Such situations forced decision making with inadequate insight into implementation, processes and outcomes. This study seeks to go beyond the initial level of counting inputs by reporting how ICTs are actually implemented in the classroom and how the impact of ICTs is perceived by students, teachers and school administrators.

III. Survey Background and Methodology

Challenge

The lack of understanding of the experience of ICT in the formal educational context of the developing world is suggested by the aforementioned unavailability of quantitative data on the topic. While there are some data on education in the developing world, there was no research conducted to compare access to, use or impact of ICT in education internationally. Difficulties in conducting such research are quite clear and include the lack of commonly accepted indicators, insufficient understanding of associated causal relationships, lack of capacity or financial resources for such an undertaking, perverse institutional incentives to disguise data and a common primary focus on providing computers and Internet as ends, rather than as a means to improve teaching and learning opportunities.[8] These and many other technical and institutional difficulties proved to be insurmountable obstacles for undertaking such assessments.

The goal in designing surveys that capture the experiences of students, teachers, and administrators is to begin exploring relevant qualitative indicators, to deepen understanding of the key components of the use of ICTs in schools that are associated with different qualitative outcomes, and to convey the value of conducting monitoring and evaluation of such programs to groups of stakeholders involved in these projects by offering benchmarks and tools for insightful analysis. The intention is not to generate the global topographic analysis of computer and Internet use in the school environment, but rather to start to understand what is happening in the developing world communities where ICT is a part of the secondary education environment.

[8] In fact, it could be argued that both executive and legislative branches of government might resist efforts of evaluation for fear of failure and associated negative political/bureaucratic consequences, reasoning that outputs (numbers of computers or connections) and anecdotal results would be safer than in-depth study.

Surveys

There were four unique group-administered survey instruments, one for each distinct population (students, teachers, heads-of-school and computer laboratory administrators). The instruments were written in English and then fully translated into Spanish and Portuguese in a manner that preserved visual uniformity of all three documents that were available online. The Jordanian and Indian surveys were translated but not formatted or made available online due to character set complexities. Hence the respondents of the last two surveys completed the English version of the online questionnaire while comparing it with a translation in their native language.

Questions

Given the diverse sample frame there were many challenges to designing questions that were understood across cultures and languages, and understood in the same way. The questions were written in as straightforward a fashion as possible avoiding less commonly used words, colloquialisms and those with multiple meanings. In addition to multiple international test administrations drawn from the sample frame, questions were reviewed by ICT-education experts from a variety of nations and professional disciplines. Each survey evolved over time and with feedback, with significant changes in composition, wording, order, response options, and physical appearance.

The questions were primarily multiple-choice, with a few open-ended responses. Originally, many questions were presented in a form of Likert scales, but were later converted into traditional multiple choice questions when pre-testing suggested that many respondents were confused by that visual continuum format. The questions were structured in the most logical order possible, so as to flow naturally for respondents.

One of the greatest single challenges in developing effective questions was not related to any of the aforementioned factors, but to the diverse understandings across languages, cultures, and experiences of different technologies and terms such as computer, Internet, e-mail and Web.[9] Distinguishing between user experiences with different tools, however, was often complicated by the need to ensure understanding of the question while limiting the length and complexity of the survey. This limitation was addressed primarily by grouping questions, and offering easily distinguished response options. For example, focusing on only one technology, i.e., asking only about computers, or grouping multiple technologies together, i.e., computers and the Internet, proved to be necessary to satisfy the complexities of the survey design.

Sample

Random sampling was impossible largely due to two factors, lack of information on ICT in schools and limited number of schools using ICT. The problem of scarcity of information on ICTs and education in developing countries that prompted this study is observed at the national level in the very limited availability of centralized data relating to the existence of ICTs in schools. In other words, not only do most governments not

[9] For example, if your computer is connected to the Internet and you are using it to send Web-based e-mail, which technology do you report yourself as using?

know how effectively technology is used in schools, they do not have systematic awareness of how many of their schools actually have access to computers and Internet. Without that information, a random sample of the schools known to have technology was unrealistic.

Because of the low absolute levels of ICTs for education programs in the developing world, selecting schools completely at random could yield a very low number of potential study participants. This proved to be true at all levels of observation (national, school and individual respondent), since not all students or teachers in a given school with access to ICTs had freedom to use them or adopted them as a practice. Furthermore, the logistical complexity of getting support in countries and schools where we did not have at least some limited partnership would have made this already complicated endeavor even more difficult.

The survey design was intended not to generate a statistically significant sample of the average experiences of ICT use, but rather to gather a representative sample of user experiences in the contexts of the countries where the survey was conducted. The sample, therefore, was selected to balance diversity of experiences with representativeness of the target population, and was effectively a combination of convenience and purposive sampling. In other words, it was drawn from a collection of the developing country contexts, and included schools with a range of characteristics that we deemed potentially relevant to ICTs in education.

The considerations of the survey design pose limitations on the interpretation of its results and applicability of the recommendations, i.e., we cannot say that the observed represented the average experiences of ICT use for education, but rather a range of observed experiences. While it should not reduce the value of the correlations found, findings must be applied with greater care than if they were based on a random sample.

It is essential to note that this approach specifically excludes communities and schools without access to ICT. It is therefore in some sense self-selecting, and this fact may in turn be related to a number of other contributing factors such as ICTs' role and presence in other aspects of society, popularly held views about ICTs, or other broad underlying social, contextual and economic factors that could have significant impact on the results of the survey.

Countries

The survey was conducted in eleven countries (Brazil, Costa Rica, El Salvador, The Gambia, the Indian state of Karnataka, Jordan, Mexico, Panama, the Philippines, South Africa, and Uganda). Participating nations were determined based on a combination of characteristics including geography (three African, two Asian, one Middle Eastern and five countries in North, Central and South America), income, language, population, ICT-education activity, and considerations of feasibility.

Size
Each national coordinator was asked to survey a minimum of ten[10] schools (Brazil, in particular, accomplished much more), with a target minimum of 30 students, 8 teachers, one head-of-school, and one computer lab administrator per school. In most cases, numbers of responses ranged between 30 and 40 students and 7 and 10 teachers per school.

Schools
Each national coordinator was given guidelines for determining school participation, and asked to develop a list of potential participant schools.[11] The final list was determined in collaboration with Cambridge and Washington, DC-based counterparts using the following criteria: schools were required to have computers and preferably Internet connectivity (at least having had it in the past[12]), offer secondary education, be principally government-funded institutions, represent different geographic areas, and not be affiliated with the same educational networks.

Physical distribution of schools within nations varied according to the size of the country, transportation costs, and time constraints, but the goals of geographic dispersion were maintained as much as possible.

Important factors that may have contributed to selection bias include the coordinators' own choices and awareness (noting that they work in the field of ICT-education), inclusion of secondary schools, willingness to participate in the study,[13] and the requirement of access to computers/Internet.

Participants
Selection of students and teachers, admittedly, presented a challenge to survey coordinators who were asked to select randomly while giving consideration to gender balance (with the exception of single-sex schools), including people who had access to ICTs but not giving preference to those who supported or rejected their use and were experienced in or new to the ICTs. This sample design allowed for little or no choice among heads-of-school and computer lab administrators.

In practice, it was observed that the number of teachers highly involved with ICTs was often limited to a few, with others having a limited exposure, and many having none. Rather than being chosen individually, students were selected by classes or grades that used (or were permitted to access) computers at least occasionally. Hence, this sample population may be more varied than the teachers.

The participant selection bias (of teachers in particular) is of greater concern than the previously noted shortcoming in school choice, because while there is significant variety of experience within a given school, truly random assignment of participants

[10] A few countries surveyed (Jordan, Uganda) performed notably fewer surveys due to administrative delays, academic schedules, and resource constraints.
[11] Names and characteristics of participating schools are found in Appendix 1.
[12] Schools' Internet access often fluctuates due to inadequate or inconsistent funding, on-site technical problems, or power shortages.
[13] The only refusals were based on exam schedules. Due to our tight timeline we were unable to reschedule and thus determine if they were simply resistant, but that did not seem to be the case.

would offer more robust statistical results – although potentially at the price of excluding the early adopters, and many of their lessons learned.

Coordinators

In many countries the field coordinator was employed by World Links[14] and worked in collaboration with the Ministry of Education. Some schools were better known to the coordinators than others. In some instances coordinators had existing or previous institutional relationships with the participating schools. There was little concern over the bias that coordinators could introduce in the study because they were not compensated for this activity and the study was not conducted to survey activities of their respective organizations. Respondents also knew that coordinators were not affiliated with the survey team, hence, could not unduly influence them.

Form, Distribution and Data Entry

In addition to basic instructions, respondents were told that there were neither correct nor incorrect answers, and were encouraged to give the best answer they could. They were invited to contact the administrator with any questions they had. They were informed that answers would not have any direct influence on their school (classes changed, computers given, etc.), and that all answers were confidential and not identified individually.

Each respondent was asked to complete a hard copy of a survey, and to enter the results at the survey's Web interface.[15] Where it was deemed inadvisable for whatever reason for respondents to enter them directly (usually due to poor connectivity or insufficient computers), the hard copies were collected and answers entered by the coordinator or someone appointed by him or her. The paper copies were subsequently returned to the research team.

Each new survey entered online was given a unique and randomly generated sixteen digit alphanumeric code that was recorded on the corresponding hard copy. This code allowed the survey participant or coordinator to re-initiate an interrupted survey entry without data loss and served security, testing and tracking purposes. It ensured that there was a paper copy for each electronic survey (reducing uninvited participation), verified that the interface was functioning properly (by checking the number of responses submitted by the coordinators and observed by the research team), and allowed for crosschecking in the cases of missing surveys or apparent survey errors.

IV. Results of the Survey Project

As decision makers plan and implement programs to place computers in schools, many factors affect how technologies are used within the school environment, and how computers and the Internet affect how students learn, teachers teach, and administrators manage. These elements extend well beyond the school walls, and include relations with the community, government policy and parental attitudes. Our surveys probe these questions, seeking to identify key issues and patterns in adoption,

[14] An international NGO incubated at the World Bank Institute that is dedicated to ICT in education with a global network of affiliated schools (see http://www.world-links.org).
[15] The html and pdf versions are identical in layout and are available in English, Portuguese and Spanish at http://cyber.law.harvard.edu/ict_survey.htm

sustainability and perception of ICT use in schools by different groups of stakeholders and the inter-relationships among them in the context of the developing world.

Numerous school characteristics could play an essential role in determining how students, teachers and managers choose to use ICTs. Many affect learning more broadly, but here we focus on factors that appear to have a direct relationship with the integration of ICTs in education, and do not include national or system-level analysis.[16] There are numerous possible ways to delineate the contributing factors, each with its own imperfections and implications.

Using multivariate regression analysis, we examined five groups of dependent variables: Teachers' Perception of PC Impact on schools, Teachers' Attitude towards PCs, Students' Attitude towards PCs, various Student Use categories, Gender and Learning. Their interactions with independent variables representing: School Environment and Respondent Demographics, Infrastructure, ICT and Network infrastructure, ICT Access, Attitudes and Perceptions, Teacher Training and Professional Development, Educational Content and Software, Teaching Pedagogy and Computer-Use, Gender, Community involvement, Policy issues, Costs, Other Challenges, ICT Use, and Effective Use/Perception of Impact. We also attempted to capture geographic variation across continents. Some elements that are clearly important were more difficult to evaluate effectively and thus were either set aside or assessed through proxies. It should be noted that given the sheer volume of data, the analysis presented here is only the first step in exploring these developed indicators and relationships. The various models for each dependent variable (or set) are located in the appendices of the paper.[17]

Imperfections in the Data

As was noted before, many variables were vulnerable to self-reporting bias and may better reflect subjective attitudes than the actual phenomenon they were intended to measure. This reflects one of the core challenges in identifying appropriate dependent variables, both self-reported and observed. It also is a reminder of the interactivity and generally bi-causal relationships expected within many of the variables. In most cases, multiple models were run on each of the dependent variables to ensure that results were robust.

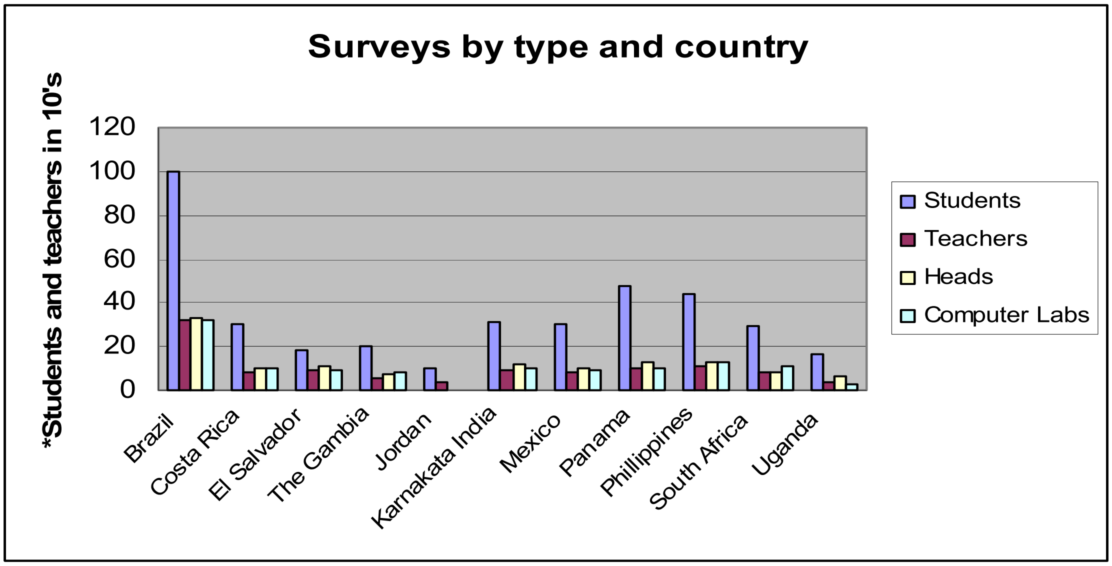
Survey Population

Between August and November 2003, the survey questionnaires were distributed to students, teachers, heads-of-school and computer lab administrators in eleven countries throughout the developing world. Overall, 3,768 students, 1,088 teachers, 126 heads-of-school and 121 computer lab administrators at 126 secondary schools in eleven countries completed surveys. The survey instruments, administration documents, and frequently asked questions can be found in the Appendices.

[16] UNESCO Asia and the Pacific Regional Bureau for Education's excellent e-book Integrating ICT into Education offers expanded considerations that focus on systemic issues such as the broader environmental context, policy and regulatory environment, monitoring and evaluation. http://www.unescobkk.org/ips/ebooks/documents/ICTLessonsLearned/index.htm, last accessed June 25, 2004.

[17] With respect to the actual numbers, because most variables were discrete – usually ranging from 1 to 5 – variation was small. To account for the discrete value range of the dependent variables, ordered probit estimations were used.

Figure 1



Organization of Survey Results
The survey results are organized into the following 15 categories:

1. School Environment and Respondent Demographics
2. Infrastructure
3. ICT and Network Infrastructure
4. ICT Access
5. Attitudes and Perceptions
6. Teacher Training and Professional Development
7. Educational Content and Software
8. Teaching Pedagogy and Computer Use
9. Gender
10. Community Involvement
11. Policy Issues
12. Costs
13. Other Challenges
14. ICT Use
15. Effective Use/Perception of Impact

In each of the above sections, the results are presented along with some of the key headlines/findings of the survey under the respective heading. At the end of each section, policy recommendations are also provided.

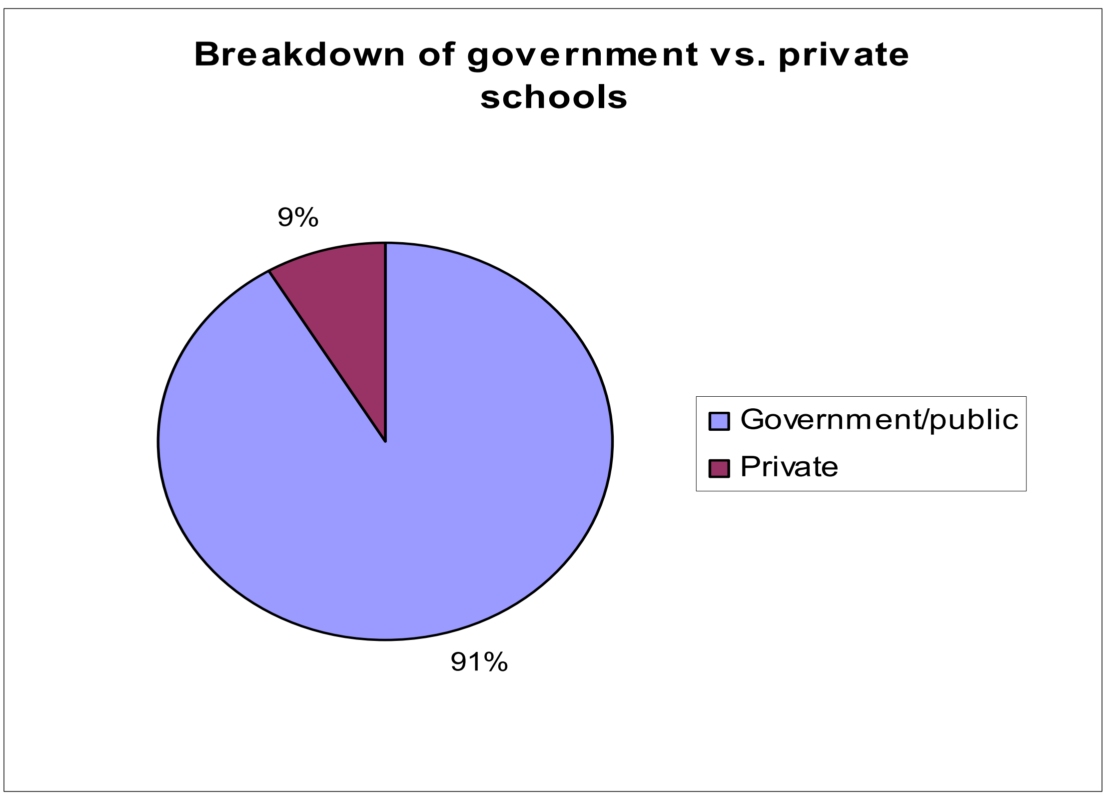
1. School Environment and Respondent Demographics
Relevant characteristics include funding and governance, geographic setting, student-teacher ratios, average class size, teachers' experience, subject matter background, and gender distribution in the schools.

As these demographics can potentially influence use and effective use of the technology, the report analyzes the characteristics of the school environment (including the individuals it is comprised of and managed by), thereby gaining a better understanding of the elements that are most conducive to successful adoption of computers and technology into learning practices. With this goal in mind, the survey was designed to systematically collect data about characteristics of schools and their student/teacher body that could affect patterns of ICT use.

Public and private schools have similar computer use levels

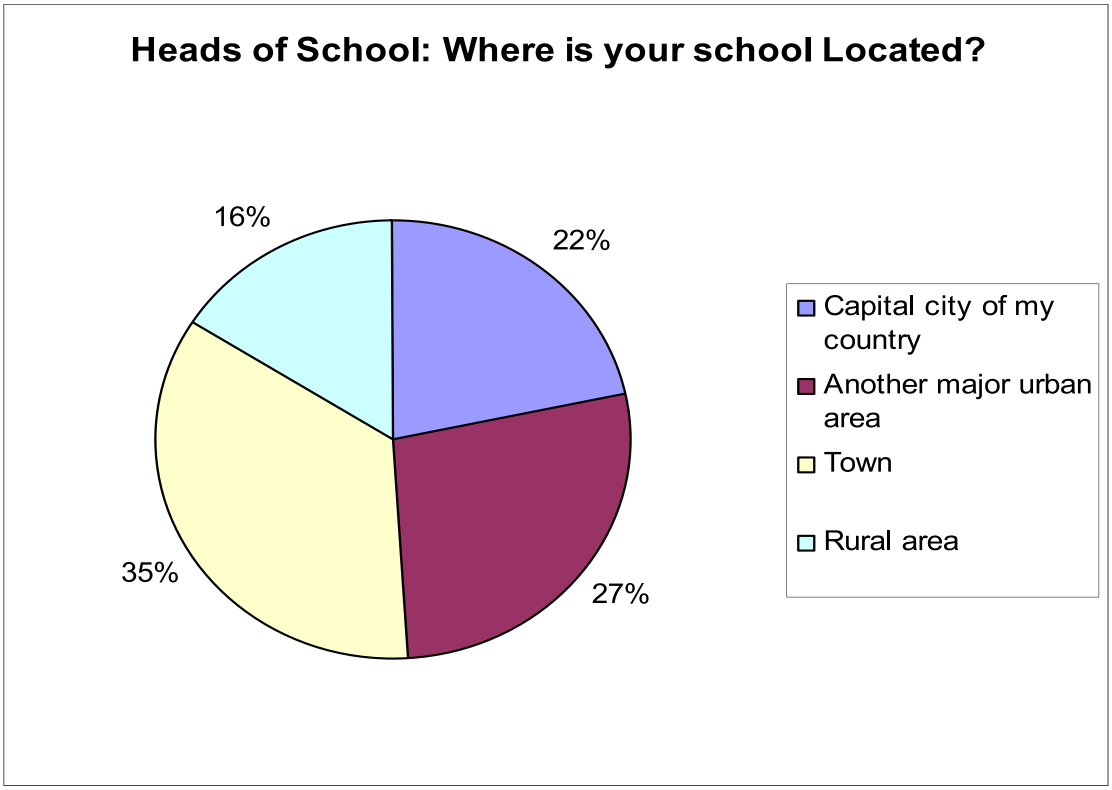
The sample schools included in the survey were primarily government-funded secondary schools. Ninety-one percent of surveyed schools were publicly-funded, and 81 percent of schools were secondary or shared primary and secondary schools. While the sample of private schools is a little less than 10 percent, the data revealed that private and public schools report comparable levels of computer use. Private school students tended to use the computers more for math, science, and social studies than did public school students, but the overall level of use was the same. This result suggests that even in schools that are assumed to have different resource levels, there remain similar challenges to effective use in teaching and learning in all schools.

Figure 2



In the majority of the schools surveyed (78 percent), the average class size varied between 25 and 49 students per class. These relatively small class sizes indicate that the schools surveyed had a better resource base than the rest of schools in the country. That being said, the survey did obtain a diverse sample of rural and urban schools; only 49 percent of the schools were located in the capital city or another major urban area. More than half of the respondents (51 percent) came from a non-urban school identified as either a rural area (35 percent) or town (16 percent).

Figure 3



Gender representation in the student survey sample was nearly equal, with girls forming approximately 53 percent of the sample, while 66 percent of the teachers were women. The students were primarily of secondary school age, with 45 percent of respondents between 13 and 15 years old, 35 percent of respondents aged 16 to 18 years (15 percent aged 10 to 12 years, and 5 percent over 19 years of age).

The majority of the teachers surveyed (59 percent) were from the Science (28 percent) and Math (31 percent) fields. The next largest groups of teachers taught local or national languages (23 percent) and Social Science/History (23 percent). Other subjects include Art (7 percent), Computers (6 percent), Literature/Humanities (14 percent), Other languages (10 percent), Music (3 percent) and Other subjects (19 percent).

Sixty percent of the teachers surveyed indicate that they teach students between the ages of 13 and 15 years of age. Thirty-five percent of teachers reported having 11 to 20 years of experience while almost a quarter (24 percent) reported five years or less of teaching experience.

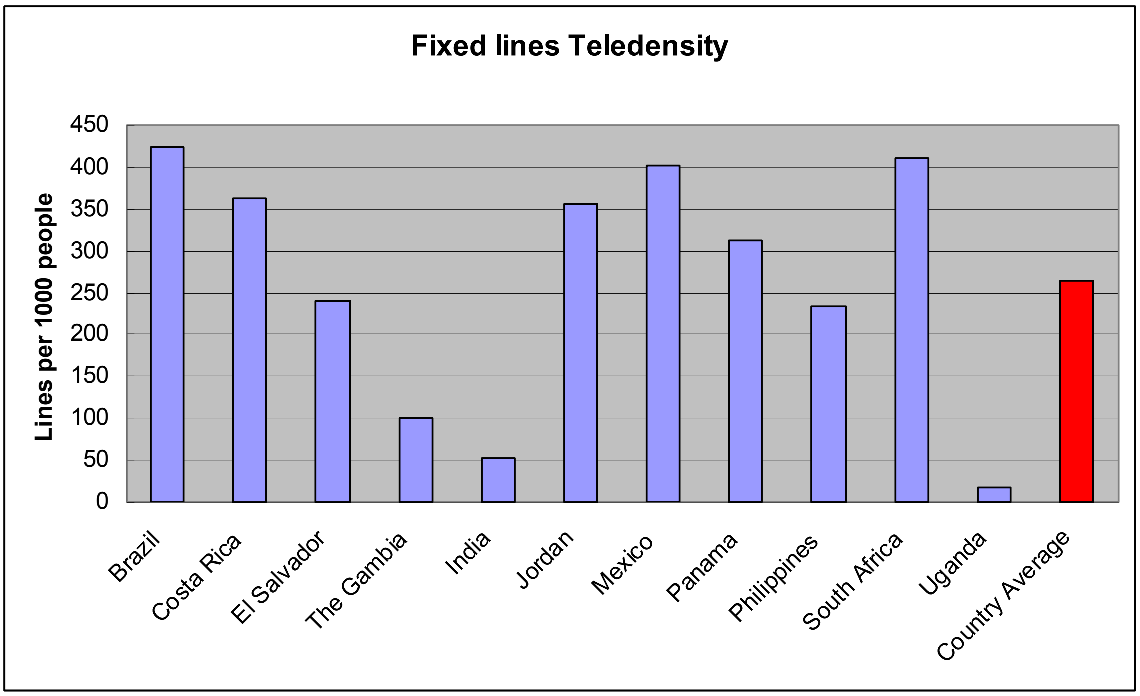
Finally, computer use among teachers is relatively limited. Forty-six percent of teachers have two years or less of experience using a computer while 31 percent report four years or more of computer use.

2. Infrastructure

Inputs and conditions that are important for ICTs in schools include reliable electricity supply, physical security, and number of telephones per person (teledensity) as a proxy for external communications infrastructure.

The report takes the number of fixed phone lines per population as a rough proxy for the level of development of the communications and other national infrastructure. The country with the highest fixed line teledensity was Brazil (424 per 1000 people), while Uganda had the lowest teledensity (18 per 1000). The average (not weighted by population) teledensity across the 11 country sample was 265.

Figure 4



High wireless teledensity among teachers: 63 percent own mobile phones.

The boom in mobile telephony is owed to numerous factors including lackluster competition and performance within fixed line phone markets, speed of mobile telephone activation, as well as the particular mix of services commonly available for wireless users (pre-paid calling, short-messaging service, mobility and ease of access). Technology pundits have long predicted that handheld wireless communications are the most likely avenue for widespread Internet access in the developing world due to cost, ease of use, low power consumption and other considerations. The significant level of teacher adoption of these devices may offer clues about educators' willingness to adopt new technologies, and the future potential for expanded use of mobile phone devices for teaching and learning.

Electrical infrastructure is not a major problem in schools surveyed: 84 percent of schools report having more than 9 hours of electricity per day.

Infrastructure affects learning: Students in schools with more hours of electricity tended to show improvements in computer-mediated literacy and learning.

Electricity access in the schools surveyed was not a major problem. Ninety-eight percent of the schools surveyed got their electricity from the electrical grid as opposed to alternative means such as a generator, a UPS system, solar, or wind energies. These findings suggest that government ICT and education programs have focused efforts on those schools with the requisite infrastructure and have not actively sought to include the most rural and disadvantaged schools as yet.

Moving forward, it will be important to undertake a deeper exploration of other infrastructure indicators, looking both at the data generated by other respondent groups to pick up effects observed within the school setting, and introducing alternative quality and reach measures for national level infrastructure such as electricity transmission loss, radio and cable television penetration. As a complement to national infrastructure measures, indicators of particular schools (size, class size, location) or school systems could offer valuable insights. Of particular interest is determining whether the teledensity measure (and like measures) is actually picking up attitudes or some other non-physical characteristic, or if it indeed reflects the robustness of the nation's infrastructure. In terms of electricity, a measure of users' expectation of energy availability (i.e., do they expect it to work?) would be important in distinguishing the effect more clearly (e.g. limited electricity supply is not viewed as problematic if the outages are at consistent times, or people have low initial expectations, whereas users with high expectation for energy availability could be frustrated by even minimal outages if they have not been anticipated and planned for).

Infrastructure affects attitudes: Both teachers and students in countries with higher teledensity rates tended to have better attitudes towards PCs.

Infrastructure affects use: Students in countries with higher teledensity rates tended to use PCs more both in general and for academic purposes.

The analysis of the data indicates that the effects of teledensity are significant in terms of both attitude toward computers and use of computers, but diminish as teledensity rates increase. At face value, this seems logical: the change from few phones to some phones seems like a much bigger change than from many phones to even more phones. With this range of teledensity in the countries sampled, the impact is indeed relevant.

It is not clear which effects the teledensity measure is capturing – the actual state of infrastructure (noting the inclusion of other factors such as electricity and computer network reliability in the models), experiences and attitudes about communication, or some other factor. As with most national measures, there is likely to be significant variation across settings within a country, so we can surmise that the measurement does not reflect so much a local reality, but more of a national one.

Policy Implications

According to the survey, the vast majority of the schools have access to electrical infrastructure through the national power grid. This suggests that ICT for education programs are not yet actively seeking to include the most rural schools in the program, which in many of the survey countries have significantly less access to electricity.[18]

While this may be an effective approach in the initial stages of integrating ICT for education, government policymakers should consider strategies to actively promote the inclusion of the most rural and poorest schools in their national school networks. These are often the schools with the greatest need for the access to new materials, interaction, and new pedagogies supported by ICT. They are also in some of the communities facing the greatest socio-economic challenges. Pilot projects with the use of alternative energy sources such as solar or wind power coupled with appropriate low-energy consuming computing devices may be a solution. From a policy and funding perspective, many governments and aid agencies are eager to integrate schools in more remote communities into emergent community access models (such as telecenters). Also, with the relatively high rate of mobile phone use, government programs could consider how to more effectively tap this infrastructure – perhaps through store and forward technologies designed for wireless phone networks.

3. ICT and Network Infrastructure

Computer and Internet infrastructure is not sufficient for integrating ICT in schools, but it is necessary to serve as a platform for educators and learners to access and produce new materials, interact across distance, and collaborate innovatively. The quality, reliability, and nature of the devices and services that students and teachers use are core concerns.

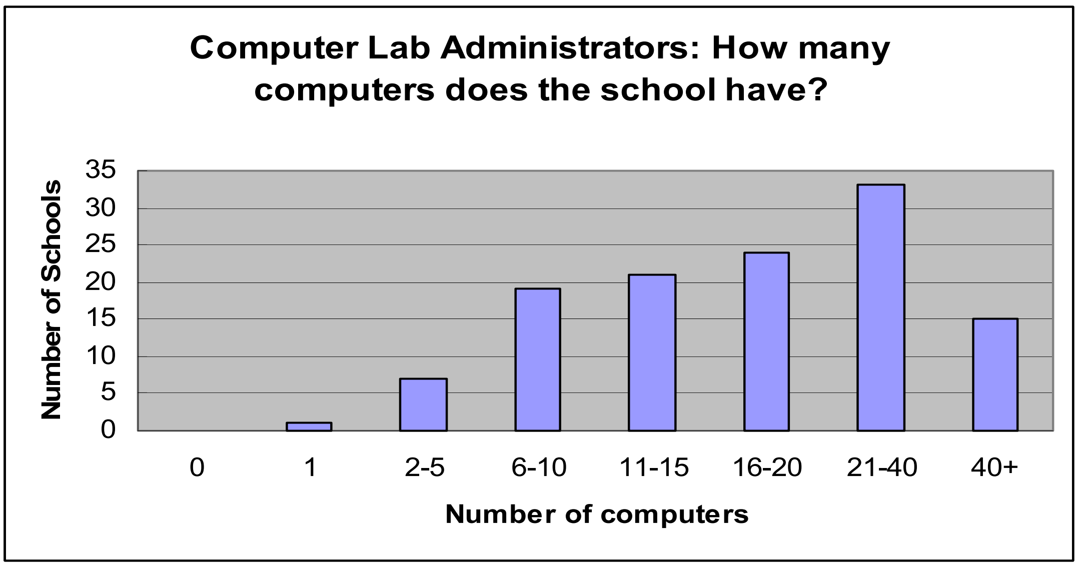
> **Computers are new to schools: 55 percent of schools surveyed have had computers for less than four years.**
>
> **Administrators also have limited ICT infrastructure: 42 percent of schools had computers in administrators' offices.**
>
> **Forty-seven percent of schools have between 16 and 40 computers available.**
>
> **Newly purchased or donated computers are the primary source of computing in schools.**

[18] Because of the non-random nature of our school samples it is possible, although unlikely, that these schools are being included in ICT for education programs.

ICT and Network infrastructure for schools in developing countries is still a very new development. The typical school in the survey sample received computers within the last four years and has placed these computers in a computer lab with a dial-up connection to the Internet. The typical survey school has a total of approximately 14 computers, which were purchased new and predominantly use the Microsoft Windows operating system. The schools average over 40 students per class. Non-instructional computers are often available for administrators in their offices. These characteristics are reported by these *typical schools*, which it should be noted, are actually towards the "leading edge" of ICT in education within their national settings. This suggests that the truly typical school in these nations has less experience (if any) with ICT infrastructure.

Of the computers available in schools, the survey indicates that the majority are either new computers purchased by the school or new computers donated to the school. Only 10 percent reported that they had purchased used or refurbished computers and only 26 percent reported having received donated used or refurbished computers.

Figure 5



Internet access is even newer to schools: 87 percent of schools have had Internet access for less than four years, and 56 percent have had it less than two years.

The Internet is not always on: 45 percent of all connections in schools were dial-up.

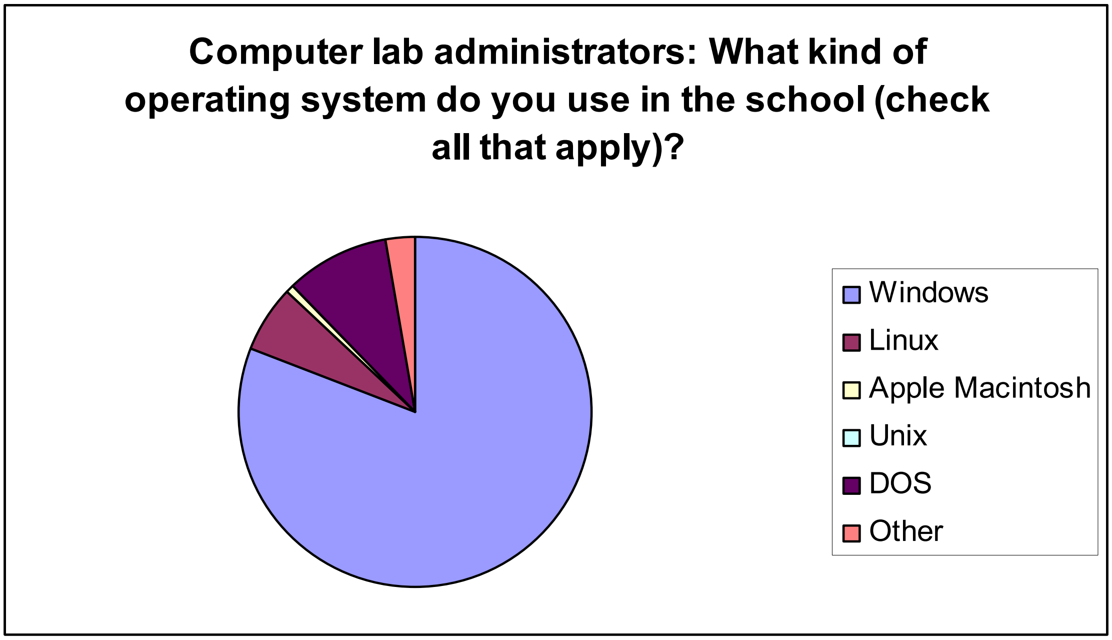
DSL connections represented the most popular broadband choice for schools: 14 percent of schools report DSL connections, more than ISDN, cable modem or wireless.

Connectivity in the schools is new, extremely limited in terms of bandwidth and not widely available throughout the system. As discussed later in the paper, this limited connectivity affects the pedagogical uses of the technology in the classroom.

Ninety-eight percent of schools use Microsoft Windows operating system.

Finally, the survey showed the marked total absence of open source software in schools, despite its significant promise due to less resource intensiveness, low/no cost, capacity for localization and customization, and other perceived benefits.

Figure 6



Classroom integration is severely lacking: Less than 7 percent of schools surveyed have computers in the classroom, while 94 percent have computers in a laboratory.

The vast majority of the schools have yet to get the technology out of the lab and into the classroom. This concentration occurs for a variety of reasons, including limitations on physical facilities, infrastructure, ICT equipment, teacher/facilitators, security, as well as other organizational and management decisions.

Reliability improves attitudes: Network reliability improves students' attitudes towards PCs, but only matters when the network is "usually" or "always reliable".

Network reliability is more important to students and teachers than network speed.

In the analysis of the data, network reliability emerged as an important factor for student attitudes toward computers, use of computers, and perceived impact of computers. Network reliability was significant and positively correlated with student use of computers both generally and for academic purposes. Improvements at the low end were not important however, with the benefits appearing in improvements from the schools' Internet connections working "sometimes", to working "usually" or "always". Network speed was also significant and a positive determinant of computer use, though the effect was smaller. This analysis suggests that reliability may be more important than speed. Another important element for consideration may be the distinction between dial-up and always-on connections.

Policy Implications

While it is important to note that the expected impact of increased Internet access is unknown (and dependent on other factors such as the believability of content that are mentioned subsequently), assuming policymakers wish to continue to broaden the number of schools with access to ICTs as well as the availability of ICTs in each school, the data offer insights into where they might begin. Policymakers will want to investigate ways in which to make actual classroom infrastructure more robust and flexible. With less than seven percent of the schools reporting computers in the classroom, common objectives such as the integration of computers and Internet across the curriculum are constrained. For instance, the adoption of wireless networks and mobile laptop computers in schools would allow computer and or Internet access from any classroom, while addressing other challenges such as inconsistent power supply and physical security. This is relevant because, as discussed subsequently, classroom access was associated with increased use, which supports learning and skills improvements. A cost-benefit analysis of this approach would need to be considered.

The data indicate that network reliability is a more important factor for use and attitudes than data transmission rates. As a result, policymakers may wish to focus their attention on reliability of the network than on its speed. Additional resource allocation for a lab technician or for technical support services to ensure that the technology is working consistently may be a better investment than a faster connection to the Internet. This is not to say that dial-up connections are more appropriate, because they tend to be both expensive and may present additional access barriers. It should be noted here that the effects of Internet access and use were mixed, and that the need for increased network investment is not explicitly supported by the data, but mentioned as a reflection of commonly-held policies.

The data suggest that very little attention has been given to alternative, cheaper sources of hardware and software, despite notable promise.[19] Policymakers should more intensively canvass the opportunities to source used and refurbished computers from the private sector, parents, or school alumni to increase the overall ICT infrastructure. There are also non-profit organizations such as World Computer Exchange and Computer Aid International which provide a range of services including access to low cost used computers and support.[20] Moreover, research and pilot tests with open source software should be implemented to better understand the pros and cons of deployment of open source software versus proprietary software. While the survey did not solicit information on portable computers, it would be worthwhile to

[19] See Community - Government Partnerships and Open Source Technology for Low Cost IT Access in India by Daryl Martyris at http://topics.developmentgateway.org/elearning/rc/ItemDetail.do?itemId=340485, last accessed September 15, 2004.

[20] http://www.worldcomputerexchange.org and http://www.computer-aid.org

ascertain whether mobile devices are widely used, and if they show promise in addressing location, security, and energy barriers.

4. ICT Access

An important determinant of use is the ability to actually get physical access to computers and the Internet, including whether ICTs are available in school – in and out of class hours, as well as other access points such as home or cybercafés.

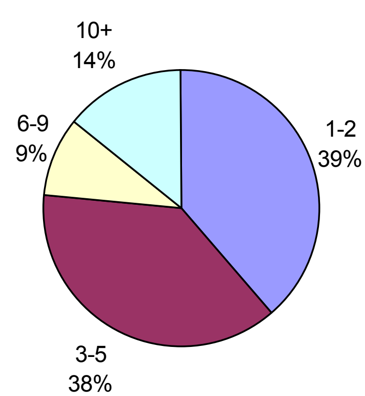
Access to computer hardware for both teachers and students is a major issue across the countries surveyed. The principal factors reportedly limiting access are the number of computers available compared with the number of potential users, the hours in which the labs are open, and the availability of out-of-school options for using computers (home, friends, Internet café, etc.).

Most schools report at least three students sharing each computer.

With best guesses of approximately 42 students per class and 14 computers per school, typical teachers must structure lessons so that at least three students share the same computer. While anecdotal experience suggests the commonality of this experience globally, it is also supported by the sample with 38 percent of schools in this survey reporting 3 to 5 students per computer and almost a quarter (23 percent) with more than 6 students per computer.

Figure 7

Computer lab administrator: On average, how many students share a computer?



Teachers and Students report, "too many people, not enough computers."

Teachers and students emphasized as a major challenge or concern the fact that their school had too many people and not enough computers. As will be discussed subsequently, the impact of a higher student to computer ratio is not clear and may actually be positive on teachers' views of impact on school, student use, and improvement in verbal skills. It is unclear whether this can be attributed purely to hardware deficits, resource management or other factors.

Figure 8

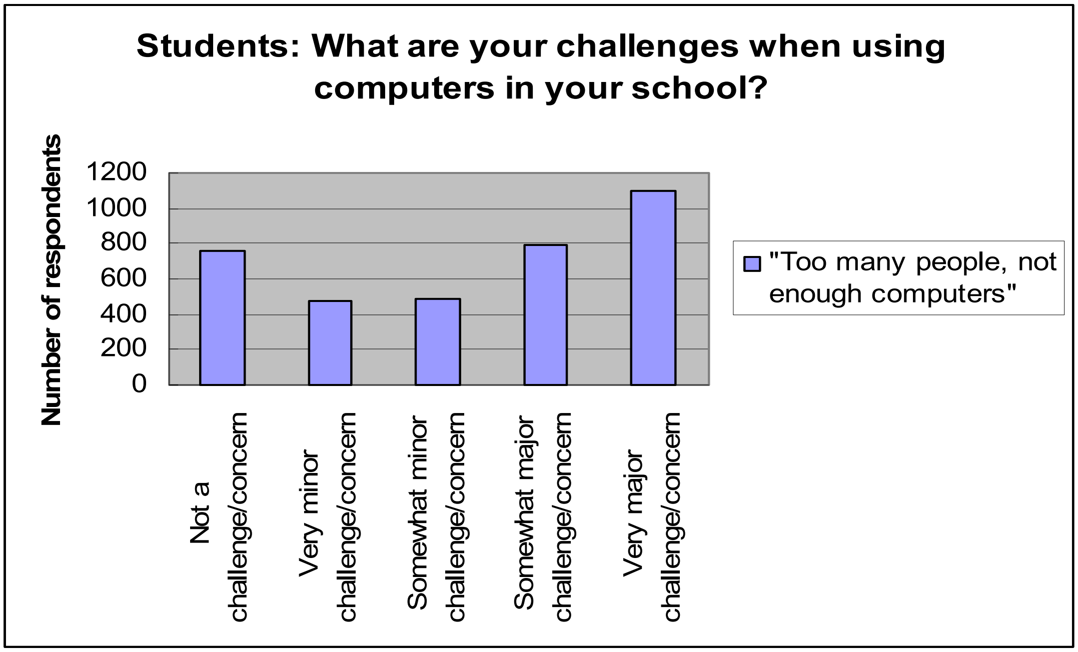
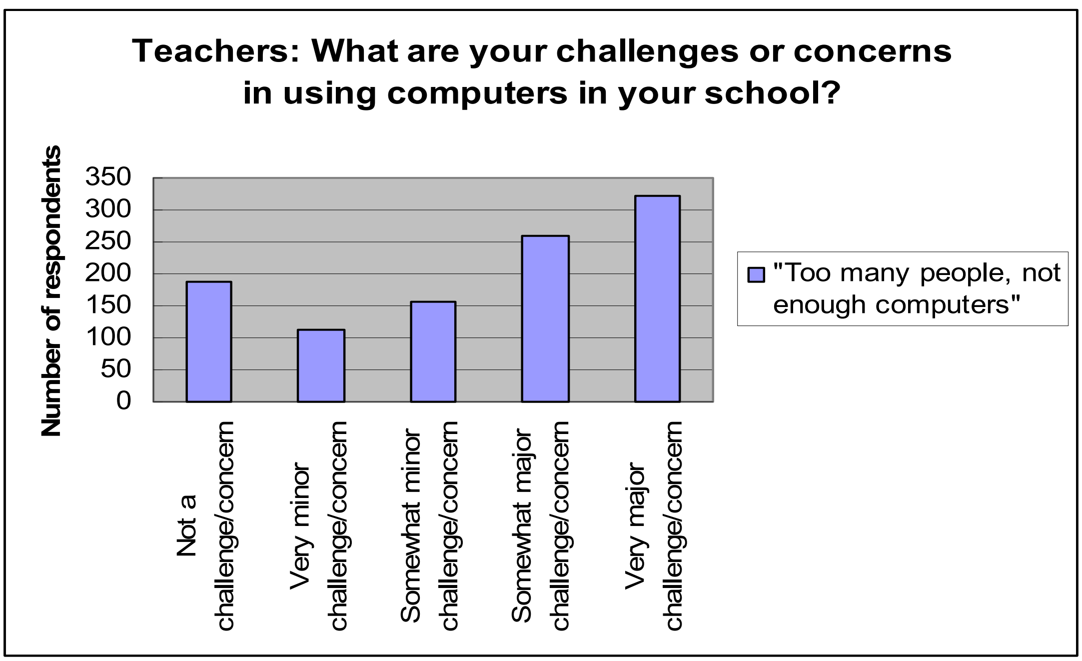


Figure 9



Forty-one percent of students report wanting to access computers outside school hours, but being unable to do so.

Access to computers after school hours is limited: 63 percent of schools are not always open after school hours to students and teachers, and almost half report they are never accessible after hours.

Beyond the challenge of the sheer numbers of individuals to serve in a school with limited resources, another key access concern has been the number of hours after school that students and teachers can access the lab. Anecdotal experience around the world reveals that many administrators close the computer labs when they are not scheduled for use as part of the school day. Reasons range from the cost to hire a lab administrator to fear of excess use of the machines and increase chance of wear and tear. The effect of out-of-school access is discussed subsequently.

Frustration hurts attitudes: Students who were unable to access school computers outside school hours have worse attitudes toward ICTs.

Students and teachers alike report wanting to use computers after school and not always being able, but among students these challenges accompany worse attitudes towards computers. While that may be as a result of frustration, improved student access to computers outside schools hours is actually associated with less overall in-school use of computers. Interpretation of this result is unclear, but may be that the lower levels of school use drive administrators to open labs after school, that the scarcity principle is important to students, that the extra access is sufficient for their needs, or that outside access is preferred for other reasons such as less supervision.

Most students do not use computers/Internet at home or Internet cafés: 60 percent of students do not use computers/the Internet at home, and 52 percent of students never use them at an Internet café.

The study illustrates that levels of use of computers outside the school environment are also extremely limited, with students rarely using computers at home or in other venues. The fact that over half of the students surveyed have never used a computer in an Internet café suggests that public access points are limited or non-existent, costly, and/or socially or culturally restricted, to the extent that they combine to limit students' use of these venues. While it is possible that students may simply not be very interested in computer use outside of school that seems unlikely given the overwhelming majority of students who report that they like computer class, and that their fellow students have positive attitudes towards computers. Further research on these limitations is required, as well as experimentation with the availability and use of computer labs after school hours.

Teacher use outside of class hours is low: 62 percent of teachers surveyed indicate that they do not use computers outside of class hours; while 35 percent of those teachers indicated that they would like to use the computers outside of class.

With almost half of the teachers reporting that the labs are only sometimes accessible after school and 18 percent reporting that they are never accessible, it is unsurprising that teachers report low levels of computer use outside of school hours. These data may reflect teachers' own very limited time to use computers outside of the school day. The finding that only 22 percent of teachers would like to use a computer after school hours may highlight an environment in which teachers simply do not have the time or perhaps even interest to take on more responsibilities outside of the classroom.

Policy Implications

In-school access to computers and the Internet remains limited with only approximately one-third of all schools reporting they were always open after school hours (and one-fifth never open after school) and only one-third open to the community. The fact that these facilities and this infrastructure are not being utilized more completely by teachers and students (and perhaps the community) when most feel there is an access deficit, suggests that infrastructure and access resources are being squandered.

It is important to note that the analysis did not find that limited out-of-school access was necessarily a detriment to teachers or students and in fact was associated with lower in-school use. Recommendations therefore to open labs are not based on statistical evidence. Objectively, however, the majority of the cost of a computer lab is ICT infrastructure and Internet, which in many cases depend little on the actual use level, and more on the period of service. So when computers sit idle, and a broadband connection goes unused in the evenings, over weekends and during holidays, the scarce ICT resource is wasted. Future monitoring and evaluation will be important to determine how these resources are best used, and whether they can be employed to increase use, learning and impact of ICT on education.

Policymakers may consider additional school support for a lab technician to stay after school hours to allow better access. Other solutions may be undertaking creative scheduling, or opening labs to the broader community (possibly on a fee basis or by using volunteers), which will assist school leaders to better leverage the ICT infrastructure they already have. The survey did not consider vacation periods, but utilizing the facilities during these periods could also create substantial value for the school and its community. There are, of course, increased challenges that arise when a larger pool of users is given access to a school's computers, including greater risks to the security of the equipment, added wear-and-tear, and possibilities of virus infection, all of which should be taken into account before any decision is made.

5. Attitudes and Perceptions

Students', teachers', administrators', and parents' attitudes and perceptions of the role, importance, and ease of use of computers and technology play a significant role in the adoption and diffusion of new technologies.

> **Students like computers: students estimate that 79 percent of their peers like using computers in their classes, including 49 percent who like using them "a lot."**
>
> **Students view computers as important in improving their studies: 68 percent say computers had made them a better student.**

Computers increase interest in school: 65 percent of students see computers as contributing to their interest in school.

Computers are key for employment: 79 percent of students say using computers in school is fairly or very important for their future jobs.

The attractiveness of computers for students cannot be disputed, but perhaps the biggest question is whether schools are leveraging the appeal to improve learning opportunities and student commitment. The vast majority of students (87 percent) reported that they like computer class – with 63 percent reporting that they like computer class a lot, but how this relates to achievement is unknown. Further data gathering is necessary to understand whether interest translates into higher attendance and graduation rates, for instance. While student perception of the importance of computer use for employment is not necessarily an indication of the value of technology to help them get ahead through increased productivity (although it may well be), it is an important contributor to their likelihood of adopting this technology over time. A more detailed picture could be created with the addition of other indicators of student attitudes towards the utility of ICT and its ease of use, for instance.

Students prefer teachers: those who learned about computers from their teachers have more positive attitudes towards computers, and use them more.

The association of positive student attitudes with teachers over friend and family members confirms that teacher engagement is a key component of students' attitudes towards ICT, and reinforces the central nature of the teacher's role in the classroom. Between the movement towards learner-centered approaches, fears that students will learn computers faster than their teachers, and the difficulty in offering effective teacher training, many have questioned the role and efficacy of teachers in the classroom. Indeed, teachers themselves who have worried about being replaced by technology should be buoyed to know that they are reported as the best source for learning about computers.

As mentioned in the ICT access section, students who wish to use computers outside school hours but were unable to, tend to have worse attitudes towards computers. They also actually use them less frequently. There may be some bi-causality in the area of actual use, but the less positive attitude could result from some level of frustration attributable to access issues (real or perceived).

Teachers report that 80 percent of students strongly like computers.

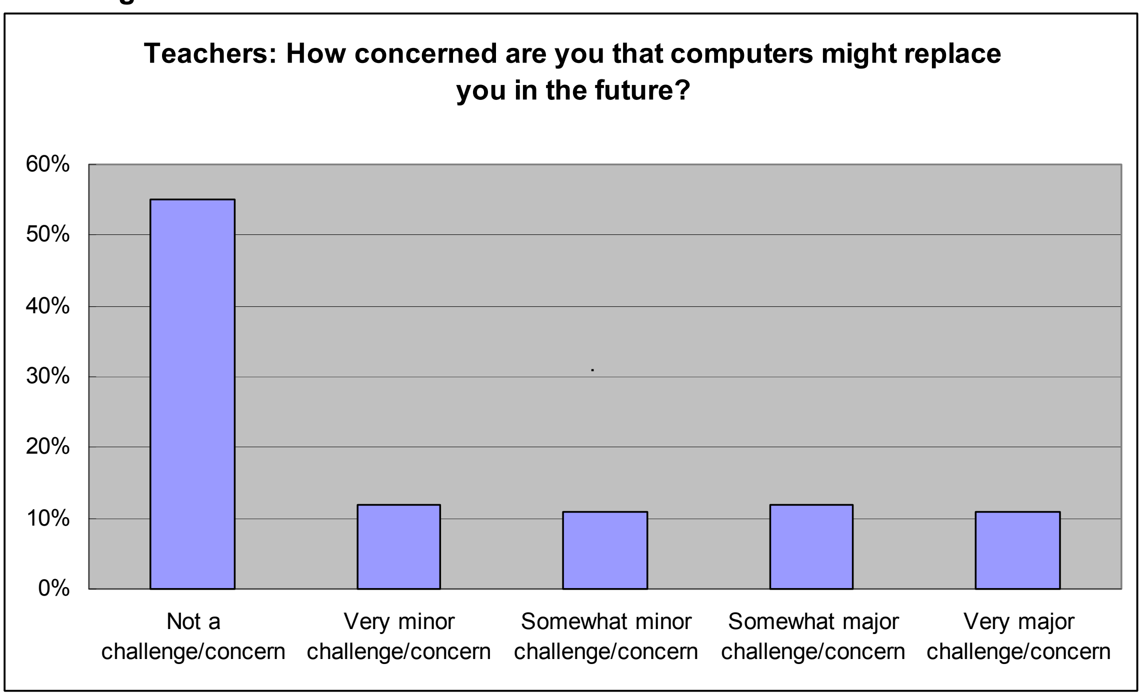
Teachers and headmasters both identified students as strongly liking computers, both within the context of other courses and in terms of computer class. Teacher attitudes toward computers are similarly strong. The vast majority of teachers surveyed like computers (81 percent) and report that their peers also like computers (76 percent). The survey however also revealed that either a smaller group of champion teachers exists in each school (borne out by anecdotal evidence) or that they underestimate other teacher's computer affinity. When teachers are asked if they themselves "strongly like" computers, 42 percent responded. However, when asked if other teachers "strongly like" computers only 20 percent responded positively.

Teachers enjoy doing what they know: Teachers with more computer experience had better attitudes towards them.

When teachers feel they face career or confidence challenges due to computers, their attitudes towards them tend to be worse.

The survey results indicate that teachers with more computer experience have better attitudes towards them, which may be explained by teachers who like computers using them more, or by teachers who use them more, liking them more. Depending on the direction of the potentially bi-causal relationship, this may be a promising finding with regard to the future possibilities for more effective curricular integration through increased training. If the relationship between student use and attitudes, learning, and skill development are an indicator, greater use would drive improved attitudes. The data also reveal a strong connection between confidence and teachers attitudes. Just as those teachers with more experience with computers have better attitudes, those who feel threatened or less confident have worse attitudes, again suggesting the importance of use and training.

Figure 10



Believability of Web-based information influences students' and teachers' attitudes towards the Internet.

Increased Internet use and accessibility was associated with negative attitudes and learning outcomes when students and teachers thought information on the Web was not trustworthy. One important clue may lie in the fact that the effect tended to be strongest when students thought information on the Web was not accurate or believable and was actually slightly positive when students thought information on the Web was accurate and believable, perhaps suggesting that technical difficulties and content doubts can reinforce each other. This relationship underscores the importance of ensuring skills in evaluating the veracity of Web-based information, including the opportunity to draw from trusted sources.

Teachers who work with young children have worse attitudes toward computers.

The fact that most teachers use computers for word processing and spreadsheet work, may partially explain this result, suggesting that teachers simply do not see the applicability of these skills for very young students. This also reveals the issue that computers may not be fully utilized for the development of creativity and exploration to the extent that they could be -- areas that would be more applicable to younger students. Another possibility is that there is simply not enough quality software and content for younger students in developing countries.

Computer teachers report worse attitudes toward computers than other teachers.

One possible explanation for this curious finding is computer teachers' attitudes is that they may expect more from their computers (and likely rely on them more in class). The perceived educational value-added may be lower for a computer teacher than a geography teacher, for instance, who with an Internet connection can suddenly access not only a map for any country in the world, but a world of other information including images, sounds and data. Because many schools have only a few teachers who are adept at using technology in learning, there are also questions about the role of the computer teacher in supporting colleagues, as well as their view of their colleagues' effectiveness.

Teachers who had taught themselves about computers had significantly and strongly more positive attitudes towards computers than did those who were taught in other ways.

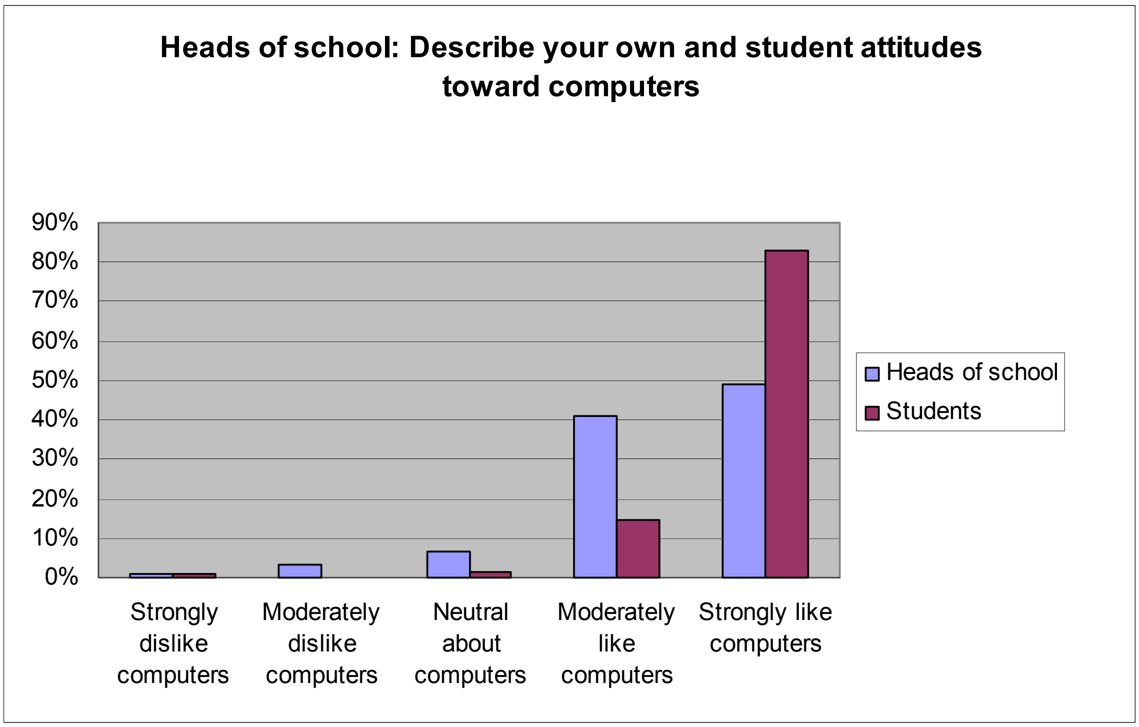
While there is likely to be a degree of self-selection or bi-causality in this finding, it is important to note the correlation between entrepreneurial and motivated teachers (with at least some affinity for technology) and positive attitudes. These results suggest the importance for school heads to create an environment where teachers are encouraged and allowed to explore and learn on their own. However, it should not be interpreted as suggesting that teachers do not require training or ongoing support in using computers and the Internet – refuted by additional analysis suggesting that teachers with formal ICT training tend to report higher levels of student use.

Headmasters report that 98 percent of students like computers and that 83 percent of students strongly like computers.

Headmasters overwhelmingly positive about computers in their schools: 90 percent report liking computers, 93 percent report computers improve teaching, and 97 percent report an overall positive impact of on the school.

As the key driver of any successful school level ICT implementation, headmasters act as change agents and are responsible for encouraging and supporting teachers to effectively use technology for their classes. Their positive perceptions of the overall impacts of ICT on the school and on teaching, the positive attitudes of others in the community, and the value they ascribe to computers in running the school can be important influences in fostering school-level adoption and integration of ICTs.[21]

Figure 11



For all groups: attitudes matter and are "contagious".

Regression analysis was used to better understand the possible causes for more positive attitudes of teachers and students toward computers. Not surprisingly, it was found that students' attitudes are strongly linked to teachers' attitudes, i.e. the more positive the teacher is, the more positive is the student. Also, the data indicate that teachers' attitudes toward computers are linked to the attitudes of others in the school community – teachers report more positive attitudes towards computers when students, parents and administrators also report positive attitudes toward technology. The analysis also reveals that attitudes of parents and students are significantly correlated with teachers' perceptions of the impact of computers on their school.

[21] As suggested by numerous variations of the diffusion of innovation theory pioneered by Everett Rogers.

When a teacher is positive about how to effectively use the computer for teaching and learning, this attitude ripples throughout the school community.

It is important to note that in all of this analysis, a bi-causal relationship is likely. The risk of endogeneity means we cannot make conclusive statements about the effects of attitudes on the impact of computers on a school, other than to say that there is a statistically significant relationship between them. Key next steps would include tracking attitudes over time, possibly helping to establish some causality, or at least a better explanation of what might be occurring with better granularity.

Policy Implications

The survey reveals that computers and ICTs are seen by teachers, students and heads in a very positive light. Headmasters and students have largely very positive attitudes toward computers and view computers as having a positive impact on the school environment, teaching and future job prospects. From a policy standpoint, this is a very encouraging sign and bodes well for use of computers as a potential catalyst for broader change in schools. If students, teachers and headmasters are largely positive toward these new technologies and experience gains from them, they may be open to some of the administrative, curricular, and pedagogical reforms that computers could facilitate at the school level.

With the indication that even early-on in the integration process, computers are largely seen as a positive force in schools, a larger and deeper scale-up of ICT for education projects in developing countries appears likely to be seen as a positive development. Where teachers reported less favorable attitudes to ICTs, the analysis revealed a strong correlation with their own confidence in using technology, fears that the new technology may threaten their jobs and uncertainty about the quality of information on the Internet. Policymakers can directly address these fears through constructive professional development that emphasizes the teachers' central role in the teaching and learning process, as well as strategies that directly address perceived information quality deficits. Basic computer literacy training can also boost teachers' confidence in what can be a daunting new tool for those who have never touched a computer. Finally, the findings about the negative attitudes of teachers for computer use among young children is novel and requires additional research to determine whether greater efforts should be made to introduce new technologies in earlier stages of school, or whether policymakers should continue to focus their energies with introduction of new technologies at the secondary school level.

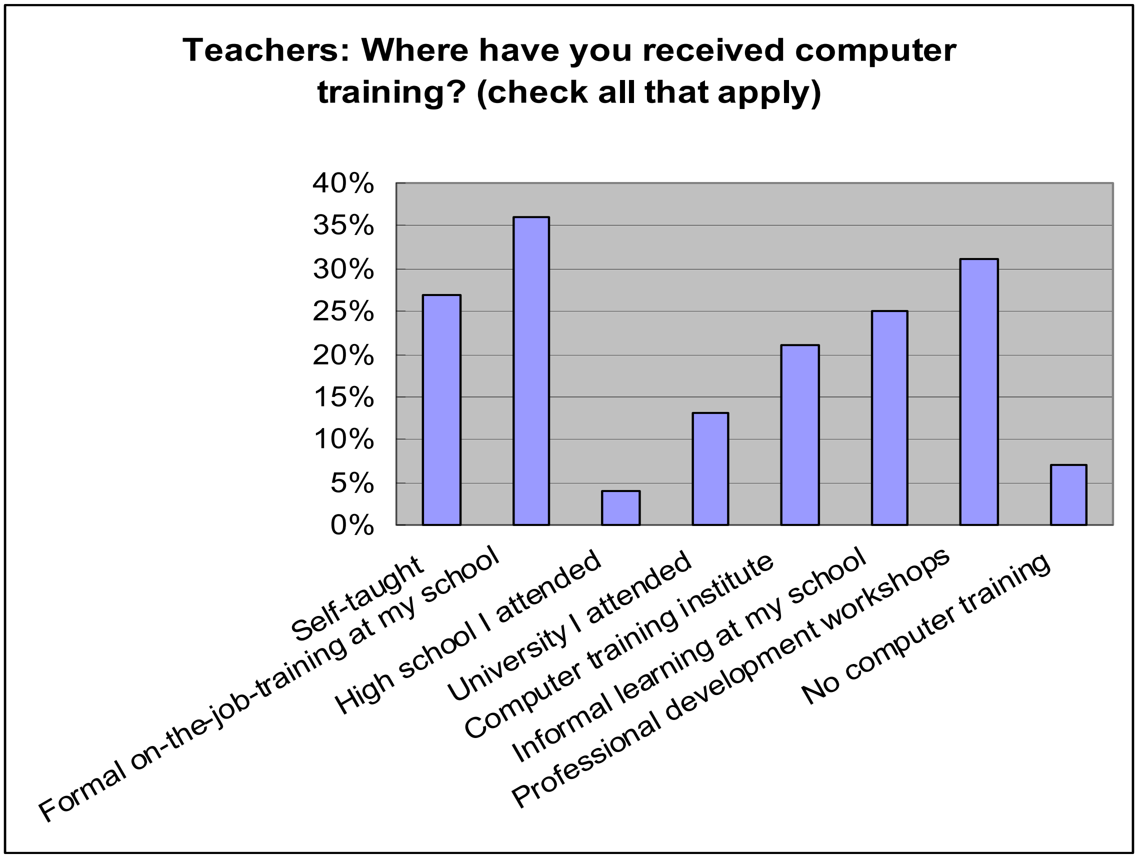
6. Teacher Training and Professional Development

Teachers' preparation and support in the integration of ICT in school is a fundamental challenge on substantive grounds as well as in terms of generating positive attitudes and orientation towards to the process. Considerations include professional development opportunities and policies for teachers, areas of formal and informal support to teachers, and the overall work environment.

> **Formal training is common, but reaches less than two-thirds of teachers.**

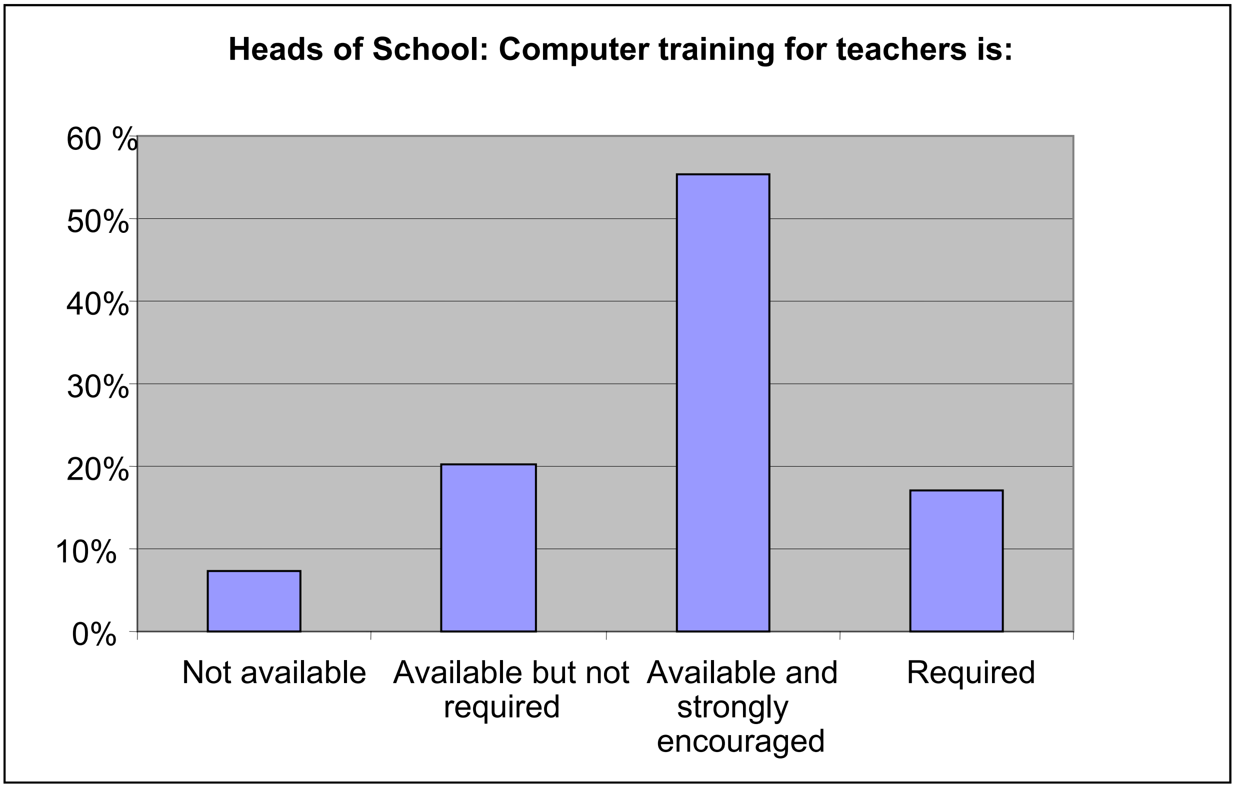
In terms of actual professional development activities, a total of 61 percent of teachers report participating in formal professional development either in workshops or on the job training at school. Not mutually exclusive from formal efforts, a significant number of teachers report using informal means of professional development, with 27 percent having taught themselves and 25 percent receiving informal training from others at their school.

Figure 12



In a numeric (but not statistical) sense, the level of professional development that teachers report appears fairly consistent with headmasters reports of professional development policies for teachers with respect to computer training. Fifty-five percent of heads-of-school indicate that it is "strongly encouraged" and 17 percent note that it is required. While it may be strongly encouraged, the low numbers of teachers reporting formal professional development opportunities beg questions about whether there are adequate incentives for training, whether opportunities are offered frequently enough, whether the format, duration or timing is appropriate to teachers, or if other potential barriers exist.

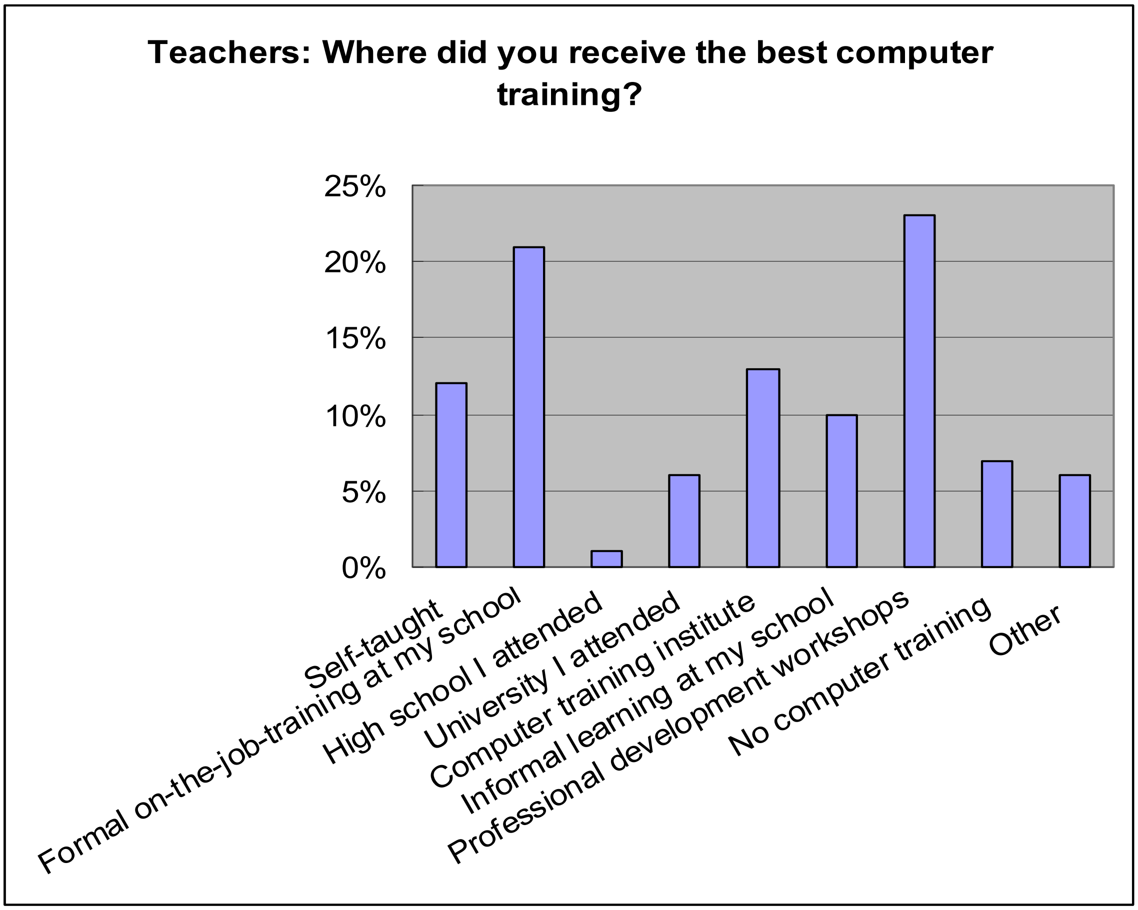
Figure 13



Teachers identify formal professional development as being of high quality.

The formal development opportunities were the most popular forms of training, with by far the highest percentage (44 percent) of teachers having received their "best" training from professional development workshops and formal on-the-job training. That means that approximately two-thirds of those receiving this training preferred it, whereas closer to 40 percent of people using informal training methods of self-teaching and learning from others find those to be superior.

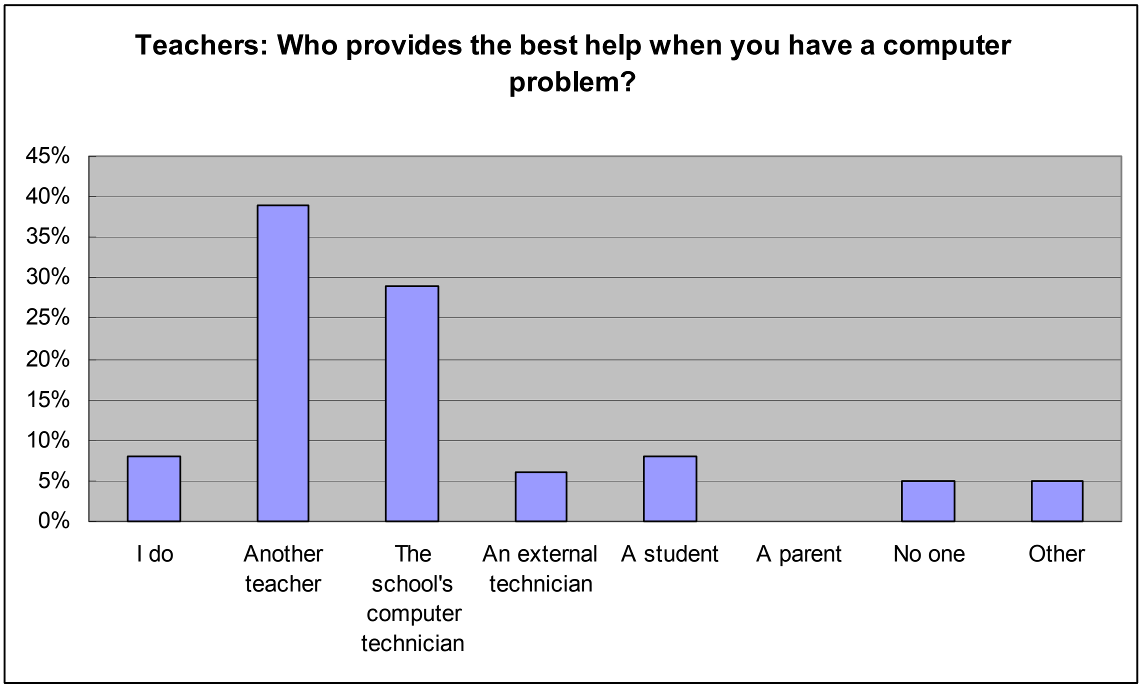
Figure 14



Peers are more supportive than technicians: 38 percent of teachers say the best support they get is from colleagues, while 29 percent identify the school computer technician as the best source of help for a computer problem.

Informal support is clearly an important element to both skill development and support among teachers. The survey asked the teachers from whom they receive the best help when they have a computer problem at school – most indicated other teachers as the best source of this support. This finding suggests that the official support structures for teachers may not be working effectively in schools. While peer support can be a powerful and sustainable resource, the roots of these decisions to seek support from a peer are unclear, whether intentional or arising due to anything from insufficient numbers of support staff, to embarrassment, to ineffective technical support personnel. Greater research is required to develop and understand functional models that integrate peer networks and support with access to technical experts.

Figure 15



Teachers who had taught themselves computer literacy have significantly and strongly more positive attitudes towards computers than do those who learned in other ways.

As discussed in the prior section on attitudes, self-taught teachers have very positive attitudes toward computers. Even though it is possible to argue that it was this reported attitude of teachers in the first place that encouraged them to teach themselves how to use a computer, we should not underestimate the significance of this finding. It actually suggests that actively encouraging teachers to embrace ICTs and creating positive incentives for them to teach themselves, may be a very effective strategy for capacity development where, as illustrated in the finding above, in the context of developing countries there is limited institutional support or established practices to stimulate computer use in the classroom. If nothing else, the pedagogical entrepreneurship of teachers may be able to compensate for lack of training, thus growing the corps of ICT champions.

Formally-trained teachers report more improvements in girls and boys learning, verbal skills and written skills.

While self-teaching may be an important indicator of interest and entrepreneurship, the analysis also suggested that teachers who were formally trained in computers reported more positive improvements in their students' literacy skills and learning. This seems to indicate the importance of respecting but not relying upon self-training as a professional development strategy. Deeper understanding of the implications of the different approaches to formal professional development, and the extent of their integration with informal support mechanisms, are essential next steps in advancing professional development capacity.

Policy Implications

The data indicate that despite headmasters' reports of encouragement and availability of professional development, relatively few teachers are obtaining training in formal professional development settings. Formal programs are the highest rated by teachers in terms of quality of instruction, but the individual elements of the training including content, approach, extent and frequency of that training remain unknown, making it difficult to ascertain its effectiveness. This further complicates the overall evaluation of formal training programs, because we do not know if those in place are even meeting their own goals.

Experience and the literature both suggest that policymakers should pay more attention to formal professional development, including making it more easily available and appealing to a larger number of teachers. One important and often reported element is providing incentives to teachers for this training – at the very least in terms of formal accreditation and certification of higher skill levels. Some school systems have provided for personal ICT use for teachers at reduced rates, others pay for training opportunities. The data suggest that the combination of incentives, real opportunities and usefulness (real or perceived) of the training are lacking. So while heads-of-school "strongly encourage" professional development for training, they may need to evaluate and experiment with the impact of more mandatory training, release time, and other incentives to improve professional development participation. Where resources are not available for formal professional development, policymakers should consider a program of self-paced learning for teachers. As indicated above in the data analysis, teachers who were self-taught displayed an overall greater attitude toward computers than those teachers taught through other methods. Another option may be a combination of formal and self-paced methodologies.

The support structures in the schools do not appear to be adequate to assist teachers with their computer problems. While peer support is a valuable and welcome source of technical assistance, with only 30 percent identifying the school computer technician as the best source of help for a computer problem, it is possible that there may be too much emphasis placed on ad-hoc structures, and that teachers may benefit from formalization. Policymakers need to reexamine the level of technical support that is provided along with the hardware and software that is given to a school, and administrators need to establish their budgetary priorities with these tradeoffs in mind. Keeping in mind that computer network reliability was identified as a major factor of student and teacher satisfaction, it is important that schools with technology also have a strong human resource base to address the minor and major problems that are inherent in the use of technology. Policymakers (including heads-of-school) may consider a more intensive training program for computer support personnel. Regional or national help desks to assist with difficult problems may be another solution.

Anecdotal experience and research both stress the importance of offering training and support in the use of technology as a crucial success factor for any ICT in education project. Beyond technical training and support, however, there are equally challenging and important pedagogical issues of integrating technology with teaching and learning. Policymakers should re-examine their in-service teacher training curriculum for ICT use and ensure that there is an emphasis not just on computer literacy and understanding of the basics of the technology, but also on use of the technology as a pedagogical tool in (and potentially outside) the classroom. Strong emphasis should be on integrating e-mail, Internet, productivity tools (word processing, spreadsheets), and multi-media (audio, video, Web-based presentations) into existing and new teaching practices so that educational benefits are emphasized to teachers.

These issues were not covered within the survey and often receive less attention and support in practice. It is clear that training must go beyond the basic computer literacy of using a keyboard, mouse, and how to use a word processing program. The added value of training should also include areas such as demonstration of successful teaching practices enhanced by the use of ICTs, management of learning sessions, classroom organization, and creation of the communities of practice and support networks to connect the teachers to each other. Also, more formal training can offer tools for monitoring student performance and learning outcomes.

7. Educational Content and Software

Educational content & software are key components of an ICT and education program, including availability, language and context appropriateness of content and software.

> **Teachers rate textbooks as a most useful tool for teaching: 83 percent of teachers surveyed identified the textbook with the highest rating of "necessary" (38 percent) or as "very useful" (45 percent) in teaching.**

> **Teachers rate e-mail as least useful among various teaching tools: 50 percent of teachers surveyed identified e-mail as "necessary" (19 percent) or "very useful" (31 percent) in teaching.**

The research shows that while teachers are enthused about the use of computers, the predominant tools for teaching remain traditional. In questions asking teachers to rate the most important teaching tools, teachers identified textbooks as the most important, followed by other materials such newspapers, art supplies, games), unique materials they prepare, and educational software and CD-ROMs. The least useful to teachers were e-mail and Internet websites, but it is not clear if this is due to technical limitations, access, ease of curricular integration or other factors.

> **Headmasters rate educational software and CD-ROMs as a most important tool for improving learning: 91 percent of headmasters surveyed identified software and CD-ROMs as "necessary" (41 percent) or "very important" (50 percent).**

Headmasters were more positive about the role of technology in teaching and learning than teachers. They rated educational software and CD-ROMs as the most important tool for improving learning in their school. Ninety-six percent of headmasters indicated that software and CD-ROMs were a "very important" or "necessary" tool, followed immediately by textbooks which were highly important for 90 percent of respondents. The lowest rated tool according to headmasters was the blackboard with only 70 percent indicating that it was "very important" or "necessary".

It is important to note, however, that given that actual use of these tools such as CD-ROMs and e-mail is not pervasive, both teachers and heads-of-school may be offering more insight into their attitudes about technology or vision for the future, than actual observations from the classroom setting.

Students surveyed also rate the textbook as the most useful tool in helping them learn. Of four choices given to students -- educational software and CD-ROMs, World Wide Web, E-mail, and Textbooks – students rated these tools as follows:

	Textbooks	*World Wide Web*	*E-mail*	*Educational software and CD-ROMs*
Necessary	28 percent	24 percent	22 percent	15 percent
Very useful	44 percent	42 percent	38 percent	42 percent

In each of the respondent groups, e-mail and the Internet websites (World Wide Web) received less positive ratings. This may stem from the reliability issues identified earlier with regard to connectivity or concerns about the reliability of information on the Internet. Another possibility may be that the quality and quantity of professional development provided to teachers to assist them to fully utilize these tools in the classroom is lacking.

Poor quality content creates worse attitudes toward the Internet among teachers and students.

As noted in the Attitudes section, the data revealed the importance of the quality and believability of information from the Internet in determining teacher and student attitudes towards the value of technology. With increased use of the Internet, teachers and students who believed that the quality of the information on the net was poor had worse attitudes toward computers and the Internet. The impact of untrustworthy information with ICT and network access is particularly interesting and merits more study, to determine the interaction with other variables related to training and experience, for instance. In policy terms, these findings suggest that an understanding of what affects believability, and supporting teachers and students to identify trusted information resources could be important in mitigating poor perceptions of ICTs, as well as increasing use.

Most schools do not have a school website.

Schools have also not begun to publish their own content to a large degree, as indicated by 60 percent of schools not having their own website. It was unclear as to whether the cause was lack of training, lack of interest, lack of resources, or some policy issue restricting establishment of a site. While the number that do report a website is not insignificant, further examination of the content, dynamism and use of the site would be important in determining whether and how schools are actually using this channel of communication.[22] The existence of a school website is easily measured, but it is a blunt instrument to measure content creation, with sites for classes, projects and the school community being of greater interest and utility. Next

[22] Chief Research of Sun and ICT-pundit John Gage has long argued that every community center and schools in particular should post content, more in "How ICTs Can Really Change the World" at http://cyber.law.harvard.edu/itg/libpubs/gitrr2002_ch01.pdf, last accessed October 28, 2004.

steps should examine the use of – and barriers to – other forms of content creation including Web logs ("blogs"), the unique materials teachers report preparing, and other less-centralized websites. Additional research on content should examine language of instruction, commonly spoken languages, and availability of appropriate educational software.

Policy Implications

The survey suggests a disconnect between the costs and challenges of Internet-based content and the appreciation of its educational benefits. As overall use of ICT (especially the Internet) remains limited, it is unsurprising that teachers appear to not yet be fully utilizing the potential of the Internet as an educational tool – accessing additional educational resources from Internet sites, facilitating collaboration and communication with other schools via the e-mail, or participating in communities of practice. Challenges of access, use and training are discussed elsewhere, but one important step is taking specific action with respect to perceived content reliability. Creating training programs, websites, and communities of practice that can provide support in the identification and communication of the trustworthiness of content is necessary to empower teachers and students to use the Internet more effectively. While the survey gathered less information about software and other electronic content, further work on availability, quality, creation and utility is clearly necessary.

Another important finding for policymakers is that teachers are less positive about technology when they doubt the quality of information that they can access. Beyond the veracity of information, educators want to know that they are getting access to the best and highest quality content. Establishment of an educational portal for access to resources that are linked to the curriculum would help teachers to access one spot with vetted and trusted information that they can use in their classes. Many portals also have established communities of practice where teachers can ask colleagues questions about difficult to teach areas of the curriculum. For instance, the Department of Education in Saskatchewan Canada offers the Evergreen Curriculum Online[23] so teachers can access subject-specific information, collaborate, and exchange views with others in the same subject area. Namibia has also created a deep bank of resources related to ICTs in education on its National Institute for Educational Development website.[24]

While it was not a significant issue in this study, if pornography or other inappropriate content is a concern, policymakers can also investigate the establishment of filters on school servers to block much of this objectionable content. These approaches raise other important issues that merit research on strategy and potential implications for education.[25]

Finally, policymakers may wish to assist schools with the development of school websites by providing them with space on a central or regional server as well as training in development and maintenance of websites. This would help develop a

[23] http://www.sasked.gov.sk.ca/branches/curr/evergreen/index.shtml, last accessed October 23, 2004.
[24] http://www.nied.edu.na/, last accessed October 25, 2004.
[25] The Berkman Center's filtering project focuses primarily on governments, but is one starting point for information gathering, online at http://cyber.law.harvard.edu/filtering/

culture of content creation and publishing that would contribute to the overall body of knowledge and information in the national school network.

8. Teaching Pedagogy and Computer-Use

Part of the enthusiasm over ICTs is rooted in their capacity to help create unique teaching materials, develop more dynamic project-based approaches to learning, and broadly facilitate a more interactive pedagogy that is student-centered and inquiry-based.

In the context of reorientation of educational systems to demands of the knowledge economy, easy access to ICT in schools both creates pressure to change pedagogy of learning by integrating technology into curricula and stimulates development of higher learning skills in students. Pedagogical paradigms influence technology use in a learning environment and determine whether the capabilities of ICT are fully explored (project-based learning) to enhance learning or are utilized at a more superficial level (drilling). Learning outcomes vis-à-vis ICTs, therefore, depend on the type of information and method of its delivery, as well as on the instructional design of educational tools. For example, if the goal of learning is to be able to recite the alphabet then "drill and kill" software design would be an appropriate tool (software that focuses on rote methods); if the goal of learning is higher order thinking, then constructivist models of instructional design are a better method (multi-user virtual environments for project-based, student-centered learning); or if the goal is just to get technology into the classroom in whatever learning capacity, then productivity applications such as word processing and presentations can be effective for base-level technical literacy.

> **Computers support materials development: Teachers who value creating their own course materials have more positive attitudes towards computers.**

> **Teachers matter: When students learn about computers from teachers they use computers more and have better attitudes about them.**

The survey brought out a number of findings that place teachers in the center of the process of integration of technology into teaching and learning. While many have registered fears that educators see technology as a threat to replace them as the main interface with students, this was not a significant factor in the survey sample. In fact, the survey revealed teacher enthusiasm for computers in both supporting their pedagogical aims, including indications that computers have empowered teachers to create their own content and teaching materials. The central role of teachers in using technology also appears to have been reinforced as indicated by findings that students who learn about computers from teachers have better attitudes toward the technology than they do if they learn from others.

> **74 percent of teachers note that the overall impact of computers in their school has been somewhat or extremely positive.**

Using computers within the classroom leads to a substantial increase in student computer use, but not computer integration in the course curriculum.

Not surprisingly, results of the study demonstrate that the presence of computers in classrooms is strongly and positively associated with use by students in general, and specifically for literature, math, social studies, and (especially) science. While there was no significant effect for learning outcomes, use is associated with learning outcomes, which underscores the importance of in-class access (regardless of the indeterminate causality of the relationship between ICT in the classroom and use). Even though only seven percent of schools in the study reported having computers in their classrooms, and despite the difficulties of getting additional equipment, schools should continue to try to get the technology as close to the teachers and students as possible. Other research, for instance, shows that there is a growing recognition of importance of the easy access to computers and the content and expert information available through the Internet that students have in these schools.[26]

Anecdotal experience suggests that the dynamics of interaction between students and teachers change when computers are brought in the classroom. For instance, the availability of computer-based reference materials and educational programs can change the function of a teacher from instructor to facilitator, create a customized learner-centered, environment, and place a higher value on collaborative learning and teaching. Based on that reasoning, moving computers from laboratories to the classroom could enhance teachers' ability to more fully utilize them.

Teachers who see greater creativity, improved problem solving skills, and increased learning resulting from computer use tend to perceive computers as having a positive impact on their school.

Teachers surveyed for the study associated the use of computers with stronger research and learning skills in students. The data showed that teachers also associate computers with the development of problem solving and creativity skills more than they look to computers for other improvements such as verbal or writing skills, which were not found to be statistically significant in their association with computer use. Recognizing the fact that large class sizes and traditional pedagogical approaches are predominant in many of the sample countries, we can posit that the problem solving and creativity skills may not be as explicitly addressed in the existing learning environments, and that computers offer teachers the perception or reality that they may support them more explicitly.

Policy Implications

Policymakers have a unique opportunity to use computers as key levers to education reform at the school and classroom level. The very positive attitudes of teachers coupled with their views that computers facilitate the development of higher order

[26] Gillian M. Eadie writes : "The anytime, anywhere access to information sources, "ubiquitous" computing, enables students to engage directly with expert sources when they are needed and the sight, sound, touch experience becomes a powerful motivator in learning." (Gillian M. Eadie, M.Ed., The Impact of ICT on Schools: Classroom Design and Curriculum Delivery: A Study of Schools in Australia, USA, England and Hong Kong, 2000.)

thinking skills such as problem solving and creativity provide policymakers with an opening to introduce new pedagogical and curricular reforms that emphasize a more interactive and constructivist approach to teaching and learning. The association between computer impact on schools and teacher participation in the planning process should underscore the importance of involving them in the reform process.

One important consideration is to explore placing the technology closer to the teachers and students by moving it from the lab to the actual classrooms where subject teachers spend their days – permanently (if there are adequate resources), in part, or temporarily through the use of portable machines. We would expect this improved access to be associated with more use (although not necessarily more learning). The impact of the likely concessions in terms of student to computer ratio, however, requires more study.

Despite some rhetoric to the contrary, educators are every bit as central to the learning process as they have always been. With technology allowing new pedagogies and approaches to learning, professional development programs need to ensure that teachers can not only survive in this new environment, but take advantage of the opportunity it offers. Professional development should continue to emphasize the central role that teachers play in the effective integration of technology in the school.

Apart from the educational benefits of technology and the role that it can play in facilitating a more student-centered, interactive classroom, the training should also assist teachers to become content creators as well as content consumers. Computers can play a strong role in the potential empowerment of teachers to create their own materials. In turn, the analysis shows that teachers who are empowered to create their own materials have better attitudes toward computers. Policymakers therefore might consider professional development for teachers to create learning resources as well.

9. Gender

One of the greatest challenges to social and economic development is improving learning opportunities for girls. This section pays particular attention to gender issues in the design and implementation of ICT, and examination of differential computer use by and benefits to boys and girls.

> **Girls use computers less frequently than boys, both generally and for academic purposes.**
>
> **Use of computers in school and in the classroom are associated with gains for boys and girls in learning, writing skills and verbal skills.**
>
> **For those who generally trust the information they find on the Internet, Web use is associated with gains both for boys and girls in learning, writing skills and verbal skills.**

Despite substantial progress made in female enrollment and education thanks to governments' sensitization efforts and close attention to gender issues by donor-funded educational programs, barriers for girls' access to education still exist throughout the world. The rapid increase in the use of computers and Internet in schools raised expectations about the potential to "redress inequities in gendered access to information"[27]. At the same time, concerns remain about the potential for the exclusion of women from access to the necessary technology. The study confirmed this concern as reports from all eleven countries reveal boys using computers more than girls.

To many observers, this finding does not come as a surprise. Higher rates of male participation in design and use of technology influences both perception of its gender appropriateness as well as the ways technology is made available to men and women at school.[28] On the other hand, the study demonstrated, that teachers' views on gains from use of ICTs in improving learning and verbal skills were not different for boys and girls. So while access varied, the impact on skills development was equal. Further research will be necessary to distinguish whether it is inappropriate design of the information technology products or the combination of a traditional aura of male dominance in the field that create barriers for use of ICT in schools by girls.

48 percent of teachers see computers helping girls to access health information.

It is important to note that almost half of the surveyed teachers reported that computers had a large or substantial influence on girls' ability to access important and potentially sensitive information, including topics such as HIV/AIDS and reproductive health. With reliable information often unavailable due to cultural or geographical barriers, this opportunity for girls to access reliable health information is significant.

Policy Implications

The main findings from this survey indicate that girls use computers less than boys but both genders reap equal educational benefits. These findings suggest that policymakers (including heads-of school) should examine ways in which to ensure equal access and use for girls. Girls are often disadvantaged in the time they have available to use computers outside of the school day due to their responsibilities at home such as chores and caring for younger siblings. A policy of providing girls more access during lunch breaks or immediately before or after school could address this time constraint. Identifying certain computers for boys and girls (i.e., marking a monitor with a B or a G) would also ensure that an appropriate number of girls would get access and not be crowded out by boys.

Working with the community and parents to create training programs built around the limited free time that is available to girls and ensuring access to ICT in those periods might also potentially address some of the underpinning causes of gender differences in technology use. The training would also provide an opportunity to better understand the type of content the girls find most valuable for their growth and educational development.

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[27] See "No space is an island: ICT, electronic adjacency and civic empowerment," by Margaret Grieco, presented at 'ICT Strategies for Islands and Small States', UNESCO, Malta, March 1999.
[28] Gender and the Information Revolution in Africa, *Eva M. Rathgeber and Edith Ofwona Adera, eds. , IDRC, 2000.*

10. Community Involvement and Planning

Because schools are important community institutions, efforts to integrate ICTs in education are effected by the involvement of both parents as well as the broader community.

The importance of meaningful community involvement in ICT-enabled education projects is widely recognized as one of the most important lessons learned from the experience of working in this field by international development agencies, national governments and local organizations.[29] However, as illustrated by the results of this study, these lessons have yet to be fully understood and adopted into practice.

In 48 percent of schools, the labs were never open to the outside community.

Only 2 out of 126 surveyed schools reported generating revenue from community telecenter fees.

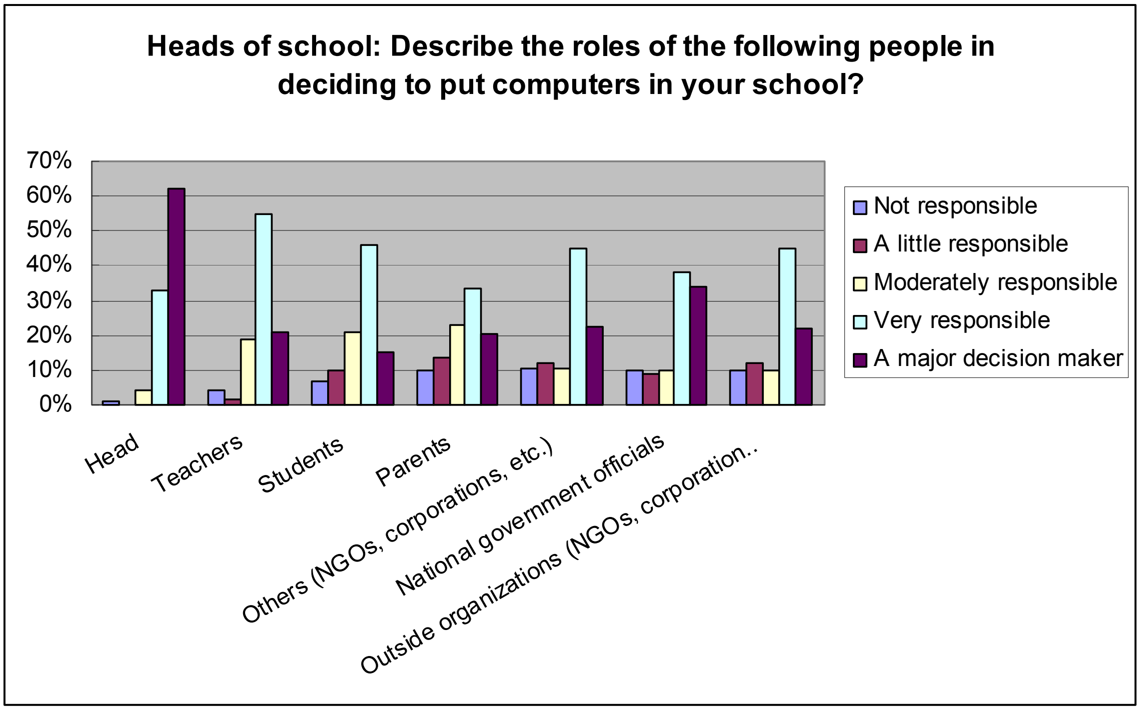
Drawing on the intellectual and capital resources of community members not only contributes to easier acceptance of ICTs by students and teachers, but also creates a larger group of stakeholders interested in sustainable and sound management of computer centers and networks at schools. This approach to outreach creates a broader role for the school in enhancing the ICT capacities of the community, and the associated social and economic advantages.

Heads-of-school are key decision makers.

Results of the study demonstrate that in identifying key players who made decisions on bringing computers to schools, sixty-two percent of heads-of-school report that the group primarily responsible for that decision was the headmaster (62 percent), followed by national (34 percent) and local (27 percent) government officials.

[29] See, for example, Robert J. Hawkins, Ten Lessons for ICT and Education in the Developing World, ICT in Education (K-12) Strategic Policy, for 2002-2005, by Department of Education of Tasmania

Figure 16



Heads-of-school are in charge: 97 percent felt either very responsible or like a major decision maker in deciding to integrate computers and the Internet.

Participatory planning process: Heads-of-school report that teachers, students, local and national government officials, and outside organizations were either very responsible or a major decision maker in 60 percent of the cases.

Teachers help plan: 49 percent of teachers report playing a somewhat or very important role in the ICT planning process, resulting in reports of greater school impact for computers.

These findings are somewhat surprising given the oft-referred to anecdotes of external decision-makers mandating the integration of ICTs in schools with little input or assistance from the school or local community. The survey sample, as reflected above, had a very different experience, widely reporting a high level of participation in the process.

The analysis of the above data also revealed that when teachers feel that they are involved in the planning process, they tend to see PCs as having a more positive impact on their school. It is not clear if this is due to some feeling of ownership in the process, or because they actually did participate and helped improve planning and implementation. On the other hand, participation in the planning process did not have a statistically significant impact on teachers' attitudes towards computers, perhaps suggesting the importance of participatory planning. Future research should compare their perceptions of participation to administrator reporting of participation in the planning process as well as an investigation of whether the teachers do in fact feel ownership in the process.

Policy Implications

Because of the costs and complexities of introducing technologies into schools, successful schools and education systems have actively reached out to a broader set of stakeholders to help them accomplish their ICT in education goals. To foster social and political sustainability, whether implemented by the ministry of education or a single school, ICT-enabled learning programs must reach out to broader community members. Parents, alumni, community organizations, academia and the private sector all have potentially important roles to play. Building a larger base of support for costly and innovative programs will not only reduce resistance to change, but also insulate against political change, and support effective use and acceptance of the new computers and online resources.

Policymakers should also consider supporting broader use of the computer labs by the community. Community ICT access can prove to be a sustainable strategy for recuperating some of the recurrent costs of telephone and Internet charges incurred by the schools, as well as building community support and fostering intergenerational learning. This strategy would require a clear capacity building component to help schools effectively manage the resource as a type of small business – ensuring effective management of costs and income – while also considering the potential impact of wider scale use by the community on student usage. It would also offer an exciting learning opportunity for students and others in the school community.

Policymakers can more actively encourage schools to integrate the community in the process of introducing computers in the schools from the very beginning. Through public planning and discussion events, existing parent-teacher associations, and community groups, headmasters can begin to mobilize the community and at the same time identify some of the skills and interests that they possess. These relationships may include assisting with sustaining computer systems, creating opportunities for students to use ICT as a link with the business community, and exploring the community ICT access models.

Finally, the very pedagogy that computers help facilitate can be a powerful tool for greater community outreach. Through the development and implementation of collaborative projects, students and teachers can identify issues that affect the broader community. For instance, in Peru a collaborative project was designed by students to identify the problems and causes associated with poor water quality in the community. The students and teachers reached out to the local water utility to share their findings and in turn the utility highlighted the project website on their monthly bills to the community. These types of projects help break down the barrier between the students and the community to create positive links.[30]

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[30] World Links 1989 – 1990 report on collaborative project in Peru can be found at http://etools.worldbank.org/etools/docs/library/36038/sri_world_case_peru_1998_99.pdf.

11. Policy Issues

In the broadest sense, virtually all of the above decisions are a form of policy, but within this more narrow context relevant issues include (but are not limited to): the existence of acceptable use policies (including content, games, access); who participates in the decision to bring computers and Internet to the school and subsequent planning and implementation; and whether computers and Internet are included in the national examinations in some fashion. Due to the complex and cross-cutting nature of these technologies, the creation and adoption of a strategic plan for implementing computers and Internet are important elements of internal and external coordination and communication. Generating not only an effective and sustainable plan, but doing it in a way that involves key members of the community (administrators, teachers, parents, students, other organizations) can lead to broader community support and engagement.

80 percent of schools report some form of "use" policy.

Best laid plans: "Use" policies appear to actually decrease student use.

The existence of a "use" policy tends to decrease student use of computers generally as well as across subjects (except science). Further, specific policies relating to games reduced computer use for literature, science and social studies. One interpretation is that use policies were too strict (or perceived as such) and were hindering students from a more extensive use of computers. There may also have been limitations on time or the unstructured access and exploration students need to become comfortable and familiar with new technologies.

Content policies improve teachers' perceptions of gains in literacy and learning.

While student-reported use decreased with the existence of use policies, the existence of a content policy and game policy tended to increase teachers' reporting of improvements in literacy skills and student learning. Whether this is an actual effect and the policies are diminishing non-educational uses, or simply giving teachers a feeling of control is unclear. Further investigation should be undertaken to establish whether there is an interaction with teachers' concern over believability of content and its interaction with the content policy, as both factors significantly and positively affect perceptions of student learning.

The juxtaposition of the two policy outcomes pushing integration in different directions clearly merits greater investigation. The pattern that is emerging with regard to use policies may be not unlike the Internet in other contexts, where the introduction of new technologies provokes fears in the existing power structure over a potential loss of control, and thus provoke efforts to control the medium. Compounding this trend is the perception or reality of use limitations either inhibiting actual exploration of the new medium on the part of students, or making them less likely to be enthused about it.

Students are key to running computer labs: 68 percent of schools report students as playing a very or fairly important role in running the computer lab.

The reason for and level of formality of student involvement within the labs is unknown, but in principle, this level of student participation sounds like a potentially positive development. From the student perspective, it can foster the further development of useful computer related skills, and potentially offer greater access to the technologies. From the administration perspective, this approach could increase feelings of student ownership (thus better care for the equipment), reduce maintenance and upkeep costs, and reduce the need for additional support personnel – perhaps even providing the opportunity to open the facility to the community at large.

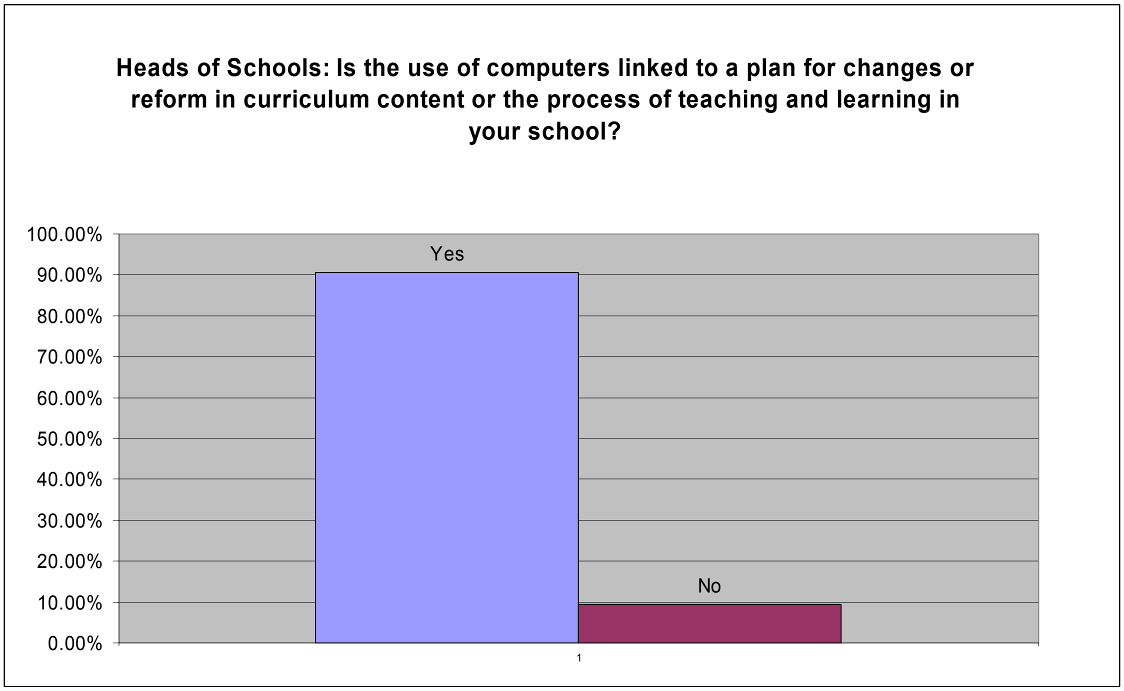
Computers are included on national examinations in 60 percent of the schools.

The inclusion of computers on a national exam can be viewed as both a potentially positive and negative development. The inclusion of computers on national examinations is important because it can help push schools to offer computer courses, and students to learn the associated material. It shows recognition that computers are an important topic for all students in the nation, regardless of setting. The results may be limited, however, depending on the actual material tested (i.e., is it actual digital fluency that requires hands-on experience, or basic knowledge that can be taught from a book?). Further, while computer skills are clearly important, much of the learning benefit expected from new technologies is not limited to programming or understanding how the hardware and software works, but to its creative application in non-technological settings. The danger is that the computer lab is timetabled during the day for basic computer literacy instruction and that no time is available for other subject matter teachers to access the lab to integrate the computers across the curriculum.

Ninety percent of heads-of-school report computers are linked to school reforms.

It is very interesting to note that such a large number of headmasters view computers not as a stand alone fad, but integrated into a much larger education reform agenda. As headmasters should be both the administrative and intellectual head of the school, this finding reveals that the potential use of ICTs to facilitate broader curricular, examination, and administrative reforms at the school level is promising.

Figure 17



Policies for integration of technology into the curriculum not viewed as a large challenge: Only 32 percent of heads-of-school found lack of clear policies for integrating computers and Internet to be a problem.

While most administrators were not concerned about the lack of policies for integrating technologies in their schools, it is unclear whether this is because appropriate policies are already in place or are deemed unimportant. The formulation of a context appropriate technology plan is widely believed to be an important component of ICT implementation and use, but further research must be undertaken to evaluate whether and when it is a useful tool. Alternatively, if administrators do not see the importance of clear policies for implementation, deeper inquiry into their current approaches and implications could prove valuable.

Policy Implications

Policymakers should carefully review their existing policies for ICTs to ensure that they are structured to promote effective use of technology across the curriculum as well as within the broader educational reforms being implemented. The positive news from the survey results is that headmasters are cognizant of existing educational reforms and see technology as an important part of these reforms. Policymakers should be clear about how the computers will contribute to these reforms and clarify ways in which to measure the impact of this contribution.

Policymakers should scrutinize existing use policies to ensure that students are protected from questionable content but otherwise are not limited in their free exploration of information and knowledge. Use policies should not be over-controlling in nature. Also in terms of student empowerment, policymakers should review ways in which to provide incentives for students to become meaningfully engaged in the management of the school network. Implementation of after-school employment schemes in which students are paid for their service might be one option that builds student capacity while potentially offering a cost-effective alternative to a professional computer technician.

Monitoring and evaluation programs are essential, but policymakers need to be cautious in developing the exams for use of computers. Clarity of the types of skills that they wish to develop must be defined so that the exams will provide the incentive for skill development. For instance, if exams only teach how to use a word processing program, many teachers and students will focus their energies there. Alternatively, if the exam tests students' ability to find information on the Internet compare/contrast it with other information and write a report of the findings, a whole separate set of skills will be developed.

12. Costs

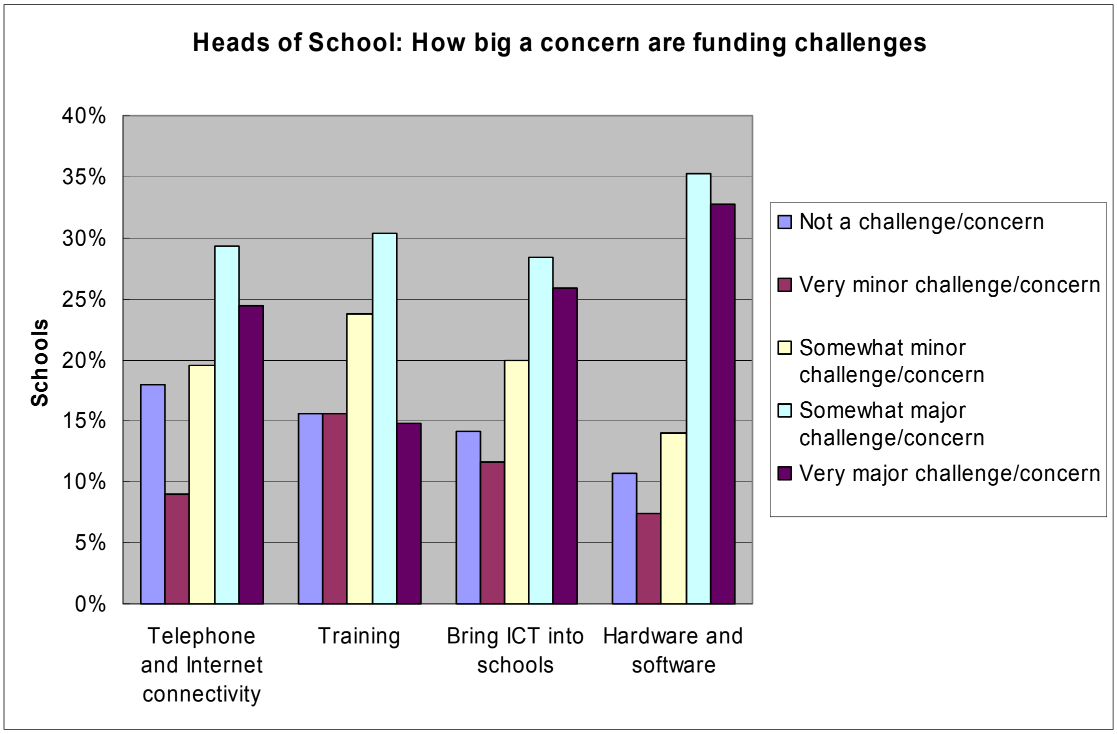
The capital and recurrent costs of ICT in education programs - as well as the sources of funding to pay for these costs – have a critical role in determining the sustainability of these programs.

While hardware, software and service costs have come down, the cost and complexity of training and implementation, ongoing access, upkeep and replacement costs are exacerbated by the severe resource constraints in developing world education systems. These challenges are not merely monetary, but influence decision-making because they are compounded by social and political factors that affect funding streams, planning and implementation.

Hardware and software funding is perceived as the biggest cost challenge: 68 percent of heads-of-school report it as a somewhat or very major concern

The hardware challenge is reinforced by previously mentioned results that identify the lack of computers as a significant problem. It is unclear, however, if the perception of the other costs as less significant challenges is because they are truly less of a challenge or that the heads have simply not paid as much attention to other more fungible elements such as training, content development, technical and pedagogical support, etc. The fact that connectivity costs are not of great concern may be because most schools had such limited Internet access and use, and actually appear to not be using the full capacity of the equipment. Heavier reliance on the Internet could imply a significant shift in these concerns. Furthermore, it is unclear why cost constraints have not led to policies that could alleviate the problem, such as use of donated or recycled machines, free and open source software, and community engagement and resource sharing.

Figure 18



Traditional funding streams dominate: Only 5 percent of Internet costs are funded by private donations or telecenter revenues.

Most of the technology cost in the surveyed schools is borne by the schools themselves (41 percent) or by government (46 percent). The school level support is most likely a reflection of the relatively higher existing resource base of the schools participating in the survey compared to the rest of the schools in a given country – in other words these schools have the computers because they can afford them in the first place.

While this result suggests important institutional support, the limited number of alternative funding sources suggests a potential lack of innovation and entrepreneurship - and is prone to risk of a change in government priorities and politics. While school-based telecenters are successfully offering Internet access to students and the community at large in many settings,[31] this potentially powerful and socially beneficial cost recovery mechanism is little-used. Similarly, with anecdotal evidence from diverse developing nations suggesting that the private sector eagerly supports the integration of ICT in education, their lack of participation suggests an untapped resource. It bears mentioning that school rules and public regulations may currently limit these activities, perhaps requiring change or creative institutional structures and mechanisms to support them.

[31] For more information, see the World Bank Institute's School Telecenter website at http://www.worldbank.org/worldlinks/telecentres/

Figure 19

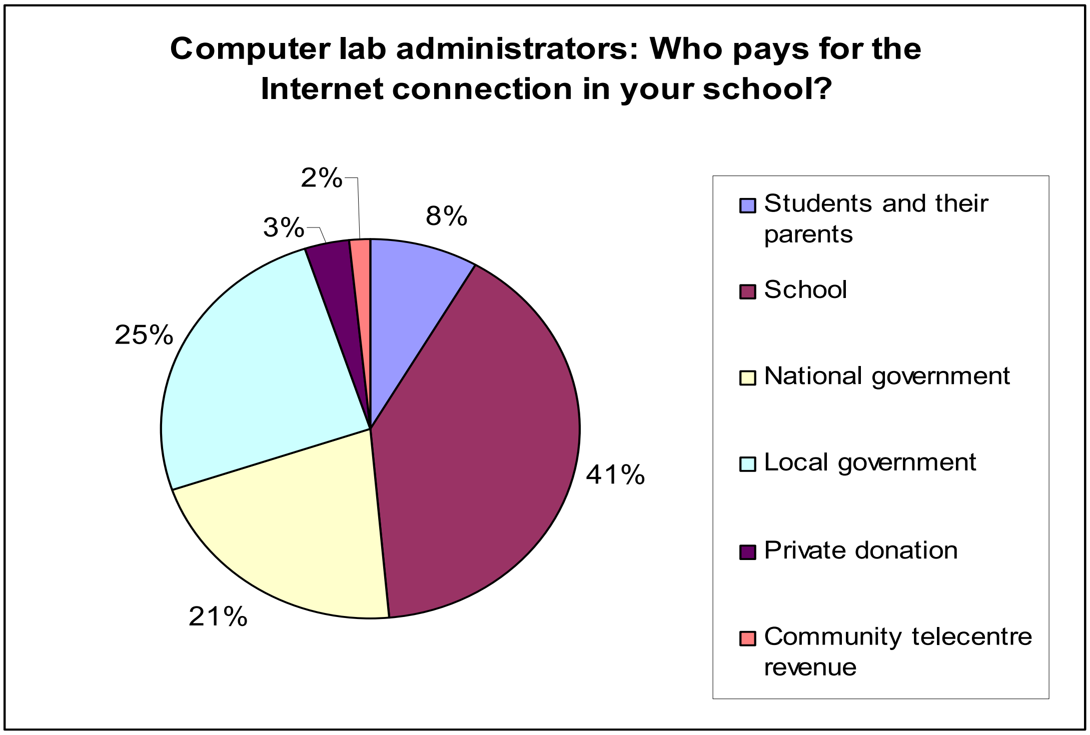
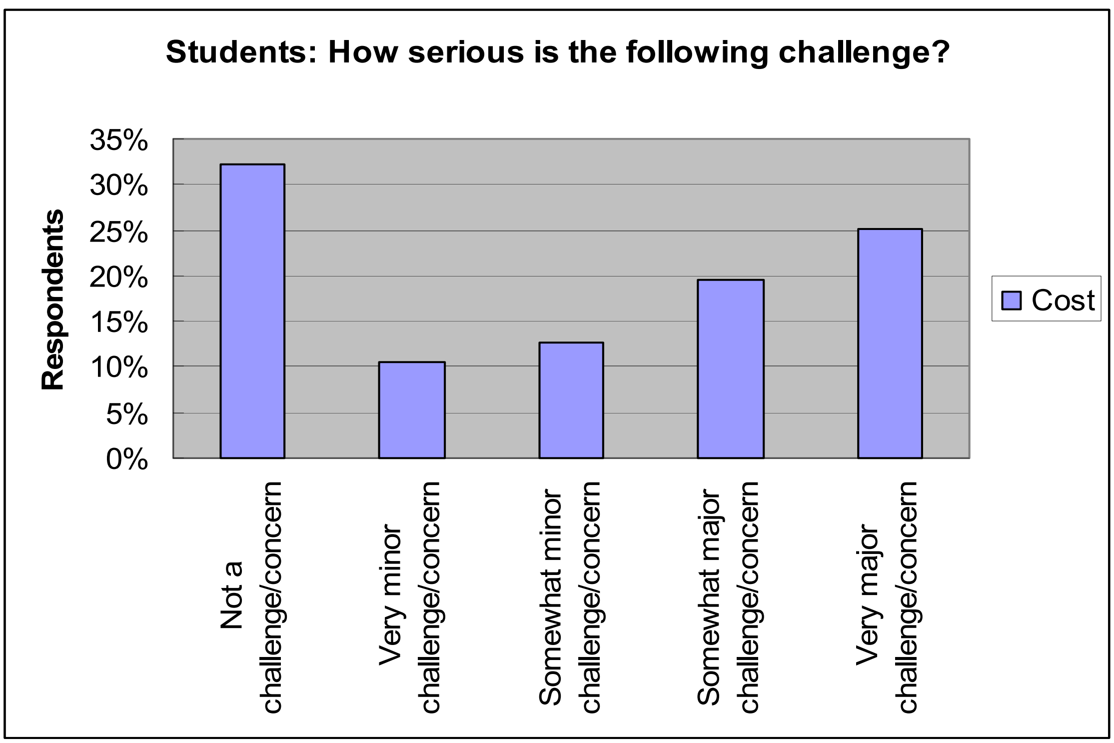


Figure 20



Computer access mostly free: 79 percent of computer lab administrators report students pay no fees for computer access.

When families pay for computer use, it decreases for academic purposes – except math, which increases.

When families pay for ICT use, students tend to use computers less for literature, science and social studies, but interestingly, increase use in math. Perhaps the combination of limited resources and greater familial involvement/control of children's computer use limit what they are able and choose to pay for, forcing some sort of prioritization. Including other information such as effectiveness of use, associated learning and parental attitudes, could reveal whether the cost constraints actually improve outcomes due to the increased attention, or simply reduce use. The model did not include parental attitudes due to the risk of endogeneity, but further research should explore willingness and choice of payment. It seems that this is also likely to vary across national setting, income level and school type, among other factors.

Policy Implications

Policymakers should have a clear and comprehensive picture of all of the costs involved in implementation and maintenance of an ICT and education initiative. These costs and responsibilities for payment should be clearly communicated throughout the system. Hardware is often the first component that is estimated and purchased in ICT in education programs. Other costs are often paid significantly less attention, with potentially debilitating results arising from deficits for training, maintenance, equipment replacement, software updates, Internet access, and other unforeseen expenses.

Although a great deal of resources is dedicated to hardware, it appears that greater demand exists for use of the equipment than the supply can handle. Some of this may be perception (i.e., there are likely ways to get more out of existing infrastructure), but policymakers (including heads-of-school) should investigate other lower cost options for supplying schools with hardware. This might include refurbished or donated computers, but also could be pilots to integrate less expensive devices into schools such as personal digital assistance (PDAs), mobile phones, and thin client computers. These challenges underscore the financial pressure for ICT in education programs and the need to identify sustainable financial strategies to address them, and allow for essential long-term planning.

Policymakers should finally examine other means with which to meet recurrent costs of the programs. Using labs as community learning facilities after school hours may provide an innovative scheme to help defray the recurrent costs, engage the local community, and provide a venue for life long learning.[32]

13. (Other) Challenges

In addition to the concerns specifically identified in previous sections, there are a variety of other challenges to effective implementation and use of ICTs in the classroom that merit consideration.

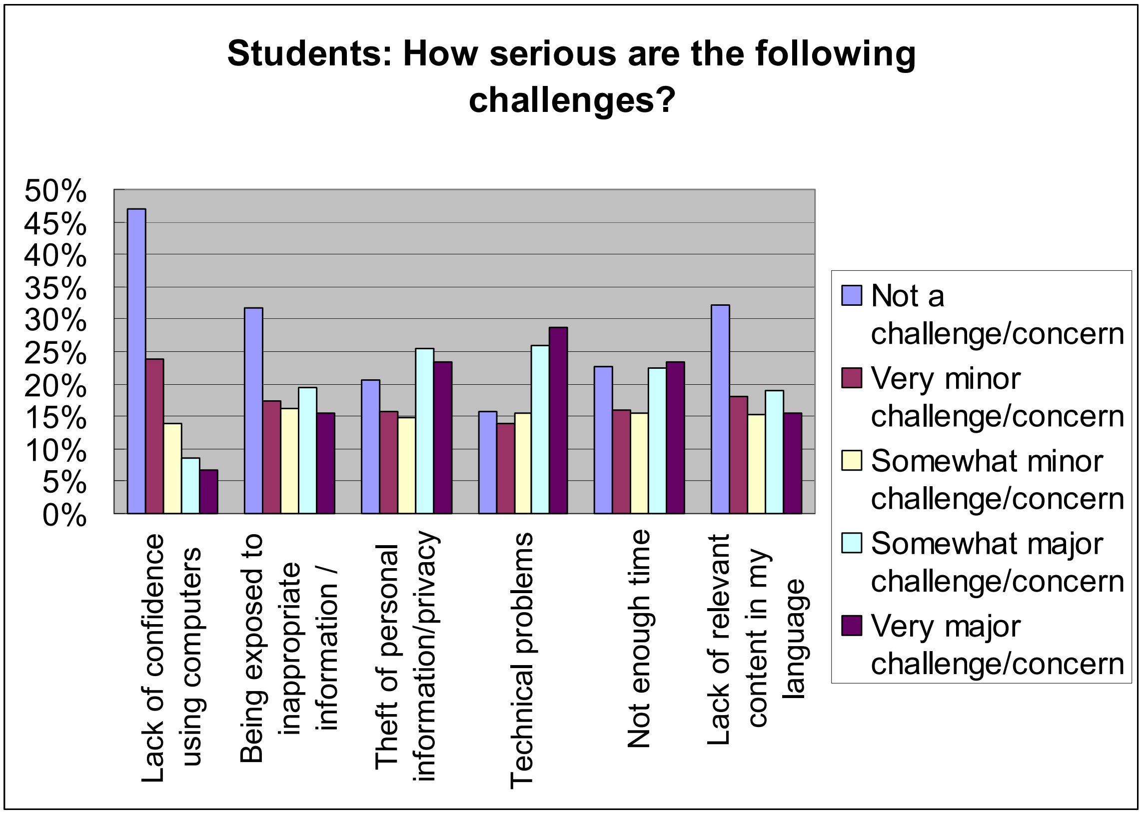
[32] http://www.worldbank.org/worldlinks/telecentres

Barriers and limitations to access, use and effective use have been discussed throughout the paper and across contexts. Diverse issues such as students per computer, network reliability, location of computers, believability of Web-based information, and teacher training, have been highlighted as being correlated with teachers' and students' attitudes towards computers. In this section, we examine self-reporting of perceived concerns or challenges, which refers less to the actual existent barrier, and more to the perception of the barrier. They may or may not be aligned with more objective realities in schools, but it may also be the case that addressing subjective issues of perception is just as important as eliminating objective barriers, or that these perceptions can alert us to other less apparent problems.

Barriers are not what they seem: Limited local/same language content and fear of technology are not reported as major challenges among students.

Development practitioners have talked about relevant content and fear for non-native English speakers as major challenges to effective implementation of technology, but these concerns may be somewhat overstated. Approximately one-third of the respondents indicated that relevant language was a somewhat or very major concern – lower levels than technical problems (55 percent), adequate computers (53 percent), privacy concerns (49 percent), time constraints (46 percent), and cost (45 percent), for example. In fact, the language challenge was statistically significant, but with a small – and surprisingly – positive effect on student attitudes towards computers. While a relatively minor effect, an interesting line of further inquiry would be to investigate whether students actually like to use computers and the Internet to develop their language skills. Of course, it is important to remember that the majority of the respondents were spending relatively little time on the Web, and may not be aware of the comparative levels of content available. It may also be that these barriers to "necessary" means of access overshadow the "sufficient" basis of content and use. Further, most respondents either spoke a world language or at least had some exposure to one, possibly causing less frustration with content.

Figure 21



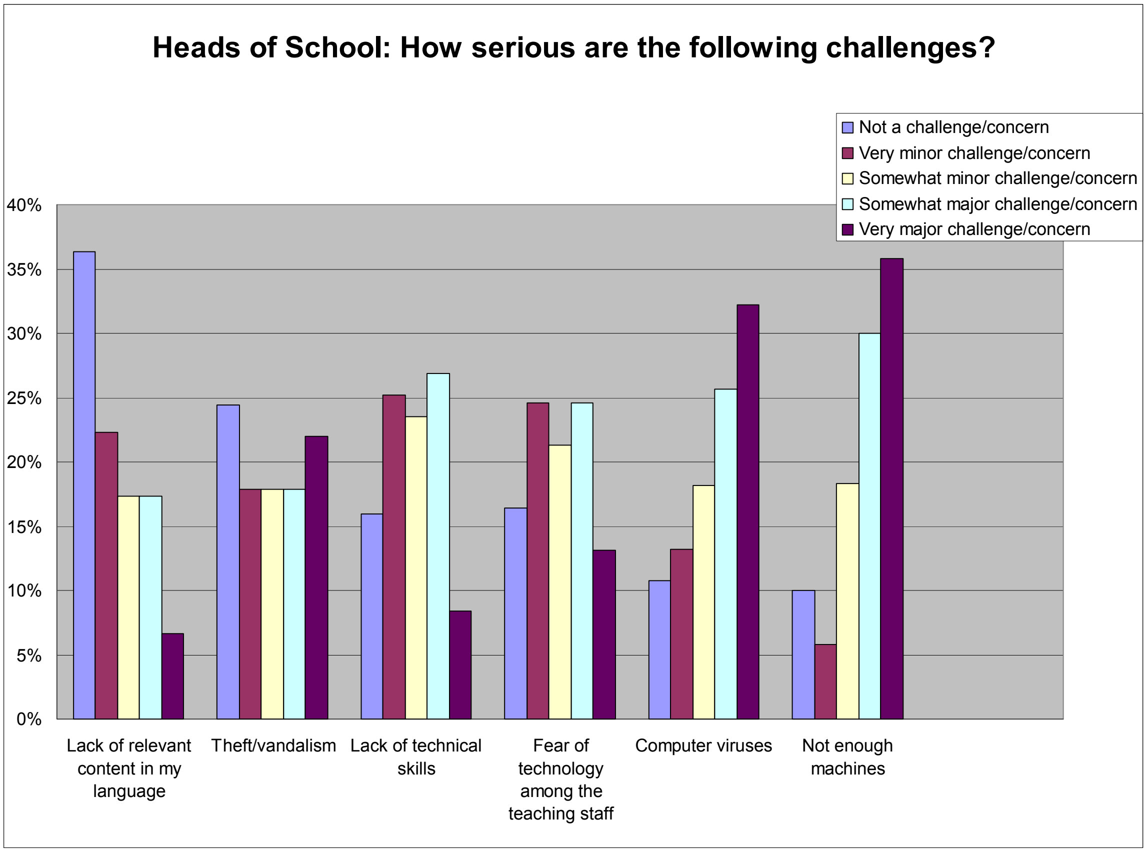
56 percent of teachers report that too many people and not enough computers as a somewhat or major challenge/concern.

Hardware and technical concerns also top the list of teacher challenges. Too few computers and technical problems with the hardware and software are the two most reported challenges that teachers face. Lack of time was the third most reported challenge, and was also raised by students. Confidence in the use of computers and basic skills such as keyboarding and the use of the mouse were not concerns or challenges for teachers.

Headmasters cite hardware and viruses as major challenges.

With nearly two-thirds of heads-of-school reporting not enough machines and over 60 percent reporting that computer viruses were a somewhat or very major challenge, technical challenges sit atop heads-of-schools' list of difficulties. One interpretation is that these are expensive areas that go under-supported due to their cost, while another is that these are the necessary components, where it is easiest to observe problems, and therefore dominates mindshare. At the same time, other problems may be more serious or severe, but not yet be apparent to heads.

Figure 22



Policy Implications

Based on the findings in the challenges section, heads-of-schools, teachers, and students are all demanding more hardware and greater technology support. While policymakers should investigate some of the options detailed earlier in the paper, they should also be cognizant that this is a small snapshot of the challenges that teachers face and must not overemphasize the hardware component of the program. Professional development, content, curriculum integration, appropriate evaluation, community involvement and appropriate incentives must also be carefully considered in devising and implementing successful ICT plans.

14. ICT Use

The extent to which computers and Internet are actually used by heads-of-school, teachers and students in schools, as well as the particular tools they choose are important output measures of ICT in education programs, because they ultimately lead to the learning outcomes which are the actual goals.

> **Internet largely unused: 48 percent of students surveyed report never using the Internet at school, while 33 percent report using it at least once per week.**

Computers get more use: 45 percent of students report using a computer in school about once per week, with 25 percent using it at least several times weekly.

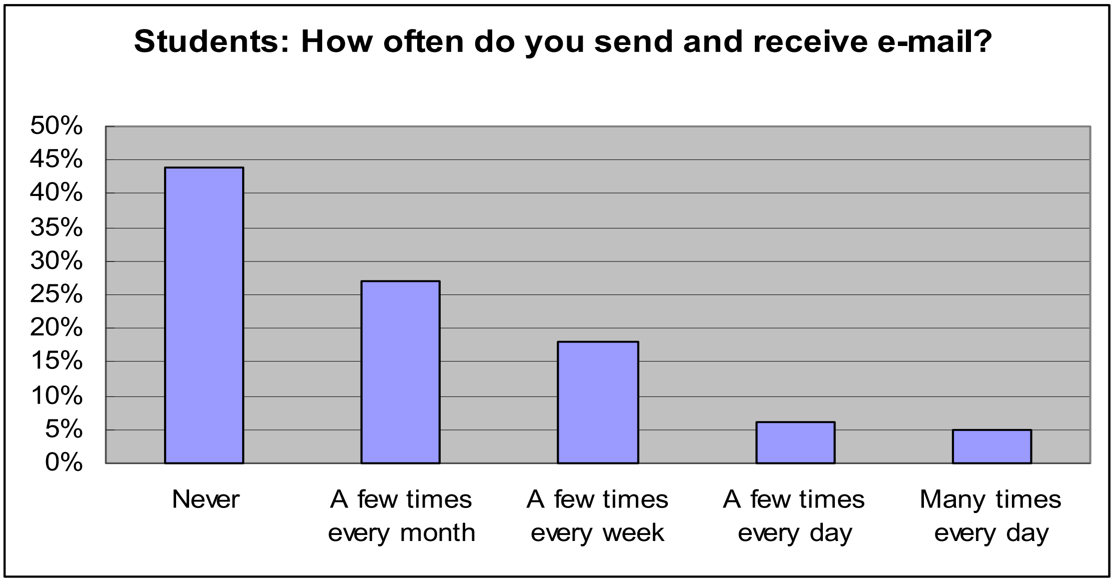
Few students use school computers outside class hours: 71 percent report they access the computers in school outside of normal hours a few times per month, and 55 percent never do.

With over a quarter of all students using computers once per month or less, and about half never using the Internet in school, it is clear that ICTs are not fully integrated in these schools. The percentage of children actually using computers and the Internet is surprisingly small considering the schools included in the sample are likely to be among the ICT leaders in their nations. This finding suggests that regardless of why the use levels are low, whether due to access issues, instructional pedagogy or other factors, that the actual integration of ICT remains incipient for many students and schools across the developing world. As noted within this document, low levels of student use can be attributed to a variety of factors including years of teachers' computer experience, not learning about computers from teachers, computers not located in the classroom, low Internet speed and reliability, the existence of use policies, as well as less understood factors such as gender and geographic location of the school.

Students in classrooms with computers used them more, although their classes did not.

While the physical presence of a computer in the class was a significant factor in explaining student use of computers for their schoolwork (across subjects), it was not correlated with an increase in use of computers within actual classes. This may suggest that students are using these computers outside of formal classroom activities, perhaps due to access issues (e.g., the lab is far away, perceived as crowded or closed).

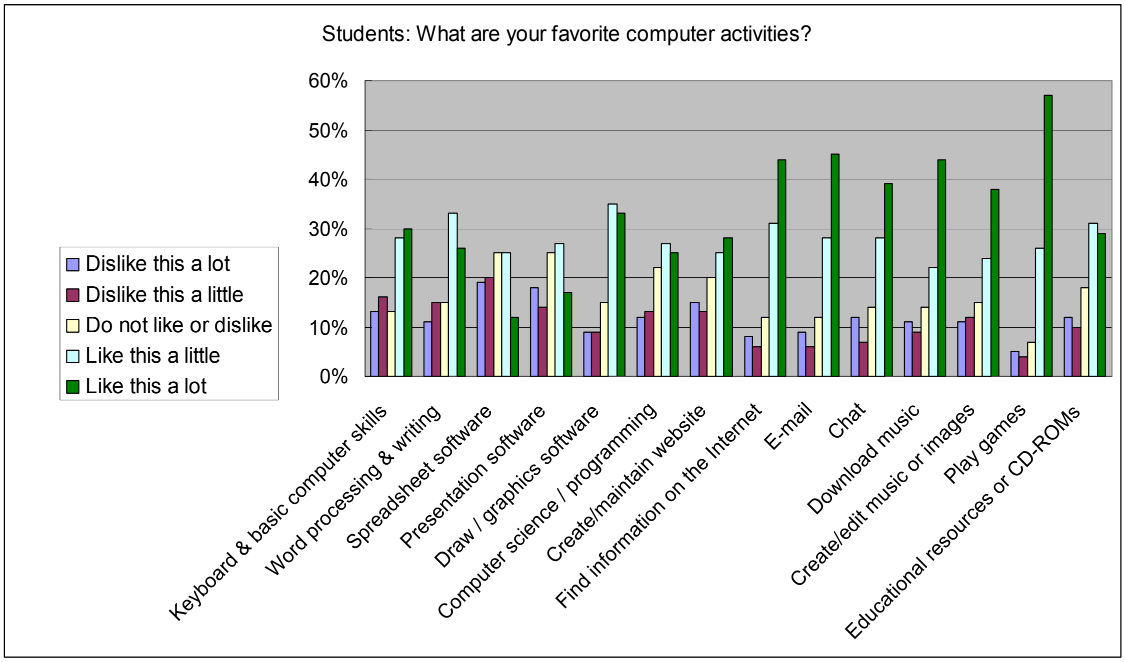
Figure 23



Students are not using E-mail.

The distribution of student E-mail is similar to Internet use, with the greatest number of students not using e-mail at all, but over a quarter using it a few times every week or more. If the frequently observed tendency to begin using the Internet for basic communication purposes (as seen in developed and developing nations alike) correlates with adoption in educational settings, this suggests that a minority of students may be well along their way to increased use of ICT tools, but that the vast majority lag significantly behind. Note that the impact of e-mail use is discussed in the effective use section. Further research using these data to ascertain whether e-mail use leads to effective integration of ICT in schools would be valuable, offering the possibility to suggest straightforward education policy changes.

Figure 24



Students tend to use computers more in subjects that they like, with their favorite applications.

Students' feelings toward the academic subject the computers are used for are significant determinants of use, the more positive students feel about a particular subject, the more likely they are to use computers for that purpose. The causation is unclear, leaving us to wonder whether a student enjoys a particular subject, so she uses a computer for it, or she uses a computer for it, which makes her enjoy it more. The relationship is the same, albeit stronger, between students' preferred application and the applications they use most frequently.

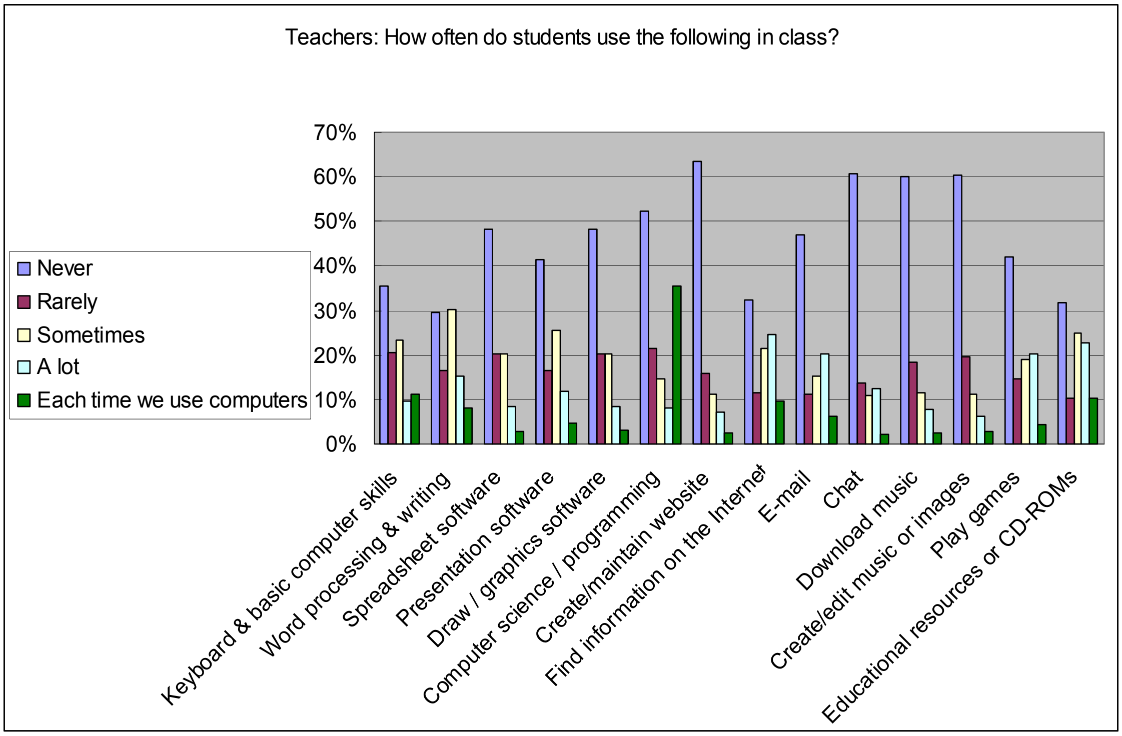
Many teachers rarely use technology: Almost half of teachers surveyed use the computer once a month or less. Four out of 10 teachers never use the Internet in school.

Teachers are conservative in use of computers: In only 12 percent of the schools surveyed have all of the teachers used computers.

Most teachers do not use ICT in class: 59 percent indicate that they never or rarely use computers and/or the Internet in the class.

Use of computers and Internet by teachers seems relatively low and uneven, and is similarly distributed in terms of their use within class. The strong statistical correlation between students learning about computers from teachers and student use, suggest that teachers' limited use of technology in the educational setting contributes to lower student adoption – or at least does not advance it. The low usage levels are certainly perplexing considering that 81 percent of teachers report moderately or strongly liking computers. Principle teacher-identified barriers include not enough computers and too many people, which 56 percent called a somewhat or very major concern, and technical problems, mentioned by 52 percent of teachers.

Figure 25



Teachers' reports of application use and student reports of application interest do not track well, and while student preferences cannot be expected to drive teachers' decisions about use, there appears to be unexploited interest on the part of the students. On the other hand, student affinity for computers is correlated with the overall use within subject areas, suggesting a relationship between student attitudes and teacher usage.

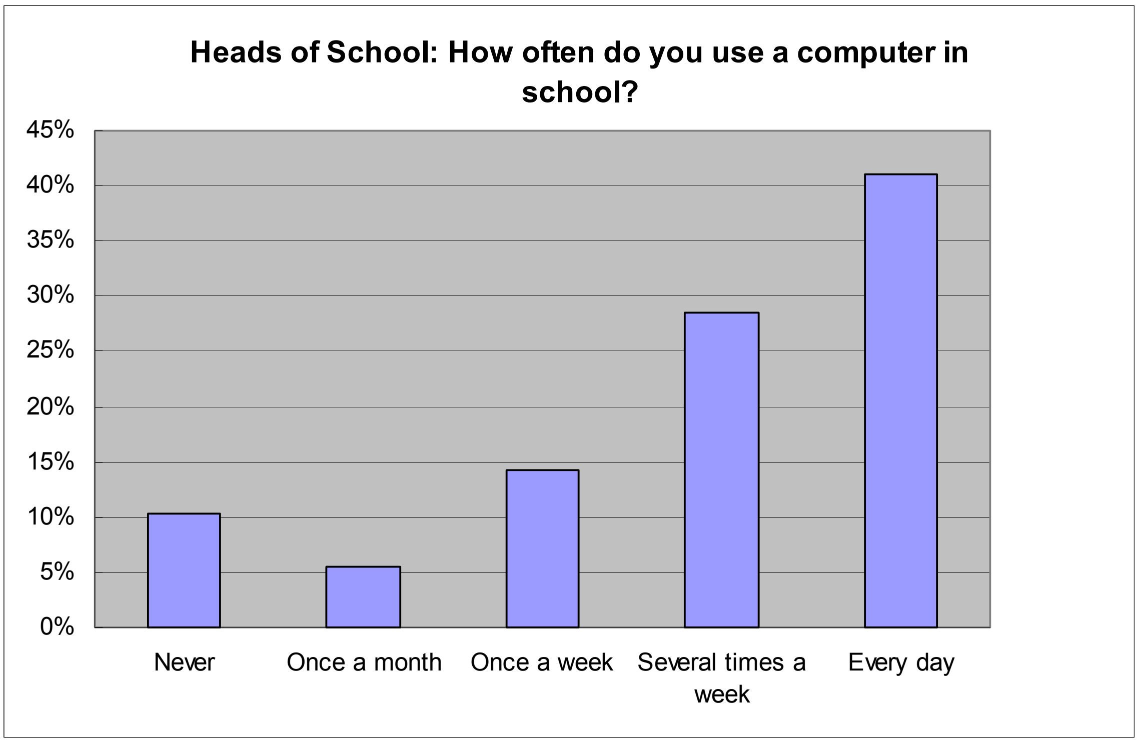
Teachers who use computers themselves, have more computer experience, have formal training, teach computers, and/or use the Web are more likely to use them in class.

These findings paint a more detailed picture of the factors that are correlated with in-class use, which is of particular importance due to its effects on skills improvement and learning. These results seem fairly logical, suggesting the importance of teachers who are prepared, experienced and use ICT in other aspects of their jobs are most likely to use technology in their actual teaching. Concerns about believability were previously recognized, but it appears that the teachers already using the Web for other purposes have confronted this challenge, leaving their use to act as a sort of proxy.

Heads-of-school computer use is substantial: 75 percent use computers at least several times weekly, with 42 percent using computers on a daily basis.

The relatively more intensive use of technology by administrators may reflect easier access and less competition for a computer than with teachers and students. While head-of-school attitudes were not found to be statistically correlated with higher student use or reported school impact, it seems reasonable to assume that the administrators who find these tools useful will be more inclined (or at least open) to their integration within the learning environment. Indeed, heads reported themselves as major or primary decision-makers in bringing technology into schools, but it seems that their enthusiasm and use has not completely translated into widespread adoption, ostensibly due to the higher costs and complexity with integration in education across large numbers of teachers and students.

Figure 26



Policy Implications

As a key driver of learning and skill development, breaking down the barriers that deter use by students and staff, supporting factors that facilitate use, and monitoring use as an output indicator of progress in integrating ICT in education are high priorities. In terms of closing the gap between teacher, student and headmaster affinity for technology and teacher and student use, the survey suggests that well functioning and accessible technologies are key. Approaches should include increasing overall numbers of computers, ensuring that those available are used more efficiently, and that they are better maintained and more reliable.

In terms of teachers specifically, policymakers may also wish to explore attempts to provide teachers free or concessionary-priced computers to improve their own exposure to (and efficacy with) new technologies outside the school setting. Increased access should be supplemented by training and support, recognizing that the former which was correlated with higher levels of student learning. Once access improves, it will be possible to better ascertain the importance of the other factors in terms of use. Until technologies begin to be used more widely, it will be difficult to determine their impact on learning, and indeed expect it to be significant.

An analysis of the motivating factors for student use would also provide valuable insight to policymakers with respect to curriculum design. Content that is rich in media and interactive seem to be the type of learning materials that most engage students. Not surprisingly, students most enjoy games and music, and also rank Internet information and e-mail as favorite activities. Educational games may provide a source of effective curricular content, and should be appealing due to their “pull” approach. Exercises that engage students in active learning through exploration and discovery of knowledge on the Web and dialogue and exchange with others through e-mail also hold great promise.

15. Effective Use/Perception of Impact

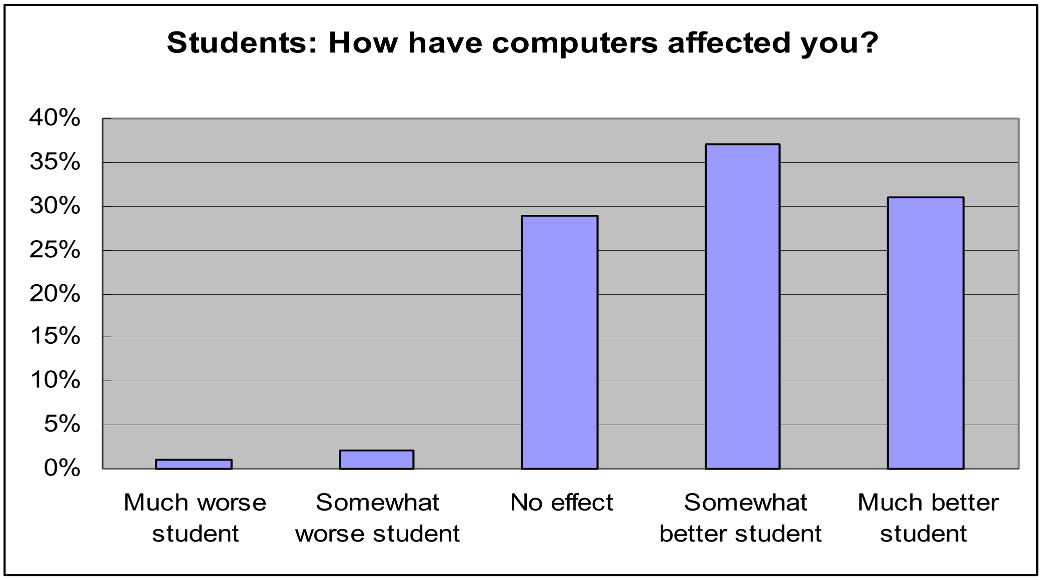
While difficult to capture, the overarching goal of the study is to understand how teachers and students are using technology, and the resulting impacts on teaching and learning.

> **In-class use of computers is associated with improved skills and learning.**
>
> **Using computers for science/programming, word processing and games, and having a game policy were correlated with skills and learning gains.**

The more frequently computers were used in school on average and by a teacher’s class (but not necessarily physically within the classroom) in particular, the more teachers felt students improved their skills in problem solving, creativity and overall learning. Applications such as science/programming and word processing were strongly correlated with these positive outcomes, while playing games was also an important factor. As straightforward uses for computers, these first two come as little surprise, while the latter may be a result of significant student enthusiasm and the subsequent familiarity with technology.

Also, as repeated earlier in the text, the effect of working with Web-based materials depends on their perceived reliability, with trustworthy materials accompanying positive improvements and suspect materials associated with declines.

Figure 27



Student use of e-mail and other electronic educational resources such as CD-ROMs were associated with decreases in skills and learning.

The explanation for why use of e-mail and CD-ROM-based educational material is resulting in decreased skill development and learning is unclear. Teacher and student reports of their e-mail interactions are consistent with limited integration in the formal learning process. Two-thirds of students report rare or nonexistent correspondence with teachers, and slightly higher levels of e-mail communication with others. While it is not clear why students and teachers do not communicate via e-mail (access limitations, cultural barriers), it is apparent that it has not earned teachers' support as a learning tool. It is unclear whether it is a distraction and simply perceived as non-supportive of learning, or if additional factors are involved.

Improvements in teaching were associated with computer teachers, in-class computer use, school computer use, perceived reliability of Web content and use, higher ratios of students per computer, and use of computers for science and programming.

Many of the same factors associated with positive learning outcomes among students also came out as important for teaching, suggesting that satisfying experiences for teachers and students go together (at least from the teachers' perspective). If we view in-class computer use as something of a proxy for the integration of computers in learning, getting computers into the classroom has potentially large benefits. Moreover, it does not seem surprising that computer teachers are associated with positive teaching outcomes, nor that content reliability matters. Computer use in general and for science and computer programming in particular suggest familiarity (or perhaps success on the teacher's part) in finding ways to integrate these activities into existing curricula. Also, interestingly, more students per computer actually increased teachers' senses of improvements in their own teaching. This could come as a result of easier management and group organization, or the peer learning associated with multiple users. Finally, higher fixed line teledensity and national earnings were also positively correlated with increased teachers' senses of improvements in their own teaching.

A number of factors had a negative impact on teacher perceptions of their own improvement. For instance, outside of school access for students, decreased teachers' sense of improvements in their own teaching. Teachers who taught younger students sensed fewer improvements in their own teaching. The presence of a network connection decreased teachers' senses of improvements in their own teaching.

The more frequently computers were used in school on average and in a teacher's class in particular, the more teachers felt students improved their skills and increased their learning. The more frequently computers were used in the teacher's school for Internet purposes, however, the worse teachers' reported their students improvement in literacy and learning – when teachers thought information on the Web was not accurate or believable. The use of Internet in class had a mildly positive effect when teachers thought information on the Web was accurate and believable.

Basic computer use is considered by teachers to be a more valuable contribution to student learning than Internet use.

The roots of this finding could help explain the limited uptake of the Internet, and assist in evaluating its effectiveness. For instance, it could be interpreted as a result of loss of instructor control, a distraction for the students, or as a reaction to adding yet another technology layer (computer plus Internet) - and a less reliable one at that. If that is the case, lines of inquiry would include examining whether teachers view games or non-academic pursuits as a disturbance, whether training can mitigate feelings of lost control/ineffectiveness, and the role of exposure over time in changing perspectives. The effect could have implications for professional development, physical infrastructure, use policies, access policies, and curriculum, among other areas.

Teachers in Latin American and African schools report more positive school impact, but less computer use.

Latin American students have greater gains than other student groups, while African students had lesser gains.

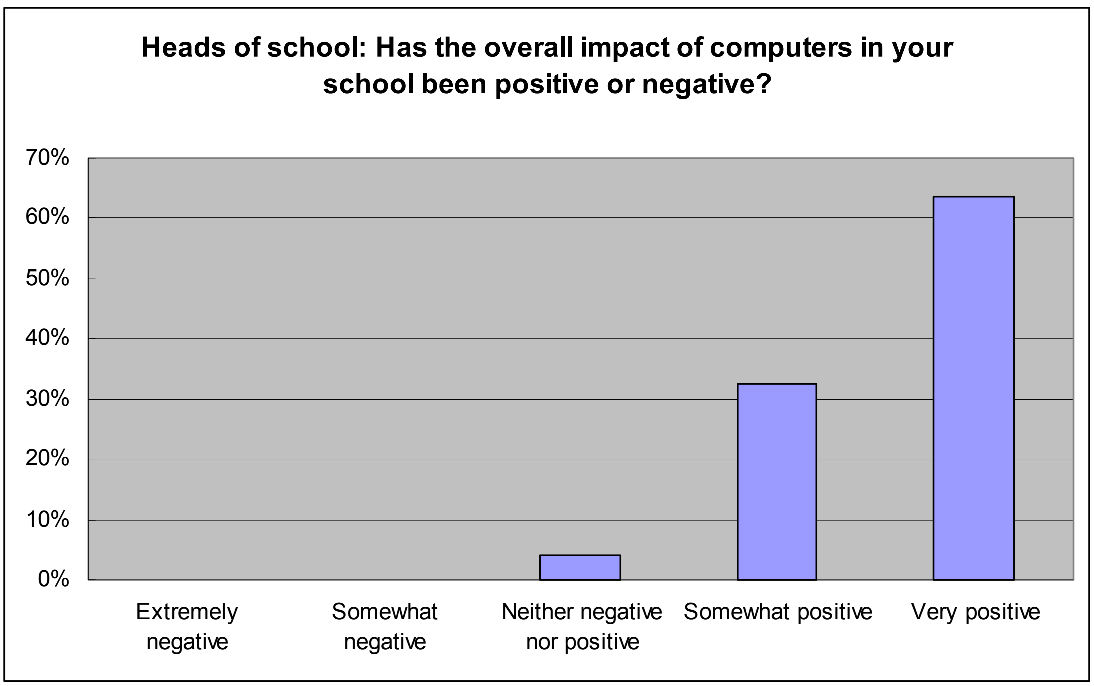
The Latin America and Africa "dummy" variables are statistically significant and strong determinants of School Impact and Teachers' Attitudes Towards Computers (as reported by teachers). Both coefficients are positive implying that there are unaccounted for factors that cause computers to be perceived as having a positive impact on schools in African and Latin American sample countries. This could be partly related to the language of instruction and exposure, which is predominantly English (and availability of software and content in English) in the African nations observed, with world languages (Spanish and Portuguese) in Latin America, and national languages in Asia/Middle East. While it seemed that differing periods of regional experience with computers could explain some of the discrepancy, including length of time in the regression yielded unclear results, again suggesting that the regional variables are picking up some other omitted factor.

In terms of impacts on students, teachers in the African nations tended to report lower levels of improvement in literacy skills and learning improvement while teachers in Latin American nations tended to report higher levels of improvements in literacy skills and learning improvement. This would seem to contradict the idea that the language of instruction matters. If language of instruction were a significant determinant of attitudes, use, and impact, we might also expect to see more improvements in literacy and learning in African countries. On the other hand, given the generally higher level of resources in Latin American nations, it may simply reflect barriers that were omitted from the survey. Interestingly, both the Latin America and Africa variables had statistically significant negative effects on PC use.

It bears mentioning that grouping these schools in different nations together regionally is a blunt attempt at capturing cultural, economic, geographical and other differences. The tremendous variation along these lines observed within each of the participant countries which makes it inappropriate to generalize effects at a national level. Similarly, there are limitations to describing trends at a continental level with data from sample schools in just a few countries.

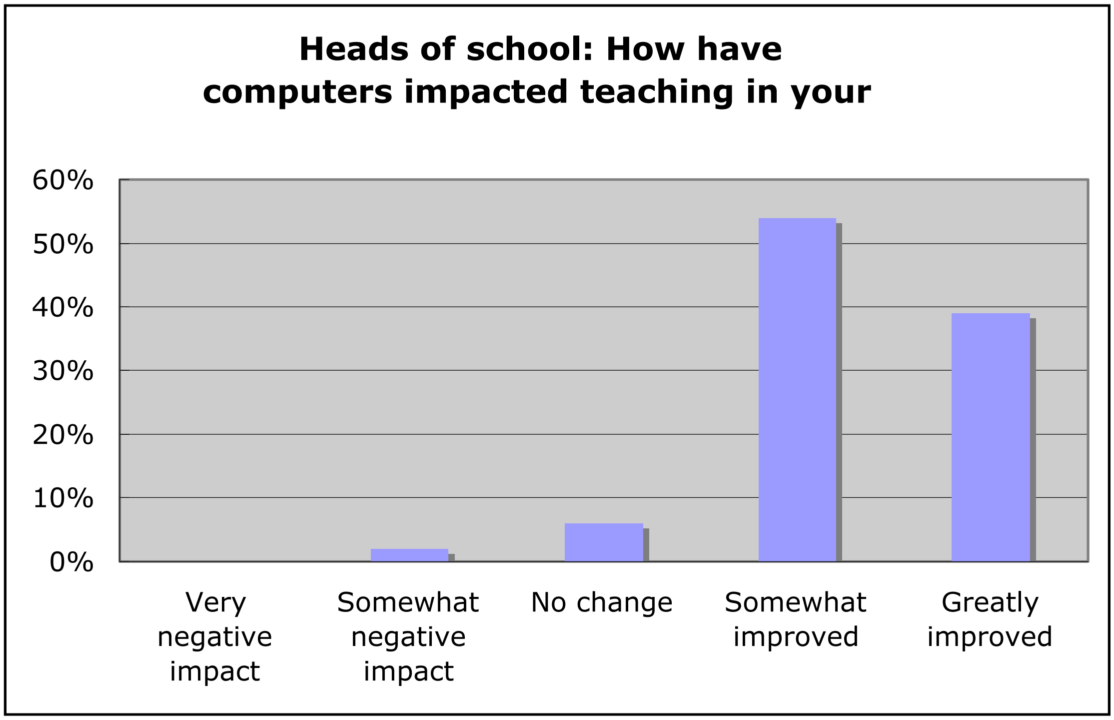
School heads overwhelmingly positive on the impact of computers in their schools.

Figure 28



93 percent of heads see some or great teaching improvement as a result of computers.

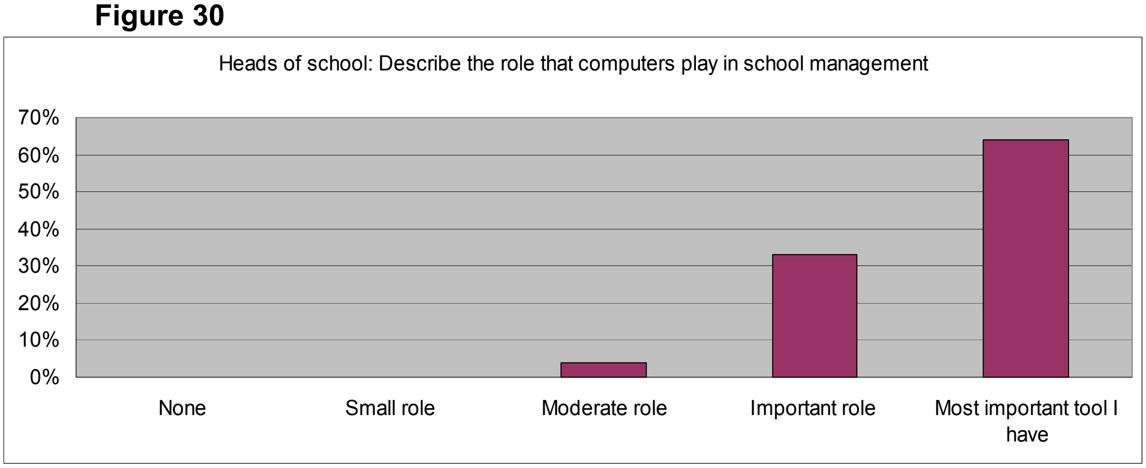
Figure 29



85 percent of administrators rely heavily on computers to manage their schools, with one-quarter indicating that they are their most important tool.

The consistency between administrative use and assessment of utility in managing the school suggest the need to further explore institutional uses of technology, its barriers and outcomes. This survey did not cover areas such as computer training for administrators, specific applications, or the availability of school level management systems.

Figure 30



Policy Implications

This section reflects the perceived gains of ICTs to development of the key new economy skills and learning gains that schools around the world are working to develop in their students. There are a host of issues that arise from this analysis that policymakers need to take into account when designing and implementing ICT in education programs. The first is the positive effects that having a computer in the classroom has on improved skills and learning. While the most practical first step is a lab, policymakers need to make greater efforts to get the tools closer to the classroom and the teachers and students who work there.

Next, clear integration of use of ICTs in the curriculum is important for their effective use in the classroom. It is not surprising that word processing, science, and programming were highly valued uses of the computer as they have clear and direct benefits to enhancing work done in the curriculum. E-mail and use of CD-ROM based educational software was not valued and integrated use of these tools and resources in the curriculum is also rarely evident in schools around the world. Only classrooms that have begun to embrace use of e-mail as a collaborative tool are effectively using it for educational benefits.

Getting computers into the hands of school heads and administrators is clearly a strong positive. While the impact of how these tools are improving management is not clear, the fact that administrators as leaders of their schools are so enthusiastically embracing the technology bodes well for further diffusion among the teaching staff and in turn more effective use of the technology for teaching and learning.

Finally, content is apparently king. Only when resources are trusted and perceived as reliable do teachers report positive impacts on skills development and learning. Policymakers need to make sure that training exists for teachers to develop information literacy skills to assist them to find and identify quality information online, and create their own materials. Development of a national educational portal would also provide teachers with a “safe” space to access vetted content.

V. Conclusions, Recommendations and Next Steps

As we conclude this phase of the GNRE project, we are left with more questions than answers, but also with data and experience that can help us to more deeply understand and probe the impact and processes associated with integrating ICT in learning. The dataset confirms widely held suspicions about tremendous enthusiasm over computers and the Internet (including adding nuance to teacher and administrator views of ICT), and gender imbalances in access. It sheds light on the truly early stage of ICT integration at which many developing world schools and teachers find themselves, including limited integration in class, low usage levels, lacking professional development and little after hours access to ICT. Our preliminary research also identifies important effects, such as the importance of trust in information for both teachers and learners, and the educational value of games.

As important as many of these seeds of understanding may turn out to be, there are also numerous shortcomings in the survey, to be expected in the first large scale iteration of any such instrument. Lines of questioning and approaches need to be revisited, additional effort needs to be made to gather external measurements such as attendance and standardized tests, and the relationships between the respondents should be established.

The result of this massive effort leaves researchers with a significant dataset to pore over and add to, a deeper understanding of self-reporting and observed metrics, and a laundry list of important questions as the field moves forward (see Appendix 7 for a partial list). Perhaps most importantly, it helps us to advance the ideal of performing evaluation and assessment on ICT in education programs, and giving policymakers, school leaders, and educators the tools and information that allow them to inform their actions based on fact rather than anecdote or supposition.

VI. List of Appendices:

Appendix 1: School Characteristics Sheet

2003 Global Networked Readiness for Education Survey
Education Program, The World Bank Institute
The Berkman Center for Internet & Society at Harvard Law School

Country: Costa Rica

#	Comp. Date	School Code	Region/ District	School Location	School Type	Class Status	Internet	Connection Type	ICT <2yrs	Special Program	Size <600	Sex	Boarding
1	8/25	CR-001	Greater	Urban	public	Middle	Y	DSL	Y	N	N	coed	Both
2	10/3	CR-002	Smaller	Semi-Urban	public	Poor	Y	modem	N	N	N	coed	Both
3	8/26	CR-003	smaller	Semi-Urban	public	Middle	N	ISDN	N	Y	N	coed	Both
4	9/30	CR-004	greater	Urban-marginal	public	Poor	Y	modem	N	N	N	coed	Both
5	9/26	CR-005	smaller	Rural-Rural	public	Poor	N	modem	N	N	Y	coed	Both
6	9/30	CR-006	smaller	Urban	public	Poor	Y	modem	N	N	N	coed	Both
7	9/29	CR-007	Greater	Urban	public	Middle	Y	modem	N	N	N	coed	Both
8	9/29	CR-008	smaller	Rural-Town	public	Poor	N	modem	N	N	N	coed	Both
9	9/29	CR-009	Greater	Semi-Urban	public	Middle	N	modem	N	N	N	coed	Both
10	9/25	CR-010	Greater	Urban	public	Middle	N	modem	N	Y	N	coed	Both

Country: Brazil

#	Comp. Date	School Code	Region/ District	School Location	School Type	Class Status	Internet	Connection Type	ICT <2yrs	Special Program	Size <600	Sex	Boarding
1	11/7	BR-001	Suzano	Urban	Public	Middle	Y	Cable	N	Y	N	Coed	day students
2	11/12	BR-002	Santo André	Urban	Public	Middle	Y	DSL	N	Y	N	Coed	day students
3	11/3	BR-003	Mauá	Urban	Public	Poor	Y	Dialup	N	N	N	Coed	day students
4	11/12	BR-004	São Paulo Taboão da Serra	Urban	Public	Poor	Y	Satellite	N	Y	N	Coed	day students
5	11/7	BR-005	Presidente Epitácio	Urban	Public	Middle	Y	Dialup	N	Y	N	Coed	day students
6	11/3	BR-006	Andradina	Urban	Public	Poor	Y	Dialup	N	Y	N	Coed	day students
7	11/11	BR-007	São Paulo	Urban	Public	Poor	Y	DSL	N	Y	N	Coed	day students
8	11/5	BR-008	Embu	Urban	Public	Poor	Y	Cable	N	N	N	Coed	day students
9	11/6	BR-009	Santo André	Urban	Public	Poor	Y	Dialup	N	Y	N	Coed	day students
10	11/11	BR-010	Carapicuíba	Urban	Public	Poor	Y	DSL	N	N	N	Coed	day students

11	11/4	BR-011	Ribeirão Pires	Urban	Public	Poor	Y	Dialup	N	N	N	Coed	day students
12	11/4	BR-012	Guarulhos	Urban	Public	Poor	Y	DSL	N	Y	N	Coed	day students
13	11/5	BR-013	São Paulo - Embu	Urban	Public	Poor	Y	Dialup	N	Y	N	Coed	day students
14	11/5	BR-014	Presidente Epitácio	Urban	Public	Middle	Y	Dialup	N	Y	N	Coed	day students
15	11/4	BR-015	Mauá	Urban	Public	Poor	Y	Dialup	N	Y	N	Coed	day students
16	11/3	BR-016	Suzano	Urban	Public	Poor	Y	DSL	N	Y	N	Coed	day students
17	11/4	BR-017	São Bernardo do Campo	Urban	Public	Poor	Y	DSL	N	Y	N	Coed	day students
18	11/5	BR-018	São Paulo - região Sul 2	Urban	Public	Poor	Y	DSL	N	Y	N	Coed	day students
19	11/7	BR-019	Presidente Prudente	Urban	Public	Middle	Y	Dialup	N	Y	N	Coed	day students
20	11/4	BR-020	Mauá	Urban	Public	Poor	Y	Radio	N	Y	N	Coed	day students
22	11/5	BR-022	Suzano	Urban	Public	Poor	Y	DSL	N	N	N	Coed	day students
23	11/6	BR-023	Guarulhos	Urban	Public	Poor	Y	DSL	N	N	N	Coed	day students
24	11/6	BR-024	Mogi das Cruzes	Urban	Particular	Middle	N		N	N	N	Coed	day students
25	11/13	BR-025	São Caetano do Sul	Urban	Public	Poor	Y	DSL	N	N	N	Coed	day students
26	11/3	BR-026	Mirandópilos	Urban	Public	Middle	N	Dialup	N	N	N	Coed	day students
27	11/3	BR-027	Presidente Venceslau	Urban	Public	Middle	Y	Dialup	N	N	N	Coed	day students
28	11/4	BR-028	Presidente Bernardes	Urban	Public	Middle	Y	Dialup	N	N	N	Coed	day students
29	11/10	BR-029	Presidente Prudente	Urban	Public	Middle	Y	Dialup	N	N	N	Coed	day students
30	10/28	BR-030	Martinópolis	Urban	Public	Middle	Y	Dialup	N	N	N	Coed	day students
31	11/3	BR-031	Álvares Machado	Urban	Public	Middle	Y	Dialup		N		Coed	day students
32	11/6	BR-032	Presidente Venceslau	Urban	Public	Middle	Y	Dialup	N	N	N	Coed	day students
33	11/3	BR-033	Andradina	Urban	Public	Middle	Y	Dialup	N	N	N	Coed	day students

Country: El Salvador													
1	11/17	1	Sonsonate/ Juayua	Semi-urban	Public	Poor	Y	Dial Up	Y	Y	Y	Coed	N
2	11/17	4	La Libertad/Colón	Semi-urban	Public	Poor	Y	Dial Up	Y	Y	N	Coed	N
3	11/17	5	San Salvador/Ayutuxtepeque	Urban	Public	Poor	Y	Dial Up	Y	N	N	Coed	N
4	17//11/03	9	Usulután/Santiago de María	Semi-urban	Public	Poor	Y	Dial Up	Y	N	N	Coed	N
5	11/17	7	Cuscatlán/San Rafael Cedros	Rural	Public	Poor	Y	Dial Up	Y	Y	N	Coed	N
6	11/17	8	San Vicente/Santa Clara	Rural	Public	Poor	Y	Dial Up	Y	N	Y	Coed	N
7	11/18	3	Chalatenango/Tejutla	Semi-urban	Public	Poor	N		Y	N	N	Coed	N
8	11/18	2	Chalatenango/San Ignacio	Semi-urban	Public	Poor	Y	Dial Up	Y	Y	N	Coed	N
9	11/18	6	San Salvador/Guazapa	Semi-urban	Public	Poor	N		Y	N	N	Coed	N
10	11/19	10	San Salvador/San Salvador	Urban	Public	Poor	Y	Dial Up	Y	N	N	Coed	Both
Country: Gambia													
1	10/3	GM-001	Kombo St Mary's Division	Urban	Private	Wealthy	Y	Dial Up	N	N	N	Coed	No
2	9/26	GM-002	Banjul	Urban	Public	Middle	Y	Dial Up	N	Y	N	M	No
3	10/3	GM-003	Kombo St Mary's Division	Urban	Private	Middle	Y	Dial Up	N	N	N	Coed	No
4	10/10	GM-004	Lamin Village	Rural-Town	Public	Middle	Y	Dial Up	N	Y	N	Coed	No
5	10/10	GM-005	Janjanbureh	Rural-Rural	Public	Poor	Y	Dial Up	N	Y	Y	Coed	Yes
6	10/3	GM-006	Kombo St Mary's Division	Urban	Private	Middle	Y	Dial Up	N	N	N	Coed	No
7	9/26	GM-007	Banjul	Urban	Public	Middle	Y	Dial Up	N	Y	N	F	No
8	10/10	GM-008	Farafenni	Rural-Town	Public	Poor	Y	Dial Up	N	Y	N	Coed	No
9	10/10	GM-009	Mansakonko	Rural-Town	Public	Poor	Y	Dial Up	N	Y	N	Coed	No
10	9/26	GM-010	Banjul	Urban	Public	Middle	Y	Dial Up	N	Y	N	Coed	No
Country: Jordan													
1		JO-001											
2		JO-002											
3		JO-003											
4		JO-004	AMMAN	AMMAN									

5		JO-005	AMMAN	AMMAN									
6		JO-006											
7		JO-007											
8		JO-008	ZARQA	ZARQA									
9		JO-009	amman	amman									
10		JO-010	amman	amman									
Country: India, State: Karnataka													
1		KA-001	Bangalore South	Urban	Government Aided	Middle	Y		N	Y	N	Coed	N
2		KA-002	Bangalore North	Urban	Government Aided	Middle	Y		N	Y	N	Coed	N
3		KA-003	Bangalore South	Semiurban	Government Aided	Middle	Y		N	Y	N	Coed	N
4		KA-004	Vartur	Semiurban	Private	Middle	N			N	N	Coed	N
5		KA-005	Bangalore City	urban	Private	Wealthy	Y			N	N	Coed	N
6		KA-006	Kolar	Rural-Rural	Government	Poor	Y		Y	Y	N	Female	N
7		KA-007	Kolar	Rural-Town	Government	Poor	Y		Y	Y	N	Male	N
8		KA-008	Kolar	Rural-Town	Government	Poor	Y		Y	Y	N	Female	N
9		KA-009	Kolar	Rural-Town	Government	Poor	Y		Y	Y	N	Female	N
10		KA-010	Kolar	Rural-Rural	Government	Poor	Y		Y	Y	N	Coed	N
Country: Mexico													
1	10/2	MX-001	Iztapalapa	Semi-Urban	Public	Poor	Y	Dialup	N	Y	Y	Coed	Day Students
2	10/1	MX-002	Iztacalco	Semi-Urban	Public	Poor	Y	Dialup	N	Y	N	Coed	Day Students
3	10/6	MX-003	Venustiano Carranza	Semi-Urban	Public	Poor	Y	Dialup	N	Y	N	Coed	Day Students
4	10/7	MX-004	Magdalena Contreras	Semi-Urban	Public	Poor	Y	Dialup	N	Y	Y	Coed	Day Students
5	10/13	MX-005	Xochimilco	Urban	Private	Middle	Y	Dialup	N	Y	Y	Coed	Day Students
6	10/15	MX-006	Tlalpan	Urban	Public	Poor	Y	Dialup	N	Y	N	Coed	Day Students
7	10/20	MX-007	Tlalpan	Urban	Public	Poor	Y	Dialup	N	Y	N	Coed	Day Students
8	10/28	MX-008	Alvaro Obregón	Urban	Priv/religious	Wealthy	Y	DSL	N	N	Y	Coed	Day Students
9	10/16	MX-009	Magdalena Contreras	Urban	Priv/religious	Wealthy	Y	Cable	N	N	N	F	Day Students

10	10/30	MX-010	Alvaro Obregón	Urban	Priv/religious	Wealthy	Y	Satellite	N	N	N	M	Day Students
Country: Panama													
1	10/3	PA-001	Chiriquí	Rural	Public	Poor	N		Y	N	Y	Coed	Both
2	10/8	PA-002	Coclé	Rural	Public	Middle	Y	DIAL UP	N	Y	N	Coed	Both
3	10/16	PA-003	Colón	Rural	Public	Poor	N		Y	Y	N	Coed	Both
4	10/13	PA-004	Coclé	Semi-Urban	Public	Middle	Y	DIAL UP	Y	Y	N	Coed	Both
5	10/8	PA-005	Coclé	Rural-Rown	Public	Middle	Y	DIAL UP	N	N	N	Coed	Both
6	10/6	PA-006	Panamá Centro	Urban	Public	Middle	Y	ADSL	Y	Y	N	Coed	Both
7	10/7	PA-007	Panamá Centro	Urban	Public	Middle	Y	ADSL	N	N	N	Coed	Both
8	10/3	PA-008	Panamá Centro	Urban	Public	Middle	Y	ADSL	N	N	N	Coed	Both
9	10/9	PA-009	Veraguas	Semi-Urban	Public	Middle	Y	DIAL UP	N	N	N	Coed	Both
10	10/9	PA-010	Veraguas	Rural-Town	Public	Poor	Y	DIAL UP	N	N	Y	Coed	Both
11	10/30	PA-011	San Miguelito	Urban	Public	Poor	Y		Y	Y	Y	Coed	Both
13	10/30	PA-012	Panama Centro	Urban	Public	Poor	Y		Y	N	N	Coed	Both
Country: Philippines													
1	1-Sep	PH-001	Reg VI / Guimbal	Rural-Town	Public	Middle	Y	Dialup		Y - WL	N	Coed	N
2	15-Sep	PH-002	Reg VIII / Leyte	Semi-Urban	Public	Middle	N				N	Coed	N
3	15-Sep	PH-003	Reg VIII / Leyte	Semi-Urban	Public	Poor	N					Coed	N
4	16-Sep	PH-004	Reg VIII / Ormoc	Rural-Town	Public	Middle	Y				N	Coed	N
5	17-Sep	PH-005	R VII / Cebu Province	Rural-Rural	Public	Poor	Y	Dialup		Y - WL		Coed	N
6	17-Sep	PH-006	R VII / Cebu City	Urban	Public	Poor	Y				N	Coed	N
7	17-Sep	PH-007	R VII / Cebu City	Urban	Public	Wealthy	Y					Coed	N
8	18-Sep	PH-008	R VII / Cebu City	Urban	Public	Middle						Coed	N
9	18-Sep	PH-009	R VII / Cebu City	Urban	Public	Poor	N				N	Coed	N
10	19-Sep	PH-010	R XI / Davao City	Urban	Public	Poor	N					Coed	N
11	19-Sep	PH-011	R XI / Davao City	Urban	Public	Middle	Y				N	Coed	N
12	19-Sep	PH-012	R XI / Davao City	Urban	Public	Middle	N					Coed	N
13	23-Sep	PH-013	NCR* / Marikina City	Urban	Public	Poor	Y	Dialup		Y - WL	N	Coed	N
Country: South Africa													
1	October	ZA-001	Eastern Region: NW	Rural-Town	Public	Middle	Y	Dialup	No	Y	N	Coed	N

2	October	ZA-002	Eastern Region: NW	Rural-Town	Public	Poor	Y	Dialup	No	Y	Y	Coed	N
3		ZA-003	Eastern Region: NW	Rural-Rural	Public	Middle	Y	Dialup	No	Y	N	Coed	N
4	October	ZA-004	Western Region: NW	Rural-Rural	Public	Poor	Y	Dialup	No	Y	N	Coed	N
5	October	ZA-005	Western Region: NW	Rural-Rural	Public	Poor	Y	Dialup	No	Y	N	Coed	N
6		ZA-006	Central Region: NW	Rural-Rural	Public	Poor	Y	Dialup	No	Y	N	Coed	N
7	October	ZA-007	Southern Region: NW	Rural-Town	Public	Poor	Y	Dialup	No	Y	N	Coed	N
8	October	ZA-008	BJ Western: NW	Semi-Urban	Public	Middle	Y	Dialup	No	Y	N	Coed	Both
9	October	ZA-009	Central Region: NW	Semi-Urban	Public	Wealthy	Y	Dialup	No	Y	N	Coed	Both
10	October	ZA-010	Southern Region: NW	Rural-Town	Public	Poor	Y	Dialup	No	Y	Y	Coed	N
11	October	ZA-011	Eastern Region: NW	Rural-Rural	Public	Poor	Y	Dialup	No	Y	N	Coed	N
Country: Uganda													
1	21/11/03	UG001	Jinja	Semi-Urban	Public	Middle	Y	Satellite	Y	Y	Y	F	Y
2	21/11/03	UG002	Mukono	Semi-Urban	Public	Middle	Y	Satellite	Y	Y	Y	Coed	N
3	21/11/03	UG003	Moroto	Rural-Town	Public	Poor	Y	Satellite	Y	Y	N	Coed	Y
4	21/11/03	UG004	Luwero	Rural-Rural	Public	Middle	Y	Satellite	Y	Y	Y	Coed	Y
5	21/11/03	UG005	Kampala	Urban	Public	Middle	Y	Satellite	Y	Y	Y	Coed	N
6	21/11/03	UG006	Masaka	Semi-Urban	Public	Middle	Y	Satellite	Y	Y	Y	M	Y

Appendix 2: Survey Instruments

Teacher Survey
http://cyber.law.harvard.edu/ictsurvey/ICT_Teacher-survey.pdf

Student Survey
http://cyber.law.harvard.edu/ictsurvey/ICT_Student-survey.pdf

Head of School Survey
http://cyber.law.harvard.edu/ictsurvey/ICT_Head-of-School-survey.pdf

Computer Background Survey
http://cyber.law.harvard.edu/ictsurvey/ICT_Computer-background-survey.pdf

Appendix 3: Administration Document

2003 Global Networked Readiness for Education Surveys
Guidelines for Survey Administration

I. School selection
II. Number of surveys to be completed
III. Survey administration checklist

School selection

A ***minimum*** of 10 (ten) schools in your country should be selected in which to administer these surveys:

- These schools should all have computers, and preferably Internet connectivity;
- We should try for a mix of schools: public and private, from different geographic areas, both co-educational and single sex.

Once schools have been selected in a country, the survey administrator must assign a five digit school code to each school in the following format:

XX-000

where "XX" is the two-digit alphabetical Internet country code and "000" is a three-digit number.

For example in Ghana, the schools could have the following school codes:

School #1: Accra Academy: GH-001
School #2: West Africa Secondary School: GH-002
etc.

A complete list of all school names and their corresponding school codes must be sent to our team at Harvard University at globalsurvey@cyber.law.harvard.edu as soon as possible.

Number of surveys to be completed

Four (4) separate surveys must be completed in each school:

1) **Head of School Survey** (1 per school)
This survey should be filled out by the school's Principal, Head Administrator, Headmistress/ Headmaster or someone in a similar position.

2) **Computer Background Survey** (1 per school).

This survey should be filled out by one individual in each school who is the person directly responsible for managing the school's computers. This person may be the computer lab administrator, the teacher who takes a very active interest/role in the use of computers in the school, or another individual in the school is extremely knowledgeable about the school's computers.

3) Teacher Survey (minimum of 8 per school)
This survey should be filled out by at least 8 teachers in each school. Ideally these teachers should regularly use the school's computers. Try to get an even mix of male and female teachers, and teachers from a variety of subject areas.

4) **Student Survey** (minimum of 30 per school)
This survey should be filled out by at least 30 students in each school who have regular access to computers in school in a variety of subjects. Try to get an even mix of boys and girls.

In total, we should get a **minimum** of **forty** (40) survey responses **from each school** (30
student + 8 teacher + 1 computer background + 1 head of school = 40 surveys). Larger
numbers of surveys responses from teachers and students are very welcome.

Survey administration checklist

A. Before going to a school:

- ❑ Determine the code for the schools where you will conduct surveys and send a list to us with school names and their code. Use the "Master List of Schools and School Codes" form (*see School Forms* document).
- ❑ If appropriate, arrange a date and time with an administrator at each school to answer any questions they might have (who the participating institutions are, what we hope to accomplish, what we expect of them, what they may expect of us, etc. – all covered in the FAQ document).
- ❑ Remember to write the school code on the surveys for the school you will visit before copying them. You can type the code in the PDF (recommended) and print a master copy for that school or just hand write it.
- ❑ Make enough copies from the master copy for the schools you will be visiting. You should have **one** Head of School survey, **one** Computer Background survey, **8** teacher surveys and **30** student surveys with the codes filled in. You should remember to **take additional copies of the surveys with you** as well in case there are mistakes or more people want to take the surveys.

B. Arriving at a school:

- ❑ In whatever order is most convenient,
  a. arrange for time and location to administer the surveys
  b. select the respondents and arrange for response to the Head of School and Computer Background surveys,

c. select the participating teachers
d. select the participating students

C. When administering surveys:

- Give some short background information on the survey (see the FAQ for background information).
- Explain that:
    - there are no right or wrong answers,
    - respondents should give the best answer they can
    - responses will not have any direct result for the school (classes changed,
    - computers given, etc.)
    - respondents should ask questions of the survey administrator if needed.

- Tell everyone taking the surveys that all answers are completely confidential and that individual responses will not be individually identified.
- Give brief instructions on how to fill out the survey, including example of the different types of questions. Note that if the school code does not appear on the survey already, survey administrators will need to tell the survey-takers the appropriate school code for their school. (This information is needed on page one of the survey.)
- Once the papers surveys have been completed on paper, the survey-takers should go to a computer and fill out the survey online at:
    - Teachers: http://cyber.law.harvard.edu/ictsurvey/teacher.html
    - Students: http://cyber.law.harvard.edu/ictsurvey/student.html
    - Head of School: http://cyber.law.harvard.edu/ictsurvey/headofschool.html
    - Background: http://cyber.law.harvard.edu/ictsurvey/computerbackground.html

- Note that, when entering the survey data online, each survey-taker will be asked to copy down the unique 16 digit survey code, as shown on the screen, on the first page of the paper copy of his/her survey.
- **Where there is no Internet or Internet connectivity is difficult, the survey administrator should collect all paper surveys and arrange for the entry of the individual survey responses online, one-by-one at his/her office, at an Internet café, etc**.
- If the Internet connection is lost while the survey data are being entered on the computer, the survey taker can return to the web site and either:
    - enter the unique 16 digit survey code (*which was written earlier on the first page of the survey*) to **resume** filling out the survey; or
    - **start again** from the beginning of the online survey, entering the new 16 digit survey code on the paper copy of the survey.

- The administrator should collect all paper copies of the survey.

D. After the surveys are complete:

- Once all of the paper surveys for a school have been completed and the data entered online, the survey administrator must assemble all (approximately) 40 paper copies of the surveys from the school and bind together.

- At the top of the pile of school surveys, the survey administrator should attach the “School Survey Completion” form (*see School Forms* document), entering the school name, code, address, number of surveys completed, etc. as required.

- Once all schools have finished with the survey process, the schools surveys should be bundled together and sent to the World Bank Institute office in Washington, DC using the World Bank pouch (through the local World Bank Resident Mission) at the following address:

ATTN: Robert Hawkins
MSN# J3-302, Room J3-081
World Bank Institute
1818 H Street, NW
Washington, DC 20433 USA
Tel: (+1) 202-473-3660

All the surveys must be completed, data entered online and paper copies of the surveys
sent to the World Bank by September 30, 2003 to be included in the first stage of this project!

Questions?

Any questions or comments should be sent to Harvard University at globalsurvey@cyber.law.harvard.edu.

THANK YOU FOR YOUR ASSISTANCE!

Appendix 4: Frequently Asked Questions on the Survey

Frequently Asked Questions

ICT/Education Survey by WBI and Berkman Center

We have prepared the survey administration guideline in the form of Frequently Asked Questions (FAQ), as listed below. To a large extent, the success of this survey depends on your knowledge of ICT in education, contacts in your community, capacity to organize a complex task, and understanding of that task. It is already clear that you are accomplished in all of those areas, and our responsibility to make sure you know what we are all working on, why and how to do it. Please contact us if you have any other questions.

Background

1. Why are we doing this survey?
A lot of money and time has been gone to creating access to technology in school, but there has been very little evaluation of what has worked and what did not, why, and how it could be improved. This is the first global survey of developing nations' use of Information and Communication Technologies (ICT) in school, and will help form the basis for a more effective approach to putting computers and Internet in schools.

The results of the survey will be used to help policymakers understand ICT and education better and help them with the policy decisions regarding the implementation and use of ICT in Education.

2. What will happen with the survey data?
The data will be cleaned and organized in a database, where researchers can examine it for correlations, trends and patterns that will help us answer the questions raised above. The results will be published by late 2003 and will be available on our website for download.

3. What about the privacy of the respondents?
We respect the privacy of our respondents. To keep the responses confidential we therefore don't ask for respondents name, email or any other personal identification information. Further, all individual responses will be kept totally confidential and the school level data will be shared with corresponding schools only after aggregation.

4. What benefit is there for the participants?
Direct benefits include the dialog and reflection that the surveys will provoke in schools, and the data generated by the actual survey. Schools will have a better picture of what is happening in their community, while being able to compare themselves with other schools nationally and internationally. *It is very important to note that their responses will neither qualify nor disqualify them from getting any additional technology resources or funding – we are gathering data for research purposes only.*

5. Whom should I contact if I have additional questions?
You may send an email to Edsurvey@cyber.law.harvard.edu or call (+1) 617-496-3210.

6. Who are the participating organizations in this project?
The lead organizations are the World Bank Institute and the Berkman Center for Internet and Society at Harvard Law School and, our partners include the national Ministries of Education in each participating nation, World Links, World Computer Exchange, iEARN, IMFUNDO, USAID, local education organizations and many others.

Range and Participation

1. *Who is the target audience for these surveys?*
   There are four different (but similar and overlapping) surveys, each targeting a different group of people -- Head of School, Computer Lab Administrator, Teachers and Students.

2. *How many schools per country?*
   Minimum of 10 schools per country

3. *How many teachers per school?*
   Minimum 10 teachers per school

4. *How many students per school?*
   Minimum 30 students per school. However, we would like to get as many students to respond as possible.

5. *Can we do additional schools?*
   Yes, please let us know if you are able to survey more schools. In general, the more schools the better – also the more teachers and students the better.

Participant Selection

1. What is Random Selection and why is it important?
One of the most important concepts behind doing good survey work is that the participants be selected randomly. Otherwise, if we wanted to, we could simply choose certain types of schools, teachers, students and administrators that we were certain would give the response we wanted. In order to ensure that does not happen, we introduce chance selection in our sample population, and if that sample is big enough and randomly selected, it will represent the larger population accurately.

2. How do we select the Schools?
We want the most representative sample of schools possible. Ideally, schools should be from urban and rural areas, wealthy and poor communities, publicly and privately funded, large and small, programs that are both experienced with ICT and new to technology, schools having Internet access versus those who don't have Internet access, and so on.

We would suggest that you begin by creating a master list of all the schools or networks with computers (and at least some Internet access), noting their characteristics. We will then select the first batch of 10 schools to survey randomly from that master list.

We like to keep the World Links schools to no more than four in the final list of 10 schools that we survey (except in cases where there are no other schools with ICT access).

3. *How do we select the Teachers?*

The teachers should be chosen at random, so that we do not only have those who use ICT frequently, but get a group that is representative of all teachers in the school. We will send further details on this in a separate packet.

4. *How do we select the Students?*

The students should be chosen at random, so that we do not only have those who use ICT frequently, but get a group that is representative of all students in the school. We will send further details on this in a separate packet.

Administration and Reporting

1. *How do we conduct these surveys?*

We will send a checklist with all the necessary components of administering a survey separately, but this section has a general description of what is needed.

Based on your requirement, we will send official letters to the Ministers of Education or to others in all participating countries asking for their help. If you need any additional institutional support in terms of letters of introduction or other documentation, we will be happy to provide those.

You should inform each Head of School of the survey, explaining the basics of who we are, what we are doing, why we are doing it, and where we are doing it (that should all be covered in this document). You should ask for their assistance in this important endeavor, explaining the benefits to their community.

It is important that you explain the survey in a manner that does not seek to influence their responses. That is to say, we want them neither to be excessively positive nor negative, but honest and accurate to the best of their ability. You should answer any specific question they might have on the survey, but in the end, they must guide themselves. Other than asking for the cooperation of staff and students, the Head of School (and teachers) should remain neutral. You may find that this is best accomplished by not providing warning to the schools of the survey.

You will undertake the selection process for teachers and students (detailed separately). You should explain the background and intention of the survey to all respondents, so that they take it seriously, respond truthfully and fully, and are eager to be participants in this process. You should be present (or at least available) as all respondents fill out the survey so that you may answer any questions they may have.

Each respondent should fill out the paper version of the survey that corresponds to him/her, and should be given all the time necessary to do so (hopefully, it will take less than 30 minutes, but it may vary). Where an Internet connection is available, they should then take the survey online, filling in the answers they have noted on paper and submitting the survey electronically. We will send you the links to the online surveys separately.

You should retain all paper copies of the survey once they have been filed.

2. Do they have to be done online?
We prefer them done online because it will use the technology we are studying, simplify many aspects of processing, improve the quality of the data, and reduce its cost. It is important that the survey is inclusive, however, and that respondents who are unable or choose not to fill it out online be allowed to submit a survey nonetheless. If the school runs a fee-based telecentre, you should pay for the computer/Internet time it takes to complete the surveys.

3. Do we have to send the filled paper surveys? If so, how?
We will ask you to collect the paper surveys and transport them to the nearest World Bank Mission.

4. What if there is no Internet connectivity in the school?
Please complete all the surveys on paper if the connectivity is poor or non-existent. Paper surveys not submitted electronically by respondents are the responsibility of the coordinator, and should be entered into the survey website at a cyber café or a telecentre. It is essential that these schools be included in the survey to share their reasons for and experience of not having good Internet access.

5. What is the timeline to complete the survey administration?
Each coordinator will generate his or her own timeline, including each step of the process. Generally speaking, we will start the survey at the beginning of August, and hope to have it completed by the end of September. We will ask you to send the implementation timeline to us beforehand.

6. Who will reimburse our expenses?
You will begin by submitting a budget before beginning the survey distribution process. Once it is approved, please inform us if there is likely to be any additional expenditure. Please document all your expenses (save receipts) and submit copies via fax to Adarsh Desai at 202-676-0961.

Appendix 5: Dependent Variable Overview

School Impact
The mean answer to the "**impact of PCs on school**" question in the teacher survey was 4.17 out of a discrete scale from 1 to 5, where 4 was "somewhat positive" and 5 was "extremely positive". The standard deviation was 0.8.

Teacher Attitude
The mean answer to the "**attitude towards PCs**" question in the teacher survey was 4.14 out of a discrete scale from 1 to 5, where 4 is "moderately like" and 5 is "strongly like". The standard deviation was 0.9. It is important to note that attitudes towards PCs were strongly and significantly correlated with assessments of PC impacts on schools. Many of the results from the impact on school section were replicated with the attitudes towards PCs dependent variable, and may be bi-causal in nature.

Student Attitude
The mean answer to the "**students attitude towards PCs**" question in the teacher survey was 4.15 out of a discrete scale from 1 to 5 where 4 is "moderately like" and 5 is "strongly like". The standard deviation was 1.1.

Student PC Use
The mean answers to the "**PC use**" questions in the student survey were on a scale where 1 is never, 2 is rarely, 3 is sometimes, 4 is very often and 5 a lot, and were:

	Mean	Standard Deviation
PC use in class	2.1	0.6
PC use for literature	1.8	1.1
PC use for math	2.1	1.3
PC use for science	2.2	1.3
PC use for social studies	2.0	1.3

Student Gender
The mean answers to the "**gender and learning**" questions in the teacher survey were on a scale where 1 is no influence, 2 is a little influence, 3 is some influence, 4 is a large influence and 5 is a substantial influence. For the most part, teachers reported that computers have had some influence in both girls and boys learning, writing and verbal skills. There was very little difference between genders. The results were:

	Mean	Standard Deviation
Girls' learning	3.16	1.1
Girls' Writing Skills	2.99	1.1
Girls' Verbal Skills	2.94	1.1
Boys' Learning	3.16	1.1
Boys' Writing Skills	2.89	1.0
Boys' Verbal Skills	2.82	1.0

Appendix 6: Regression Analysis Results

	School Impact Regression Results		
	Model 1	Model 2	Model 3
Gender	0.019655	-0.13059	-0.07229
Latin America	0.542972 **	0.947132 **	0.816812 **
Africa	0.809051 **	0.687592 **	1.190296 **
Art teacher		-0.0492	-0.03476
Computers teacher	0.186348	0.19236	0.180623
Humanities teacher		0.082019	-0.03834
Language teacher		-0.03453	0.021494
Other language teacher		0.18805	0.185655
Math teacher		0.039526	0.006163
Music teacher		-0.0576	-0.13637
Science teacher		0.142951	0.105421
Under 9 years old	0.18788	0.075578	0.070842
9 to 12 years old		-0.12485	-0.09259
13 to 15 years old		0.125422	0.130645
16 to 18 years old		0.057598	0.02938
Years teaching	0.060548	0.081688 *	0.070024 *
Years of pc experience	0.001805	0.035049	0.013949
School pc use	0.154731 **	0.050195	0.050835
School Web use	-0.32256 **	-0.19729 *	-0.15457
Believability * Web use	0.075586 **	0.052905 **	0.046047 *
Importance of standards			0.080462
Importance of PC skills			-0.02511
Supplement importance			0.103621 *
Overall importance		0.004051	-0.01122
Career challenges	-0.06871 *		-0.07203 *
Confidence challenges	0.004525		-0.04158
Language challenges	0.024946		0.021414
Electricity challenges	-0.05476		-0.01616
General challenges	-0.00288	-0.00928 *	-0.00024
PC Problem: Self help	0.086146	0.04038	0.150397
Self training	-0.0616	-0.01482	-0.0558
Formal training	0.068008	0.041072	0.081703
Informal training	0.070229	0.106108	0.1315
No training	-0.12326	-0.19711	-0.17025
Textbook importance			0.098598 *
Blackboard importance			-0.07011
Video useful			0.036654
Teaching materials important			0.007648
Fixed phone lines per 1000 people	-0.00089	0.0000965	0.011386 **
Fixed phone lines squared			-0.00002 **
Verbal skills improved		0.013417	0.013912
Writing skills improved		-0.06203	-0.04445
Creativity improved		0.16082 **	0.133531 **
Problem solving skills improved		0.185787 **	0.169453 **
Job prospects improved	0.176029 **	0.099552 **	0.064875
Test scores improved	0.101366 **	-0.04274	-0.02875
Learning improved	0.325055 **	0.168715 **	0.194432 **
Teacher has cell phone	0.034993	0.024655	0.067231
PC in room	-0.13931	-0.16329	0.077908
GNI per capita	-0.00003	-0.00014 **	-0.00044
GNI per capita squared			4.04E-08
Average growth			2.470892
Network connection	-0.42169 **	-0.08253	-0.16418
Network reliability		-0.17461 **	
Network reliability: 2 of 5	-0.20633		0.009788
Network reliability: 3 of 5	-0.22579		-0.17153
Network reliability: 4 of 5	-0.33978 **		-0.20851
Network reliability: 5 of 5	-0.5617 **		-0.41886 *
Hours of electricity	0.086356	0.105592	0.258763
Hours of electricity squared			-0.02532
Students per PC	0.060735	0.10185 **	0.106843 **
Teacher involvement in ICT plan		0.365335 **	0.390945 **
Students attitude (student reported)		0.320162 **	
Parents attitude (student reported)		0.098876 **	
Admin attitude (admin reported)		0.074892	

* Statistically significant at 10% level ** Statistically significant at 5 % level

	Teacher's Attitude Regression Results					
	Model 1	Sig	Model 2	Sig	Model 3	Sig
Gender	-0.1423872		-0.1297045		-0.1698102	*
Latin America	-0.5878243	**	-0.0742061		-0.2324799	
Africa	0.7802891	**	0.6995566	**	1.018505	**
Art teacher			-0.2167951		-0.1884871	
Computers teacher	-0.4105741	**	-0.3367702	*	-0.520699	**
Humanities teacher			0.0994621		-0.0117519	
Language teacher			-0.1622563		-0.0547666	
Other language teacher			-0.0741309		0.062452	
Math teacher			0.0900852		-0.0079476	
Music teacher			0.2010371		0.066251	
Science teacher			0.1959134	**	0.0956264	
Under 9 years old	-0.2847413	**	-0.3829857	**	-0.3379279	**
9 to 12 years old			-0.1362658		0.0094533	
13 to 15 years old			-0.0993402		-0.0894676	
16 to 18 years old			0.0392051		-0.0168929	
Years teaching	-0.0787422	*	-0.1024257	**	-0.1050817	**
Years of pc experience	0.1868384	**	0.2287272	**	0.2111538	**
School pc use	0.1328449	**	0.0909019	*	0.0958237	**
School Web use	-0.3782907	**	-0.2984414	**	-0.3095767	**
Believability * Web use	0.0943434	**	0.0814084	**	0.0941464	**
Importance of standards					0.0873074	*
Importance of PC skills					0.0949122	**
Supplement importance					-0.0464419	
Career challenges	-0.0879673	**			-0.0739694	**
Confidence challenges	-0.0637379	*			-0.0998506	**
Language challenges	0.0552885				0.0613427	*
Electricity challenges	-0.0067768				-0.0213786	
PC Problem: Self help	0.0769019		0.0404035		0.0530996	
Self training	0.2535674	**	0.2989722	**	0.223155	**
Formal training	0.071765		0.0558862		0.1060152	
Informal training	0.0979933		0.0512605		0.1307456	
No training	0.1826376		0.0763538		0.0975358	
Textbook importance	0.1586783	**			0.1636981	**
Blackboard importance	-0.0018124				-0.0119541	
Video useful	-0.0039797				-0.0146297	
Teaching materials important	0.1873525	**			0.19616	**
GNI per Capita	-0.0000282		-0.0001423	**	-0.0007479	**
GNI per Capita Squared					9.59E-08	**
Average growth in GNI per cap in last 5 years					-2.484366	
Fixed phone lines per 1,000 people	0.0019864	**	0.0031697	**	0.0179213	**
Fixed phone lines squared					-0.0000283	**
Verbal skills improved			0.0490446		0.0736338	
Writing skills improved			-0.080391		-0.0978801	
Creativity improved			0.1102348	**	0.070277	
Problem solving skills improved			-0.1058581	**	-0.0815854	
Job prospects improved	0.0339005		0.0702397	*	0.0391561	
Test scores improved	0.0251992		0.0149425		0.0260985	
Learning improved	0.2108014	**	0.1888435	**	0.2105975	**
Teacher has cell phone	-0.17616	**	-0.1284805		-0.0630468	
PC in room	-0.2165227		-0.4085135	**	-0.0214902	
Network connection	-0.2745612		0.0672098		0.0688733	
Network Reliability			-0.1549194	**		
Network reliability: 2 of 5	-0.4260732	*			-0.3829332	*
Network reliability: 3 of 5	-0.2464033				-0.1578894	
Network reliability: 4 of 5	-0.4448311	**			-0.3662138	*
Network reliability: 5 of 5	-0.6010266	**			-0.4007339	*
Hours of electricity	0.0596793		0.0125566		-0.3120237	
Hours of electricity squared					0.0445078	
Students per PC	0.0453853		0.0133298		0.062918	
Teacher involvement in ICT plan			-0.0181199		-0.0153571	
Students attitude (school average)			0.2872298	**		
Parents attitude (school average)			0.2366665	**		
Admin attitude (school average)			0.2245899	**		

* Statistically significant at 10% level ** Statistically significant at 5% level

Student's Attitude Regression Results

	Model 1		Model 2		Model 3	
Student's age	-0.0476989		-0.0702719	**	-0.0753506	**
Student's gender	0.0554814		0.0917301	**	0.0795999	*
Latin America	-0.0389378		-0.0024956		0.1495234	
Africa	-0.012591		0.1167682		0.1292306	
Years of PC experience	-0.0075366		-0.0144871		-0.0086151	
School PC use	0.0896516	**	0.096591	**	0.0684142	**
School Web use	-0.2342073	**	-0.2975183	**	-0.2736435	**
Believability * school Web use	0.0555529	**	0.0703654	**	0.0699097	**
Use PC at home					-0.0344525	**
Use PC at friend's house					-0.0082083	
Use PC at Internet café					-0.0483583	**
Use PC for games					0.02913	
Use PC outside of classroom					-0.0149609	
Use for educational purposes					-0.0146927	
Use for e-mail					0.0227631	
Use for art					0.0080081	
Art use * art feelings					0.001042	
Use for computer class (CC)					-0.13466	**
CC use * CC feelings					0.0404321	**
Use for literature					-0.1157042	**
Literature use * literature feelings					0.0266163	**
Use for national language					0.1038625	**
Language use * language feelings					-0.0141443	
Use for other language					-0.0932251	**
Other lang use * other lang feeling					0.0132541	
Use for math					-0.0131507	
Math use * math feelings					-0.00575	
Use for science					0.0815297	*
Science use * science feelings					-0.0123431	
Use for social studies (SS)					-0.1090415	**
SS use * SS feelings					0.034051	**
Use for music					-0.1306057	**
Music use * music feelings					0.0228029	**
Self taught	-0.0633904		-0.0563086		-0.0626536	
Teacher taught	0.1307671	**	0.1239325	*	0.0928493	
Friends taught	-0.0790995		-0.1196175		-0.1416075	*
Family taught	-0.0666385		-0.0495595		-0.035737	
GNI per capita	-0.0000196		-0.0000159			
Ln(GNI per capita)					-0.4317154	**
Fixed phone lines per 1,000 people	-0.0000115		-0.0008034	**		
Fixed lines squared					0.4480889	**
PC in room	0.0220158		0.039691		0.0550038	
Network connection	-0.1743325	**	-0.1508104	**	0.0380542	
Network reliability	0.1212375	**	0.119849	**		
Reliability: 1 to 2					0.0088131	
Reliability: 2 to 3					0.1718825	
Reliability: 3 to 4					0.3319099	**
Reliability: 4 to 5					0.4071384	**
Hours of electricity	-0.0362228		0.0097677			
Ln(hours of electricity)					0.0772727	
Students per pc	0.06043	**	0.0718589	**	0.0902886	**
Student involvement in planning	0.0070386		0.0064451		0.0078756	
Confidence challenges			-0.015187			
Language challenges			-0.0152695			
Theft challenges			0.0312103	*		
Technical challenges			0.0136031			
Time challenges			-0.0015859			
PC challenges			0.0157649			
Electricity challenges			-0.0309083	*		
Cost challenges			-0.0111942			
Outside challenges			-0.1287236	**		
Use policy	0.0469294		0.0273473			
Content policy	-0.0952335	*	-0.1307152	**		
Game policy			0.0743256			

* Statistically significant at 10% level ** Statistically significant at 5% level

	Use Regression Results									
	School PC Use		Literature Use		Math Use		Science Use		Social Studies Use	
Private school	0.020049		-0.0689024		-0.2050287	**	-0.2211424	**	-0.1784633	**
Teachers' attitudes (school average)	0.29237	**	0.0082929		-0.0713133		-0.0308331		0.0390954	
Administrator's attitude	-0.0107604		-0.0310809		-0.0126488		0.0033064		-0.0253472	
Student's age	0.0261216		-0.0030677		-0.0241685		-0.1180228	**	-0.0630281	**
Student's gender	-0.1436118	**	-0.2057283	**	-0.1283395	**	-0.171554	**	-0.1377307	**
Years of PC experience	0.1202242	**	0.0423631	**	-0.0295868		0.0364372	**	0.0356047	*
Latin America	-0.2393268	**	-0.1685042		-0.29277	**	-0.3120376	**	-0.1421609	
Africa	-0.3437392	**	-0.494984	**	-0.205732	**	-0.4469761	**	-0.6628838	**
Believability of net content	0.0459867	**	0.0065951		0.0562877	**	0.0345146		0.0187531	
Confidence challenges	-0.0029208		0.0146452		-0.009647		0.0023143		-0.0038948	
Language challenges	-0.0023696		0.0608217	**	0.0504267	**	0.0492702	**	0.0590496	**
Theft challenges	0.0204923		0.0103302		0.0148754		0.0283435	*	0.0365081	**
Technical challenges	-0.0169631		-0.0438819	**	-0.0555	**	-0.0489026	**	-0.0531686	**
Time challenges	0.006124		0.0048645		0.0038791		-0.0035297		-0.002678	
PC challenges	-0.0282305		-0.066071	**	-0.0438793	**	-0.0346546	**	-0.0619924	**
Electricity challenges	0.02321		0.0496466	**	0.0588961	**	0.0447068	**	0.0529898	**
Cost challenges	0.0049694		0.0051108		-0.0258237		-0.0224095		-0.0037154	
Outside challenges	-0.2395419	**	-0.1053389	**	-0.0683855	**	-0.1133548	**	-0.0946787	**
Students per PC	0.06154	**	0.0766436	**	0.0258027		0.105666	**	0.0766402	**
Outside access	-0.2415115	**	-0.0560177		-0.1506601	**	-0.075555	**	-0.0496022	
Hours of electricity	0.0077687		-0.0188962		0.008357		-0.021277		-0.0260379	
Student pays	-0.0098645		0.0066079		-0.0631753	**	0.0316603		-0.0005134	
Family pays	-0.1408479		-0.3726545	**	0.1841233	**	-0.445346	**	-0.2932853	**
PC in room	0.6198203	**	0.3088047	**	0.4246713	**	0.9117584	**	0.4117364	**
Net connection	-0.0699138		-0.0177484		-0.0210007		0.0806721		0.1213358	*
Net reliability	0.0982098	**	0.0939189	**	0.2034277	**	0.2042107	**	0.1562894	**
Net speed	0.1437956	**	0.0813095	**	0.0829636	**	0.0752386	**	0.0618844	**
GNI per capita	0.0000844	**	-0.0001166	**	0.0000095		-0.0000799	**	-0.0000171	
Fixed lines	-0.0011275	**	0.0013818	**	0.0006216	*	0.0004811		-0.0011033	**
Self taught	-0.0373981		-0.297901	**	-0.093304		-0.1176128		-0.0927089	
Teacher taught	0.4507197	**	0.029283		0.1022488		0.0144074		0.090728	
Friends taught	0.0668494		-0.1527207	*	-0.1377062	*	-0.1326459	*	-0.0503372	
Family taught	0.0073885		-0.2253268	**	-0.1109103		-0.2548569	**	-0.1743657	**
Use policy	-0.2869988	**	-0.3113645	**	-0.1560012	**	-0.0180735		-0.2006661	**
Content policy	-0.0853323		0.2123869	**	-0.281481	**	0.1860954	**	0.1597874	**
Game policy	0.1036559		-0.1523023	**	-0.0247713		-0.2724942	**	-0.1505998	**
Student involvement in PC planning	0.0494372	**	0.0277173		0.0342816		0.0318236		0.0105197	
Literature feelings			0.1650391	**						
Math feelings					0.0889815	**				
Science feelings							0.1914223	**		
Social studies feelings									0.1308809	**

* Statistically significant at 10% level ** Statistically significant at 5% level

	Gender Regression Results					
	Girls Learning	**Girls Writing Skills**	**Girls Verbal Skills**	**Boys Learning**	**Boys Writing Skills**	**Boys Verbal Skills**
Teacher's gender	0.102059	0.062195	0.097466	0.086783	0.112172	0.168416 **
Latin America	0.777284 **	0.953681 **	1.049119 **	0.645046 **	0.943484 **	1.058485 **
Africa	-0.46465 **	-0.20537	-0.20595	-0.43053 **	-0.12567	-0.11373
Teacher teaches computers	0.365821 **	0.341189 **	0.245168	0.303117 *	0.196841	0.226905
Teacher teaches under 9	-0.20714	-0.23949 *	-0.11983	-0.21255	-0.2087	-0.18421
Teacher teaches 9 to 12	-0.01842	-0.02973	-0.11521	-0.02486	-0.01185	-0.08653
Teacher teaches 13 to 15	-0.03389	-0.04728	-0.09277	-0.12582	-0.01703	-0.05336
Teacher teaches 16 to 18	-0.03086	-0.04544	-0.02129	-0.0022	0.029694	0.014309
Years teaching	0.054369	0.067231 *	0.067554 *	0.081814 **	0.062706 *	0.077098 **
Years of PC experience	-0.01735	-0.02118	-0.036	-0.0152	-0.02055	-0.02823
Class PC use	0.190326 **	0.162935 **	0.14623 **	0.158746 **	0.168977 **	0.146575 **
School pc use	0.206888 **	0.185463 **	0.206589 **	0.212543 **	0.183502 **	0.186967 **
School Web use	-0.49524 **	-0.38877 **	-0.25635 **	-0.42141 **	-0.39496 **	-0.29281 **
Believability * school Web use	0.148599 **	0.130783 **	0.099025 **	0.120568 **	0.11901 **	0.10285 **
Teacher has cell phone	0.128321	0.008181	-0.00363	0.138947 *	0.00112	0.015021
Confidence challenges	-0.00952	0.006519	0.054125	0.007158	-0.00576	0.029928
Language challenges	0.033305	0.080207 **	0.062738 *	0.038335	0.088529 **	0.071005 **
Theft challenges	0.00373	-0.04137	-0.01065	-0.03406	-0.05755 *	-0.01406
Technical challenges	0.057043 *	0.073839 **	0.045723	0.041564	0.068006 **	0.043576
Time challenges	0.002869	-0.02363	-0.04043	-0.0304	-0.02519	-0.03396
Pc challenges	0.03648	0.016022	0.029124	0.043378	0.001409	0.016224
Electricity challenges	-0.01008	-0.02646	-0.03049	0.004951	-0.02351	-0.00879
Problems: Self help	-0.55058 **	-0.235	-0.37415 **	-0.46184 **	-0.19092	-0.33133 **
Self trained	-0.11823	-0.15265 *	-0.12998	-0.12905	-0.11771	-0.11789
Formally trained	0.289327 **	0.266124 **	0.203827 **	0.186331 *	0.226607 **	0.158499 *
Informally trained	-0.12449	-0.08094	-0.04511	-0.10749	-0.0741	0.003115
GNI per capita	-0.00023 **	-0.00023 **	-0.0003 **	-0.00023 **	-0.00024 **	-0.00033 **
Fixed phone lines	0.00024	0.000781	0.000629	0.000542	0.000498	0.000749
PC in room	-0.06407	-0.14647	0.137003	-0.05874	0.027467	0.082981
Network connection	-0.12074	-0.30392 **	-0.22928 **	-0.07812	-0.22931 **	-0.16385
Network reliability	-0.01608	-0.00023	-0.00812	-0.02365	-0.00212	-0.01626
Hours of electricity	0.155129 **	0.134851 **	0.179629 **	0.098678	0.150265 **	0.164227 **
Students per PC	0.060958	0.052979	0.084016 **	0.029133	0.05388	0.086071 **
Use policy	-0.13814	0.038222	0.031787	-0.00392	0.046614	0.03957
Content policy	0.339516 **	0.303369 **	0.274317 **	0.14172	0.232553 **	0.194788 *
Game policy	0.192225 *	0.166746	0.184123 *	0.265051 **	0.184305 *	0.19339 *
Outside use	-0.07436	-0.03156	-0.02555	-0.06208	-0.0389	-0.02436
Administrator's attitude (self reported)	-0.0851	-0.05139	-0.0355	-0.04954	-0.07597	-0.04096

* Statistically significant at 10 percent level ** Statistically significant at 5 percent level

Class PC Use Regression Results

	Model 1	Sig
Private school	-0.260964	
Student attitudes (student reported)	0.0442346	
Admin attitudes (admin reported)	0.0870524	
Teacher gender	-0.0851211	
Latin America	0.7933247	**
Africa	-0.4049681	**
Computer teacher	1.33904	**
Teaches under 9	-0.2386736	*
Teaches 9 to 12	0.0770231	
Teaches 13 to 15	0.116571	
Teaches 16 to 18	0.084141	
Years teaching	0.045585	
Years pc experience	0.1402331	**
Formal training	0.2946798	**
Informal training	0.1112972	
Self training	-0.0332997	
Self help	-0.1673631	
School Web use	0.3468345	**
Believability and use	0.026739	
Confidence challenges	-0.093717	**
Language challenges	0.0352289	
Theft challenges	-0.0237794	
Technical challenges	0.0914822	**
Time challenges	-0.0587641	*
Pc challenges	-0.0132836	
Electricity challenges	0.0659527	*
GNI per capita	-0.0000771	
Fixed lines per 1000 people	0.0009039	
PC in room	-0.0089129	
Net connection	-0.15007	
Net reliability	0.0939273	**
Hours of electricity	0.033352	
Students per PC	-0.0531383	
Use policy	0.1595971	
Content policy	0.1274152	
Game policy	-0.232497	*
Access	0.0632343	

* Statistically significant at the 10 percent level
** Statistically significant at the 5 percent level

Appendix 7: Select Research Agenda

Hardware/Software Infrastructure & Access

- Are disparities in access or quality caused by physical shortcomings of the current system (electricity, connectivity, numbers, location, hours)?
- What are the most fundamental physical (infrastructure, money, phone lines, viruses, equipment) barriers to integrating ICT in education goals?
- What improvements have the greatest effect per dollar invested?
- What improvements can be made when infrastructure is a limiting factor? Where should the focus lie?

Perceptions of the Value of Technology

- How do student interest and teacher perception of computer utility vary?
- How do students perceive ease of use, and value of use of ICT? What do they use it for most? Didn't we ask this question on use?
- How do teacher and student perceptions of students interest, utility and need for computers vary?

Student use and effective use

- How does the use of technology address learners needs? Whose needs does it address most/best? Is technology improving learning? How is this being assessed?
- What skills is technology being used to develop (fundamental or higher-order thinking)? How is this measured?
- Does technology usage influence student involvement, participation or engagement in classroom activities (or perception thereof)?
- Do students improve higher order thinking skills (including questioning) when using computers?

Pedagogy

- Is technology incorporating/supporting different types of pedagogy?
- Are new pedagogical approaches supported by administrators, teachers and learners?
- Are technology resources sufficiently robust to support its formal integration in teaching and learning?
- What changes in the learning environment are needed and how is technology being used to address those needs?
  How do teacher perceptions of technology affect its integration into existing curriculum?
- How does technology play a supportive role for instruction? How is this being assessed?
- Which are the most useful technology tools in teaching and learning?
- Does locally produced/relevant content matter?

Professional Development

- Are teachers/heads-of-school/lab supervisors given sufficient training and support to address learning needs and effectively use technology in the classroom?
- What are the most common and most effective forms of support for teachers?

Gender

- What are some of the enabling/disabling environments for access and use of ICTs for girls? In which contexts (school, groups, supervised, AUP) are girls more likely to use ICT?
- What policies are developed to ensure the equal involvement of girls and boys in ICTs (AUP's for equal access, physically/temporally separation of boys and girls, space reservation by gender, incentive approaches)? Do these policies work? Are they necessary?
- Are girls given equitable access to computers? How does this vary by location, type of school, funding, etc.? How does this affect how/what they learn and their future academic and professional potential?

Participation by schools and community

- How do community attitudes about ICT and involvement with it affect its use (in and out of schools)?
- Is there a correlation between stated policies/attitudes of Head-of-school and teaching/learning?

Acceptable Use Policies (AUP)

- What are the most common fears around new technologies?
- Are there effective policies in place (or the potential for them) to allay these concerns?
- What are the potential downsides to AUPs?

Appendix 8: Select Additional References

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