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The vision is being overwhelmed by the reality of business, politics, logistics, and competing interests worldwide.

BY KENNETH L. KRAEMER, JASON DEDRICK, AND PRAKUL SHARMA

One Laptop Per Child: Vision vs. Reality

AT THE WORLD Economic Forum in Davos, Switzerland, January 2005, Nicholas Negroponte unveiled the idea of One Laptop Per Child (OLPC), a $100 PC that would transform education for the world's disadvantaged schoolchildren by giving them the means to teach themselves and each other. He estimated that up to 150 million of these laptops could be shipped annually by the end of 2007.[4] With $20 million in startup investment, sponsorships and partnerships with major IT industry players, and interest from developing countries, the nonprofit OLPC project generated excitement among international leaders and the world media. Yet as of June 2009 only a few hundred thousand laptops have been distributed (they were first available in 2007), and OLPC has been forced to dramatically scale back its ambitions.

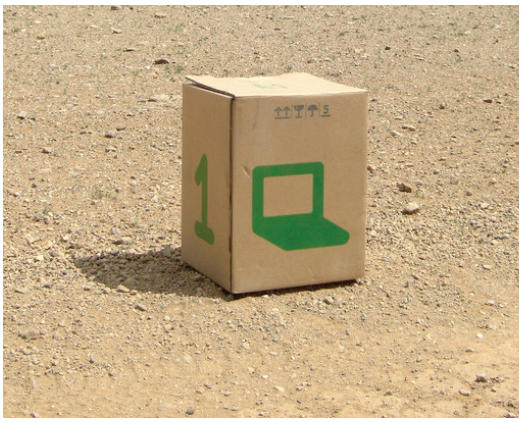
Although some developing countries are indeed deploying OLPC laptops, others have cancelled planned deployments or are waiting on the results of pilot projects before deciding whether to acquire them in numbers. Meanwhile, the OLPC organization (www.olpc.com/) struggles with key staff defections, budget cuts, and ideological disillusionment, as it appears to some that the educational mission has given way to just getting laptops out the door. In addition, low-cost commercial netbooks from Acer, Asus, Hewlett-Packard, and other PC vendors have been launched with great early success.

So rather than distributing millions of laptops to poor children itself, OLPC has motivated the PC industry to develop lower-cost, education-oriented PCs, providing developing countries with low-cost computing options directly in competition with OLPC's own innovation. In that sense, OLPC's apparent failure may be a step toward broader success in providing a new tool for children in developing countries. However, it is also clear that the PC industry cannot profitably reach millions of the poorest children, so the OLPC objectives might never be achieved through the commercial market alone.

Here, we review and analyze the OLPC experience, focusing on the two most important issues: the successes and failures of OLPC in understanding and adapting to the developing-country environment and the unexpectedly aggressive reaction by the PC industry, including superpowers Intel and Microsoft, to defeat or co-opt the OLPC effort.

OLPC created a novel technology, the XO laptop, developed with close attention to the needs of students in poor rural areas. Yet it failed to anticipate the social and institutional problems that could arise in trying to diffuse that innovation in the developing-country context. In addition, OLPC has been stymied by underestimating the aggressive reaction of the PC industry to the perceived threat of a $100 laptop

FROM THE TOP LEFT PHOTOGRAPH BY: 1. CARLA GOMEZ MONROY; 2. DANIEL DRAKE, 3–5 ONE LAPTOP PER CHILD; 6. DANIEL DRAKE, 7–9 OLPC; 10. DANIEL DRAKE; 11. RODOLFO ARCE; 12. OLPC; 13. CARLA GOMEZ MONROY; 14. OLPC; 15. NIELS OLSON

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Worldwide distribution of XO laptops.

Country	OLPC Web site[a]	Actual Deployments	Date of Actual Deployment Information/Detail
Uruguay	202,000	150,000	November 2008[b]
Peru	145,000	40,000	100,000 in distribution[c]
Mexico	50,000	50,000	Starting to be shipped[d]
Haiti	13,000	Dozens	Pilot began in summer 2008[e]
Afghanistan	11,000	450	Expected to rise to 2010[f]
Mongolia	10,100	3,000	G1G1 laptops beneficiary[g]
Rwanda	16,000	10,000	Arrived, not deployed; infrastructure issues[h]
Nepal	6,000	6,000	Delivered April 2007[i]
Ethiopia	5,000	5,000	Three schools[j]
Paraguay	4,000	150	4,000 planned next quarter[k]
Cambodia	3,200	1,040	January 29, 2009[l]
Guatemala	3,000	—	Planned before third quarter 2009[m]
Colombia	2,600	1,580	January 25, 2009[n]; agreement to buy 65,000 XOs[o]
Brazil	2,600	630	February 6, 2009[p]
India	505	31	January 20, 2009[q]

a OLPC numbers include "XO's delivered, shipped, or ordered" but do not distinguish between these categories; wiki.laptop.org/go/Deployments

b Tabare, V. Uruguay: When education meets technology. *Miami Herald* (Nov. 22, 2008), A21.

c Peru on the up and up, lessons to be learned. *Business News Americas* (Dec. 18, 2008).

d www.bnamericas.com/story.xsql?id_sector=1&id_noticia=431002&Tx_idioma=I&source=

e www.olpceu.org/content/xo_stories/haiti/Haiti.html

f www.olpcnews.com/countries/afghanistan/olpc_afghanistan_first_school_day.html

g www.olpceu.org/content/xo_stories/mongolia/Mongolia.html

h www.olpceu.org/content/xo_stories/rwanda/Rwanda.html

i www.olpceu.org/content/xo_stories/nepal/Nepal.html

j http://www.olpceu.org/content/xo_stories/ethiopia/Ethiopia.html

k Bucaramanga computers, OLPC, Gemalto. *Business News Americas* (Feb. 9, 2009).

l wiki.laptop.org/go/OLPC_Cambodia

m wiki.laptop.org/go/OLPC_Guatemala

n wiki.laptop.org/go/OLPC_Colombia

o PIlar Saenz, OLPC Volunteer in Colombia (email)

p download.laptop.org/content/conf/20080520-country-wkshp/Presentations/OLPC%20Country%20Meeting%20-%20Day%204%20-%20May%2023rd,%202008/Brazil%20-%20Jose%20Aquino%20-%20Govt%20of%20Brazil.ppt#266,8,Slide 8

q www.olpceu.org/content/xo_stories/india/India.html

being widely distributed in places the industry sees as emerging markets for its own products.

The case of OLPC can be seen as a study in the general diffusion of innovation in developing countries. Our analysis draws on diffusion-of-innovation theory, exemplified by Rogers,[18] and illustrates the difficulty in getting widespread adoption of even proven innovation due to misunderstanding the social and cultural environment in which the innovation is to be introduced. We also bring to bear specific insights from the literature on adoption of IT in developing countries,[2,25] using them to analyze the OLPC experience and draw implications for developers and policymakers.

The original OLPC vision was to change education through the development and distribution of low-cost laptops embodying a new learning model to every child in the developing countries. Despite shifting over time, it can be characterized by the following text from the OLPC charter: "OLPC is not, at heart, a technology program, nor is the XO a product in any conventional sense of the word. OLPC is a nonprofit organization providing a means to an end—an end that sees children in even the most remote regions of the globe being given the opportunity to tap into their own potential, to be exposed to a whole world of ideas, and to contribute to a more productive and saner world community" (www.olpcnews.com/people/negroponte/new_olpc_mission_statement.html).

Conceived and led by Nicholas Negroponte, a former director of MIT's Media Lab, OLPC aimed to achieve its vision through extraordinary innovation in hardware and software that fosters self-learning and fits with the often-harsh environment in developing countries. The hardware was to be a $100 laptop that would make affordable the large-scale deployment of computer networks in their schools.

The XO laptop developed by OLPC reflects hardware innovation in the power supply, display, networking, keyboard, and touchpad to provide a durable and interactive laptop (see the figure here). The shell of the machine is resistant to dirt and moisture, with all key parts designed to fit behind the display. It contains a pivoting, reversible,

dual-mode (monochrome for outside, color for indoors) display, movable rubber WiFi antennas with wireless mesh networking, and a sealed rubber-membrane keyboard that can be customized for different languages. For low power consumption and ruggedness, the XO design intentionally omits all motor-driven moving parts. It was developed jointly by the MIT Media Lab, OLPC, and Quanta, a Taiwan-based original design manufacturer, and is manufactured by Quanta in Songjiang, China.

The software for the XO consists of a pared-down version of the Fedora Linux operating system and specially designed graphical user interface called Sugar. It was developed by the project to explore naturalistic concepts related to learning, openness, and collaboration.[a]

Pilot Implementation

High-level officials, including even prime ministers and education ministers, in some developing countries are enthusiastic about OLPC, committed to purchases and/or trial-distribution projects. OLPC pilots in a half-dozen countries report positive changes (such as increased enrollment in schools, decreased absenteeism, increased discipline, and more participation in classrooms), but it is not clear if these changes are directly related to OLPC, as many evaluations are neither independent nor systematic. Independent evaluations in Ethiopia and Uruguay cite a positive effect on the availability of learning material via the laptop but also problems with buggy input devices, connectivity, software functionality, and teacher training.[8,12,13]

As of June 2009 the largest ongoing pilot project is in Peru, which planned to distribute 140,000 XOs in 2008, even into rural areas high in the Andes where electricity is often limited and Internet connections are not available. There is enthusiasm among students and teachers in the villages and support from the national education ministry and regional governors who have requested 500,000 more laptops.[9] However, reports from the classroom suggest that teacher training is limited, and willingness to adopt a new approach to teaching is questionable. Children are excited but somewhat confused about the use of the machines, and educational software is lacking or difficult to use. Also, if a machine fails, it is up to the family to replace it or the child must do without.[20]

Expecting a laptop to cause such revolutionary change showed a degree of naiveté, even for an organization with the best intentions and smartest people.

Targeted Cost

Despite its considerable innovation, or perhaps because of it, the OLPC project has been unable to achieve its $100 targeted cost. The current cost of each unit is listed on the OLPC Website as $199 (www.laptop.org/en/participate/ways-to-give.shtml). However, this does not include upfront deployment costs, which are said to add an additional 5%–10% to the cost of each machine (wiki.laptop.org/go/Larger_OLPC), and subsequent IT-management costs. Nor does it include the cost of teacher training, additional software, and ongoing maintenance and support. OLPC initially required governments to purchase a million units, then reduced the number to 250,000 in April 2007. Such large purchases are difficult to justify for governments in developing countries, and the requirement was ultimately eliminated.

Some countries eventually lost interest due to the higher costs of the XO. For example, Nigeria failed to honor a pledge by its former president to purchase a million units, partly because they no longer cost $100 apiece.[21] Meanwhile, other countries, including Libya, have opted for the Intel Classmate, which is priced at approximately $250 for the PC alone. Officials in Libya, which had planned to buy up to 1.2 million XO laptops, became concerned that the machines lacked Windows, and that service, teacher training, and future upgrades would not be provided directly by OLPC. Subsidies from Intel, including donated laptops and teacher training, also helped persuade the Libyan government to choose the Classmate.[21]

Production, Sales, Distribution

OLPC originally estimated that it would

a Chief among them are collaboration and expression (such as Web browsing, email, online chat, word processing, drawing, music sequencing, and programming); groups and neighborhoods to signify other users in physical and logical proximity; a view-source-code key to encourage users to tinker with the code; replacing files and folders with "journals" that store activities performed by users; and tagging, clipping, sharing, and searching as systemwide features.[22]

ship 100–150 million XO laptops by the end of 2007, but the program has clearly fallen far short. Under more modest goals, production was supposed to reach five million laptops by the end of 2008. By contrast, industry analysts report that Quanta's manufacturing effort began only in December 2007 and reached a total of 370,500 units by third quarter 2008.[16]

Early commitments for a million XOs each from Brazil, Libya, and Nigeria evaporated, but relatively large purchases were made by Uruguay (200,000), Peru (145,000), and Mexico (50,000). In November 2007, OLPC launched a philanthropy program called Give One Get One (G1G1, www.olpcnews.com/countries/usa/olpc_xo_laptop_sale.html) where people in the U.S. could buy two machines for $399, with one being sent to a child in a developing country. The first program was successful, with about 167,000 units sold, but a second G1G1 program in November 2008 resulted in only 12,500 units sold.

Lagging production and sales mean that distribution has also lagged. The table here lists distribution as reported by OLPC, but many units have yet to be deployed to their intended recipients. What has the project accomplished? Why is it so short of its original goals? To answer, we look in more detail at where OLPC succeeded and failed in understanding the developing-country environment and how it was being confronted by the PC industry.

PC makers across the board are still seeking a formula for well-designed, low-cost computing devices, along with a complementary delivery value chain, market strategy, and business model.

Analysis

OLPC dedicated a great deal of effort to designing a laptop that would function well in a developing-country environment. OLPC's technologist culture encouraged innovation, showing a good understanding of what was needed in developing countries. For example, the XO is sealed to keep out dirt, has a display that can be read in bright sunlight, runs on low power, and is rugged.

At the same time, the decision to use the Linux/Sugar operating system and interface was driven by a combination of pragmatic considerations and open source ideology. From a pragmatic point of view, Linux doesn't require the computing power of Windows and has a price tag (zero) compatible with the goal of minimizing cost.

Diffusion of IT innovation does not depend only on the nature of the innovation itself. Often, more important is the social and cultural environment in which it will operate.[3,26] Information technologies are not standalone innovations but system innovations, the value of which depends largely on an ecosystem that includes hardware, applications, peripherals, network infrastructure, and services (such as installation, training, repair, and technical support). Deployment involves training teachers, creating software and digital content, delivering maintenance and support, and sustaining a long-term commitment. Such capabilities are in short supply in developing countries,[7,26] and OLPC simply never had the resources to provide them.

The OLPC plan was to rely on governments to buy its machines, provide distribution and support, train teachers to use and maintain them, and even sponsor development of local-language software. OLPC established its own distribution network or worked with local voluntary organizations in some countries to help with implementation. For global distribution, OLPC reached (in 2007) a comprehensive agreement with cellphone distributor Brightstar of Miami, FL, to help manage the complexities of entering diverse markets.[23] However, none of these institutions had the ability to scale up to deployment of millions of machines. This situation is common in developing countries where endemic problems of infrastructure, financial resources, technical skills, and waning political support "hinder both the completion of IS innovation initiatives and the realization of their expected benefits."[b]

IT innovation is also part of socially embedded systems, the use of which cannot be isolated from the social and cultural environment or from local norms of practice.[1,25] In some cases, teachers and the educational establishment have resisted innovation that

b Negroponte seems to question whether teachers are needed at all. Speaking about providing the rural poor a solid educational basis for development at the 2007 Digital, Life, Design conference in Munich, Germany, Negroponte said: "It's not about training teachers. It's not about building schools. With all due respect [to Hewlett-Packard's e-inclusion efforts], it's not about curriculum or content. It's about leveraging the children themselves."[24]

requires a significant change in pedagogy and that might reduce teacher status.[b] Even when the laptops are adopted, they are not always used as envisioned by OLPC or by education ministers. One Peruvian teacher said, "The ministry would want us to use the laptop every day for long periods of time. But we have decided to set rules in our school and, really, the laptop, it's only a tool for us."[10]

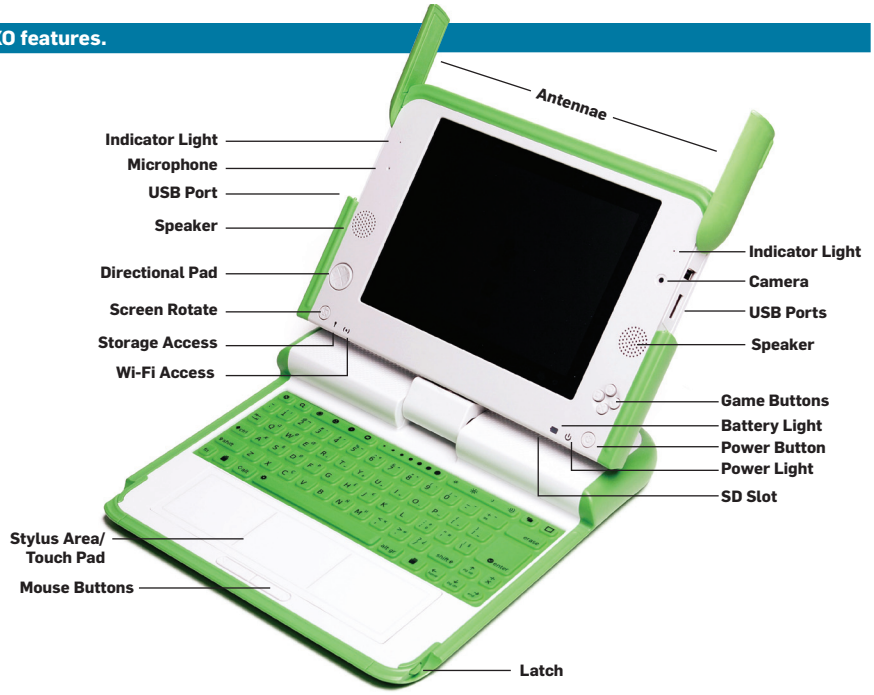
Such resistance is no surprise to students of innovation diffusion or of IT for development. Rogers[18] pointed to examples where innovation diffusion failed due to cultural norms and the effects of such innovation on existing institutional arrangements. Avgerou[2] noted that attitudes toward hierarchy are particularly problematic in developing countries. An example illustrating both themes is that the Peruvian experiment was initiated without being explained to the national teachers' union.[10] OLPC has strong support from the Peruvian Education Ministry, but ultimately teachers must actually use the machines in the classroom, and they are likely to see the union as an ally while possibly mistrusting the ministry.

The fact that OLPC was much stronger in developing innovative technology than in understanding how to diffuse it may reflect the engineering orientation of the organization and its lack of understanding of the needs or interests of the nontechnical people who will ultimately buy and use the innovation. This is illustrated by David Cavallo, OLPC's chief education architect, saying, "We're hoping that these countries won't just make up ground but will jump into a new educational environment."[9] Expecting a laptop to cause such revolutionary change showed a degree of naiveté, even for an organization with the best intentions and smartest people.

Competitive Response from the PC Industry

The OLPC project was a potential threat to the PC industry in emerging markets. OLPC's use of an AMD microprocessor and Linux operating system was a potential threat to the dominant position and historically high profit margins of Intel and Microsoft. Its targeting of a new market (developing-country schools) that existing PC makers were not serving raised the prospect that OLPC might gain a foothold in emerging markets more generally. Moreover, the XO's ultra-low price raised the likelihood of a new price point for notebooks, potentially forcing PC makers to cannibalize existing low-end products in order to compete (and is what ultimately happened).

XO features.



Branded PC makers have always faced competition from cheap local brands and clone makers in developing countries, but OLPC threatened to grab a share of education budgets worldwide that PC makers hoped to tap for themselves. Negroponte's high-profile announcement of the project and the publicity he garnered quickly caught the industry's attention.

Leading companies first responded by disparaging the XO as a useless toy. Intel's Craig Barrett called it "a gadget," saying people want the full functionality of a PC.[17] Bill Gates said "...geez, get a decent computer where you can actually read the text and you're not sitting there cranking the thing while you're trying to type."[11] Before long, however, the industry began to respond with action, not just words.

In 2006, Intel introduced a small laptop—the Classmate—for developing countries that today sells for $230–$300. Intel has since licensed the Classmate reference design to PC makers to manufacture and distribute and is marketing it aggressively against the XO worldwide. It secured deals to sell hundreds of thousands of Classmates in Libya, Nigeria, and Pakistan, some of the very countries OLPC was counting on. Intel launched a series of pilot projects in these countries, saying it will also test the Classmate in at least 22 others while donating thousands of machines.[21] Intel briefly joined OLPC in July 2007 but got into a nondisparagement dispute with Negroponte and dropped out only seven months later.[14]

In 2007, Microsoft offered to make available Windows, a student version of Microsoft Office, and educational programs to developing countries for $3 per copy when used on computers in schools. OLPC then decided to allow Windows on the XO, a choice driven by demands from some governments for Windows-based PCs. Even in countries with very low levels of PC penetration, officials who make purchasing decisions may favor a technology standard (the Wintel design) they are familiar with or believe children must learn on systems they will encounter later in the work force.

The OLPC project also stimulated innovation in low-cost, low-power PCs. Seeing OLPC's success in developing a sub-$200 notebook, Asustek introduced the EeePC notebook in 2007 for the educational and consumer markets in both developed and developing countries, selling more than 300,000

PHOTOGRAPH BY MIKE LEE

The 2010 version of the One Laptop per Child, the XO-2, will have a foldable e-book form and reduce power consumption to one watt.

units in four months. It was soon joined by major PC makers, including Acer, Dell, Hewlett-Packard, and many smaller ones in creating a new category of PC known today as netbooks.

While the XO was specifically designed for the poor, rural education market in developing countries, netbook vendors target urban consumer and education markets in developed, as well as emerging, markets. In 2008, the netbook market exploded, with sales of 10 million units worldwide mostly running Intel's low-cost Atom processor and Windows; sales are expected to double in 2009.[16]

The OLPC has been credited with spurring the netbook market, but the competition it spurred is now OLPC's own biggest challenge. Developing countries today have a wide choice of vendors offering inexpensive netbooks, and, though not designed like the XO for the rigors of poor rural villages, they are competitive in large, easier-to-serve urban populations. OLPC responded by announcing in January 2009 that its second-generation laptop design would be licensed freely to PC makers to manufacture and distribute, hoping to use the resources of these firms to get millions of laptops into the hands of poor children in developing countries. Negroponte hopes to have a prototype in 18 months (from January), selling them for perhaps $75 each.[5]

Lessons

The OLPC experience offers lessons for innovators and others aiming to introduce and deploy IT innovation to benefit the poor, as well as for the governments of developing countries. For innovators, we thus draw three general lessons:

Diffusing a new innovation requires understanding the local environment. OLPC recognized correctly that laptops could reach the poorest children only if they were subsidized by government or other funding sources. This is similar to rural electrification and telephone service, which usually cannot be provided economically and end up subsidized by government or by charges to urban customers who can be served profitably. However, innovators should understand that governments are not monolithic entities, nor are they the same from one country to the next. In some cases, funding can be allocated by an education ministry, in others it must be approved by the legislature, and in others provincial or local governments have jurisdiction. Commitments from high-level officials or political leaders are as binding as a politician's campaign promises.[26] Flying into a country and winning initial support is only a first step and must be followed by a sustained effort by people with a deep understanding of the local environment to ensure commitment leads to money and action.

Likewise, social, economic, and cultural environments vary greatly across and even within countries, and deploying new technologies requires understanding these environments. Innovators must consider the need for expertise in sociology, anthropology, public policy, and economics, as well as for engineers, and establish coherent criteria for selecting countries to target based on social, economic, and political characteristics. Success in a few developing countries is critical to broad diffusion, as potential adopters look to their peers for evidence of the value of the innovation.[18]

Innovative technology can be disruptive and trigger a backlash from incumbents. Some innovations pose a threat to industry incumbents, who may seek to undermine the innovator's efforts. The more visible the threat, the stronger the reaction is likely to be. This illustrates a dilemma for developers. A program less ambitious and less publicized than OLPC might not attract the attention of industry incumbents but also might not attract the partners, investors, and other sponsors needed to develop and deploy the innovation. As multinational companies direct more attention to emerging markets and so-called "bottom of the pyramid" consumers, there is more likelihood of competition but also more opportunity for cooperation as well. PC makers across the board are still seeking a formula for well-designed, low-cost computing devices, along with a complementary delivery value chain, market strategy, and business model.

Innovative information technologies do not stand alone. A technology like the XO is a system-level innovation that requires complementary assets to be valuable. While OLPC was able to deliver high-level design and hand off development and manufacturing to Quanta, it had no one to handle marketing, deployment, and support.[15] Unlike the commercial PC companies, it was not part of any established business ecology and lacked resources to establish its own ecology.

For developing countries, international agencies, and philanthropists, there are other kinds of lessons:

PHOTOGRAPH COURTESY OF FUSEPROJECT

Understand the true costs and risks, as well as benefits, of innovation. IT innovation like the XO may offer great benefits but also involves costs and risks. The purchase of a laptop is merely the start of a stream of ongoing costs. The total cost of ownership for a laptop program could include infrastructure investment, training, tech support, hardware maintenance, software licenses and upgrades, and replacement expenditures. Cost can also include the opportunity cost or the foregone investment in teachers, facilities, or other educational materials[7] cited by India's education ministry as its main reason for not joining OLPC.[6]

There is also a risk that the expected benefits might not be realized. Problems in implementation could limit actual use, and the need for ongoing funding means that the innovation might not be sustainable beyond some initial period.[2, 13] Another risk is investing in a technology platform that might not be supported in the future; for instance, investment in software, content, and training for the XO platform could be wasted if OLPC would disappear.

Policymakers are able to reduce the risk if they make major acquisition decisions only after careful evaluation of pilot projects that enable learning firsthand how the technology fits with their educational goals and environment. Learning from other countries' experience can be valuable even when the context is different; Al-Gahtani[1] says that successful pilot projects by peers in other developing countries help reduce the perceived risk of adoption.

Adopting organizations need to develop internal capabilities and set priorities. Although governments might receive outside assistance for trials, they must be able to sustain the innovation in the development of digital educational content, training of teachers to integrate ICT-based educational materials in the teaching-learning process, and design and installation of supporting IT and power infrastructure. For example, one independent evaluation concluded: "While the Uruguayan government is making a great effort in providing funding for the hardware, there is no funding for designing and developing software and content for use with the laptops or for conducting a thorough evaluation of the educational and societal outcomes of the project."[13] Other evaluations argue that the countrywide deployments envisaged by OLPC are simply beyond the resources of any developing country, saying that governments must set priorities regarding goals and the regions, sectors, and schools to be served.[8, 12]

Conclusion

The potential significance of the XO, as well as of other IT innovations, in developing countries calls for systematic, independent evaluation—a true "grand challenge" for the computing and social science communities. Researchers can provide value by conducting well-designed studies of the diffusion and results of such innovation. The knowledge created promises to prevent wasting a great deal of money and effort and lead to quicker diffusion and better use of innovations that prove beneficial. While OLPC has so far fallen short of its goals, there is much yet to be learned by studying this case of IT innovation.

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