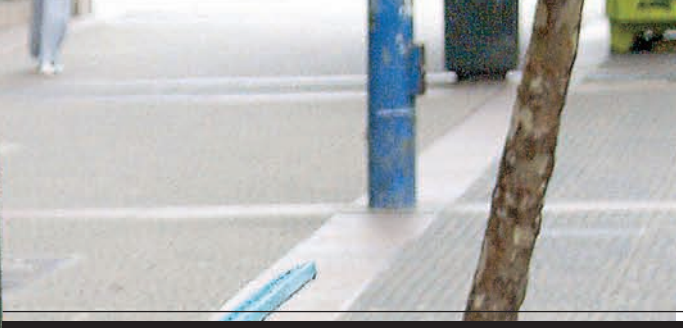
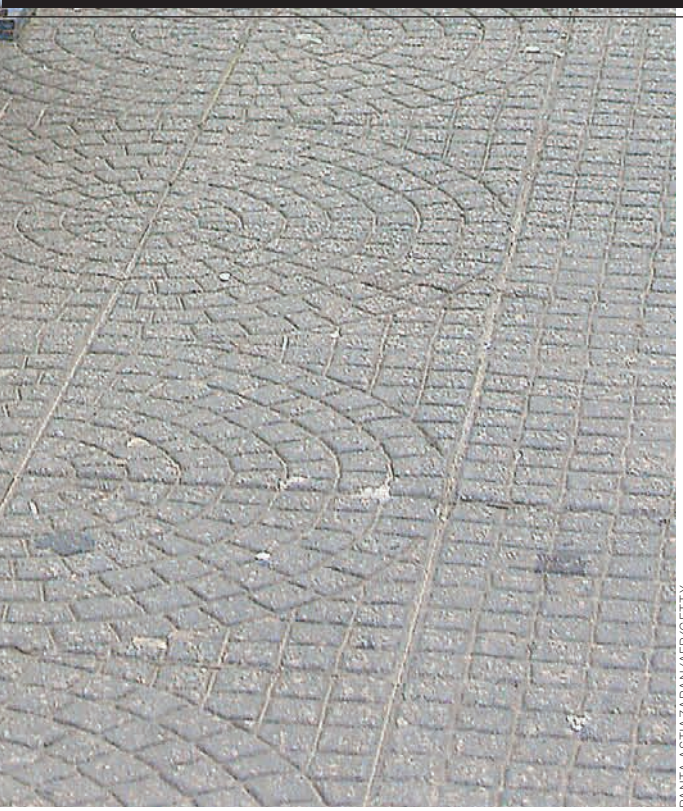


A child uses his XO computer in downtown Montevideo. To date, 570,000 XO computers have been given to public-school students in Uruguay.

The Digital Divide and Social Inclusion

Far from being a magic bullet, access to technology can increase existing inequalities—even if it's provided for free and with the best of intentions. By Mark Warschauer



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IN A WORLD WHERE TECHNOLOGY HAS delivered changes unimaginable even 10 years ago, as well as created sharp divides, it's only logical that many would see computer proficiency as a fundamental learning skill.

Today, quality education requires broad access to information and content, a medium for communication, and tools for analyzing data—all things that computers and the Internet provide as no other media have in history. And the ability to know and use these devices is a boon in itself, since even higher-paying jobs across sectors (from law and medicine to manufacturing and banking) become linked to the knowledge-based economy.

For these reasons, access to technology has come to be seen as the key to social inclusion, whether through educational reform that incorporates information technology, or as a tool for learning the skills of the modern economy.

But mere access does not guarantee learning, as anyone who has witnessed a child wasting hours playing games on a computer can testify. Instead, research has shown that beyond just having the hardware, what is important is the "social envelope" it comes in: the technical and social support provided to children as they learn.

It may seem a simple concept—long held true in other areas of pedagogy—but it's one that seems to have been forgotten when it comes to technology.

In 2005, Nicholas Negroponte, then head of the MIT Media Lab, put forth a bold, original idea: design a $100 laptop and get it into the hands of impoverished children around the world. Negroponte predicted that up to 150 million laptops would be distributed within four years, and that children would use these computers to teach both themselves and their parents.[1]

Unfortunately, the One Laptop per Child (OLPC) initiative has struggled to reach its goals. After seven years of development, OLPC's XO laptop—specially designed for the project—still costs nearly double the intended $100 price and has been plagued by technical problems in the field.[2] Fewer than 2 million children are using the XOs.[3] More than two-thirds of those are in two countries, Uruguay and Peru, each of which signed on to the project more than five years ago. The program's cost, breakage rates of the laptops, and difficulties demonstrating measurable results have all dissuaded other countries from joining.

While OLPC has lost some steam, broader attempts to equip children with digital media continue. Other countries in the Americas, including Argentina, Venezuela and Brazil, have moved forward with plans to distribute large numbers of laptops, albeit using different hardware and approaches.

The technology has also changed. The more recent emergence of digital tablets has created renewed interest in "one device per child" programs in schools around the world, whether through using iPads in the United States or inexpensive Android devices in India and elsewhere. With funding from the semi-conductor firm Marvel, OLPC itself has shifted its efforts to develop a lower-cost tablet and may recapture its momentum with a new device.

The Difficult Trade-Offs for Low-Income Countries

The most basic question is whether providing laptops or tablets for all children is viable in the poorest countries of the world. Assuming a four-year lifespan, and based on the publicized price of $188 per laptop when purchased in bulk, hardware costs would total about $47 per child per year. When implemented at large scale, such as in Uruguay, with added costs for Internet access, spares, delivery, operating costs, and teacher training, the total comes to $100 per year.[4]

This investment per student, when multiplied by the number of students, exceeds the entire educational budget of many of the poorest countries. For example, Haiti's national education budget in 2006 was about $83 million for its 2 million children, or roughly $41 per year per child.[5]

International donors (say, the World Bank or the U.S. Agency for International Development) would need to weigh such an investment against other more traditional aid programs. For example, according to the projections of the Partnership for Maternal, Newborn and Child Health in 2010 , a mere $8 per person per year over five years for basic health care expenses could save 11 million lives in Africa.[6] An investment of roughly 50 cents per pupil per year in Kenya on de-worming medications was found to increase school participation by 14 percent.[7]

Building schools, hiring additional teachers, providing subsidies to mitigate costs of school attendance, and spending on textbooks have all been shown to improve educational outcomes in impoverished countries.[8] Given the known social and educational benefits of less costly programs, and the largely untested benefits of individual laptop use, it is a tough sell to donor nations or organizations.

How About the Others?

Few countries in the Americas are as poor as Haiti. Once we remove truly low-income countries from the equation, a more complex question emerges: what is the value of individual student laptops or tablets in middle- and high-income countries that can afford them?

Here the answer depends on the nature of the intervention.

Simply passing out laptops is unlikely to have much positive effect, since students' use of laptops for learning will depend on the kinds of technical and social support they receive. In addition, since students who have greater literacy skills, intellectual ability or social capital will likely make better use of laptops for independent learning, a strategy of simply passing out laptops can exacerbate inequality rather than reduce it.

Sound educational reform initiatives that include access to technology as one of many elements have a better chance at success. To see why, it's worth reviewing OLPC's record to date, focusing on two middle-income (Peru and Uruguay) and one high-income (U.S.) country. Since OLPC efforts in different countries are organized independently of one another and take a variety of approaches, a look at several programs can shed light on how implementation strategies may affect outcomes.

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Uruguay has the only national one-computer-per-child XO deployment, with more than 500,000 XOs in use by primary and secondary school students and teachers across the country. With a per capita GDP of nearly $15,000 and a well-organized Ministry of Education and Culture, Uruguay is well situated to organize a laptop program, and has put substantial funding into technical infrastructure and support. Wireless connectivity has been extended throughout the country and 98 percent of children with XOs can reportedly access the Internet at school.[9] Relay points are being set up to extend this access beyond the school, with the goal of bringing a wireless hot spot within 300 meters (984 feet) of children's homes.[10]

Initial teacher training of eight hours is now being supplemented with training materials that will be delivered online or via television. The government offers free repairs for any laptop that malfunctions following proper use and subsidizes the repair of laptops that break due to user error.

Yet hardware and software problems remain a serious concern. Some 30 percent of laptops are out of commission at any given time, with the highest rates of unrepaired computers in low-income communities.[11] In addition, the laptops get relatively infrequent use in schools. Nevertheless, even at a minimum, the program's extension of Internet access may bring benefits, and surveys suggest that the program is popular among parents, teachers and administrators.[12]

In 2007, the government of Peru ordered 290,000 laptops for use on an individual basis by children in rural schools, and Lima has since reportedly ordered about 600,000 more, making it the world's largest purchaser of XO laptops. A preliminary evaluation carried out by the Inter-American Development Bank (IDB) and an independent investigation each suggest that the program has become mired in infrastructure difficulties.[13] A number of the country's rural schools still lack electricity, and others that do have electricity sometimes have only one outlet in the principal's office, making charging—and subsequently using—the laptops difficult.

There is also the problem of training teachers. According to the 2010 IDB study, only 10.5 percent of teachers report receiving technical support and 7 percent report receiving pedagogical support for laptop use.

Even when training was offered, teachers in one-room schools are often unable to abandon their classrooms to attend the training, and are typically unwilling to travel for unpaid training during their vacation time. Less than half the students bring the laptops home, since many teachers or parents forbid it out of fear they will be held responsible if the computers are damaged.

A follow-up study by the IDB in 2012 compared students who used the laptops to control groups of students in similar contexts who were not provided laptops. After 15 months of use, the study found there was no statistically significant positive impact on children's academic achievement in reading or math.[14]

What the evaluation did find was that students who used the laptops had advanced more in cognitive tests measuring non-verbal abstract reasoning, verbal fluency and processing speed. These differences were statistically significant only for the non-verbal reasoning test, though they were also significant when combined into a single overall cognitive ability measure. Overall, they were estimated to represent an advantage of about five extra months of cognitive development for the students using laptops over a four-year period. The study found that the positive cognitive gains were concentrated in schools that began with higher academic achievement and that boys gained more technological skills from using the laptops than girls did.

Unlike Uruguay, Peru never moved on to a national one-laptop-per-child program. In 2010, the government announced that subsequent deployments of the XOs would be to schools rather than to individuals, with students sharing the laptops in their school's technology resource centers.[15]

Though OLPC originally targeted developing countries, XO laptops have also been distributed in some developed countries, such as the U.S., Canada and Australia. The largest U.S. deployment of XOs occurred in Birmingham, Alabama, a city with high poverty. The program was initiated by Larry Langford and John Katopodis, mayor and city council president at the time. To

pay for the program and other initiatives, a one-cent increase in the city sales tax was imposed and business license fees were doubled.

Setting out the program's vision, Langford declared, "If we give them these XOs and get out of their way, they'll be teaching us about the world."[16]

Despite little buy-in from the school district, Langford persuaded district officials to give out XOs to all of its first- through fifth-grade children after offering only a less-than-six-week pilot program in a single school. No funds were provided to expand Internet access in classrooms, most of which lacked it; nor were funds made available for laptop repair. Only two hours of paid training were offered to teachers.

Surveys conducted by University of Alabama's Shelia Cotten of students before and after they received the laptops found that within the first 18 months of implementation, large numbers of laptops were broken or otherwise unusable and the computers were little-used in school.[17] The study also revealed that students reported spending less time using computers for homework or research after they got they XOs than before.

After both the mayor and city council president were imprisoned in 2010 on unrelated corruption charges, the city council eliminated further funding for the program.

In contrast, small OLPC programs led by non-governmental organizations in Nepal, Nicaragua, Paraguay, and Australia have gone to great efforts to develop broader educational interventions incorporating the XO laptops.[18] In each of these countries, substantial effort has gone into curriculum development, technical support, teacher training, and community engagement. In both Paraguay and Australia, changes to the overall approach followed less than satisfactory results in earlier stages of implementation, and were based on an explicit recognition that a more holistic approach to laptop integration in schools was required.

Evaluation of educational outcomes are not available in these countries, but reports from Paraguay noted that laptop use in the classroom increased significantly following expansion of pedagogical and technical assistance.

Broader research on technology access by children reinforces many of the lessons gleaned from these OLPC efforts. Simple access to technology has not provided much benefit, and often worsens divides. For example, one study by Harold Wenglinsky in 2005 systematically analyzed data from the National Association of Educational Progress in the U.S. over several years.[19] It found an overall negative interaction between frequency of technology use and academic achievement in reading, math and science. However, this overall impact was strongly mediated by students' socioeconomic status: students in well-to-do communities benefited from school technology use; those in poor communities did not.

Similar results have been found from studies examining the effects of home access to computers.[20] For example, in 2010 two Duke University economists, Jacob Vigdor and Helen Ladd, found in North Carolina public schools that home computers had small, negative effects on student math and reading scores, with the greatest negative impact on African-American and low income students.[21] An earlier 1999 study carried out by Paul Attewell and Juan Battle reported positive effects from home computer access on reading and math scores; but, like the Vigdor and Ladd study, the impact differed by race and ethnicity, with students from well-to-do families getting more than four times the benefit in math and more than twice the benefit in reading from having access to a home computer.[22]

The reason for these kinds of differences in benefits from computers can be illustrated by a 2006 study that examined the introduction of computers into libraries in Philadelphia.[23] Middle- and upper-middle-class children, often accompanied and guided by parents, used the computers to increase their amount of library reading by accessing texts online. Low-income children, in contrast, reduced the amount of reading they carried out in libraries; instead, they spent time waiting for computers or playing simple games on them that involved little text. As a result, introducing computers into libraries exacerbated differences in the amount of reading in libraries between high- and low-income children.

> Students in well-to-do communities benefited from school technology use; those in poor communities did not.

The library study points to an important concept known as the "social envelope" of computing.[24] In other words, it is not the presence or absence of a computer *per se* that makes

the difference, but the kinds of technical and social support that children have for using computers for learning. This can include access to the right software and peripherals. It especially refers to the differential expectations and guidance for learning children receive from peers and parents.

Combining Pedagogy with Technology

Are we then left with two bad choices: either denying young people access to technology, or providing it in a way that only worsens divides?

Fortunately, the notion of a social envelope points to a third way: providing technology that is accompanied by the kind of curricular reform, teacher professional development and infrastructure support that enables diverse groups of children to use their devices for learning.

Our research team recently investigated two district-wide school laptop programs in California and Colorado.[25] Both districts supplied low-cost netbook computers to all children in one or more grade levels as part of a curricular reform focused on literacy instruction. Those programs specifically created learning environments for the students and teachers, provided professional development for the teachers, and offered technical support.

In each of these districts, Hispanic and low-income learners benefited substantially from the interventions, helping to reduce literacy gaps. This suggests that while providing equipment alone often amplifies inequality, providing laptops for use in well-designed educational interventions can promote social inclusion.

Of course, combining a laptop program with other forms of support is more expensive than simply providing laptops themselves. But such interventions are better if they are more narrowly targeted. A carefully planned and educationally sound laptop program in some grades would likely be more sustainable and beneficial than a program that just provides hardware for a broader range of grades.

This is an approach that Argentina appears to be taking. It is distributing 3 million netbook computers to all public school secondary students and teachers, while also putting substantial resources into curriculum development, teacher professional development, technical support, and program evaluation.[26]

Low-income countries need not eschew all uses of technology. Shared use of computers can bring benefits to children and are more reasonable alternatives in many nations.[27] In addition, other school uses of technology have also proven valuable. For example, a study in India found that merely tracking teachers' attendance by providing digital cameras with date and time stamps, and requiring a daily photo of the teacher at school reduced teacher absenteeism from 42 percent to 22 percent, and led to a 40-percent increase in students' graduation rate to the next level of education.[28]

That intervention cost only a few dollars per child per year—a fraction of the cost of providing individual laptops.

The attractive and easy idea that giving children laptops and getting out of their way will alone generate great benefits is too deterministic, based on an idea that technology is a tool to be passed out and that technological effects are direct and immediate.

How technology affects education is contingent on a number of factors: socioeconomic background of the students, the role of parents, the expertise and knowledge of educators, and infrastructure. Technology is a socio-technical network more than a tool. Implementation is ongoing and the effects are often indirect. Moreover, social repercussions are unpredictable. Politics is central to any strategy for incorporating technological tools, and contexts are highly complex.[29]

Laptops and other digital media can play a role in improving education, including for those most in need. But since the poorest countries cannot provide laptops for all, they should instead focus on lower-cost educational initiatives, including some judicious uses of technology at a school-wide level.

Middle- and upper-income countries should consider providing laptops or tablets to all students, but only to the extent that they can also provide broader technical and social support to make such efforts worthwhile. These include funding for Internet access, maintenance and repair, curriculum development, and professional training for teachers.

While there is no magic bullet for solving educational and social inequity, well-planned initiatives with technology can play a positive role.

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