Updated Module 2: Disseminating-Low-Cost-Computing-Devices-in-Schools

Table of Contents

1 Introduction

A growing number of governments around the world are investigating or implementing pilots or programmes to distribute *low-cost computing devices* (LCCDs) for schools in their countries. The potential LCCD market is vast. According to the International Telecommunication Union (ITU), only 25 per cent of developing-country households had a computer and 20 per cent had Internet access. [1] Considering the availability of computers in educational institutions, a wide disparity exists in the ratio of computers to students. For example, across Latin America in 2010, learners-to-computer ratios in primary and secondary schools ranged from 1:1 to 1:122. [2] However, the increasing spread of mobile devices may help to improve access to educational resources. A 2011 McKinsey/GSMA study, for example, stated that “the increasing affordability of mobile devices, with entry-level feature phones costing as little as USD 20, can help m-education solutions transform education for 1.2 billion K-12 students, 160 million higher and vocational education students and many more lifelong learners around the world.” [3]

This toolkit module examines the LCCD arena, analyzes costs, identifies implementation issues and reviews different countries’ experiences with LCCD programmes. The module also takes into account the increasing interest among policymakers, educators, vendors and other stakeholders in using mobile devices to achieve educational goals. Just a few years ago, the use of LCCDs in the classroom was limited to desktop and laptop computers. Now, there is emerging interest in how tablets, e-readers, smartphones and feature phones can be used in educational settings. Such devices are often less expensive and more portable than more traditional computer form factors, and they are expected to play an important role in expanding access to information and communication technologies (ICTs) among both students and educators, partly because of their increasing ubiquity. This module incorporates recent and ongoing developments in the use of such devices to enhance educational initiatives.

More specifically, Section 2 defines LCCDs and provides examples of devices that are currently being tested and deployed in school projects around the world. Section 3 identifies the various cost elements involved in LCCD deployments. In addition to the LCCD itself, there are other items that must be considered in implementing an LCCD project, including electricity, networking, software, training, transport and distribution and maintenance.

Section 4 examines implementation details such as coordinating LCCD programs and deciding which schools and students should receive LCCDs. Section 5 provides several case studies about LCCD deployments in different countries around the world. There is also a “checklist” for planning and implementation of an LCCD project.

[1] ITU, “The World in 2011: ICT Facts and Figures,” available at http://www.itu.int/ITU-D/ict/facts/2011/material/ICTFactsFigures2011.pdf .

[2] UNESCO, “ICT and Education in Latin America and the Caribbean: A regional analysis of ICT integration and e-readiness,” (2012), available at http://www.uis.unesco.org/Communication/Documents/ict-regional-survey-lac-2012.pdf .

[3] McKinsey & Company, “Transforming learning through mEducation,” (April 2012) at 7, available at http://www.gsma.com/connectedliving/wp-content/uploads/2012/04/gsmamckinseytransforminglearningthroughmeducation.pdf .

2 Low-cost computing devices for education

Low-cost computing device is a relative term, given the wide differences in economic development around the world. A USD 100 difference in the price of a computer may not seem significant in a developed country but can make an enormous difference in a developing country. For example, in Benin, "…the cost of a generic PC is equivalent to a teacher's salary for eight months." [4]

The increasing prevalence of mobile devices, including lower-cost smartphones and more recently, tablets, also has sparked consideration of mobile devices as platforms for the delivery of educational content, or m-learning. This can include SMS messaging, multimedia live classroom sessions, webcasting and podcasting, text recaps of lessons, educational games, multiple choice tests, and mobile whiteboards for interactive discussions. [5]

[4] http://blogs.worldbank.org/edutech/print/497

[5] World Economic Forum, "Accelerating the Adoption of mLearning: A Call for Collective and Collaborative Action," (2012), p. 4. Available at http://www3.weforum.org/docs/WEF_GAC_AcceleratingAdoptionMLearning_2012.pdf .

2.1 The first LCCDs: computers and laptops in education

To many researchers, academics, development specialists and government officials, a low-cost computing device is a specific concept, grounded in a philosophical context. The idea behind low-cost computing devices developed from then-MIT Lab researcher Nicholas Negroponte, who articulated a vision of an inexpensive laptop for every child in the world.

A prototype of such a computer was shown at the World Summit on the Information Society (WSIS) in 2005. [6] Describing the benefit of LCCDs, former UN Secretary-General Kofi Anan said: "Children will be able to learn by doing, not just through instruction - they will be able to open up new fronts for their education, particularly peer-to-peer learning." He added that the idea was inspiring, with real potential for students' social and economic growth in developing countries. [7]

Initially, low-cost computing devices were considered to be laptops with rugged construction and low power consumption that were specifically designed for students in developing countries. However, several computer manufacturers now market laptops with similar features to the general public. The common features of LCCDs, regardless of the brand or specific functionality, are a relatively low price (less than USD 300 for the device), a laptop form factor, and a small size (*e.g.*, screen size less than 10 inches).

The cost of computers has influenced national strategies for introducing information technology in schools. The typical way to reduce expenses has been to install a "computer lab" -- a shared location in the school where a few computers can serve multiple students. In many countries, the strategy has been to increase the number of such labs, introducing them into schools that previously had no computers. For instance, in 2003 Indonesia adopted its "One School One Lab" programme aimed at expanding the availability of computer labs in its educational institutions. [8]

Another strategy has been to reduce the ratio of students to computers. Take Chile, for example, where the number of students per computer dropped from 70 in the year 2000 to 26 in 2007, with the government aiming for 10 students per computer by 2010. [9] Lower-cost computers make it more affordable for countries to distribute them widely in schools.

One important distinction is the difference between "one lab per school" and "one computer per student." Policies for introducing computers in schools have traditionally revolved around labs, with a number of students sharing one computer. The low-cost computer device movement is oriented towards each student having his or her own laptop:

"The mission of the One Laptop per Child (OLPC) movement is to ensure that all school-aged children in the developing world are able to engage effectively with their own personal laptop…" [10]

"The ultimate goal is to reach the point where there is one laptop for each student…" [11]

The *one-to-one* concept gives pupils more time on the computer than in a shared, lab-type environment. A calculation carried out for the Nepalese government found that a computer lab user only spends 1 per cent of the time on a computer that a student with an LCCD spends. [12] The Solomon Islands initially explored providing each school with a computer lab, but with LCCDs, "…an even better outcome was ensured, as every child and teacher would have a laptop." [13]

Another model for reducing the cost of computers in schools is the “thin-client” approach, in which a simple computer (the “client”) is connected to a server that carries out most of the processing. This is similar to the environment that existed in the pre-personal computer era, when terminals were connected to host computers. This model is attractive from a cost perspective, since thin clients are cheaper than conventional computers. It is also attractive for a school environment where a teacher has more control over the computer learning environment. This solution has been used in rural schools in Brazil, where the cost per workstation is around USD 50. [14]

While one-to-one computing is attractive, it is an expensive proposition. The cost of outfitting perhaps more than a billion developing-country students with their own laptops would be more than USD 100 billion (assuming a USD 100 cost for the laptop), not including all of the other associated costs, such as transport, distribution, maintenance and training. The advantages and disadvantages of different approaches—one-to-one computing or computer labs—are shown in the table below. Given the high cost of providing each student with their own laptop, this is not a feasible short-term approach for many developing countries; a more practical strategy may be a mix of approaches.

Table 2-1: Pros and cons of computer labs and one-to-one computing

Model	**Pros**	**Cons**
One computer per student (laptops/smartphones/tablets)	• Portability: Can be taken home and shared with family • Creates sense of ownership with less theft and damage • Some designed for developing country rural environment (*e.g.,* handle extreme temperatures, low battery use, etc.)	• Relatively expensive • Can be disruptive • Applications optimized for smartphones/tablets still limited

Model	Pros	Cons
	• Some designed for children (*e.g.,* rugged, ergonomic) • Some include educational software and ecosystem of support • More democratic in that all children receive computers • Rapid adoption of smartphones outside the school setting can be leveraged for educational use	
Computer labs (recycled computers, thin clients)	• Less disruptive than one-one model • Computer lab more economical than one-to-one • More practical for shared settings such as computer labs or community centres. • Generally more powerful than laptops Generally more powerful than laptops	• Higher maintenance and support, due to non-standard computers • Students spend less time with computer • Labs may not be equitably distributed throughout school system or computers can be dominated by certain students

One way to offset such costs is to utilize used computers, which can also be considered low-cost computing devices. Although there are costs involved with recycling, the computer itself is generally donated for free. Furthermore, some experts argue that recycled computers can be cheaper than low-cost laptops when all of the costs are factored in, including waste and social benefit to the country. A study on the sustainability of computers for schools in Colombia suggests that used computers that are refurbished in the beneficiary country have the highest "utility," which factors in benefits to the local economy, job creation, and the environment. [15]

In addition, as the prices of computing devices continue to fall, laptops that were not purpose-designed for educational use continue to be viable options for schools and students. Specifically, low-cost netbooks and laptops, which can cost less than USD 300, are widely available and can be deployed in educational settings, even if they may be more expensive than the education-specific products.

Leading examples of LCCDs include:

- xo-1 – A laptop developed by One Laptop Per Child (OLPC), the xo-1 is specifically designed for primary school students in developing nations, and it has a range of features appropriate to that environment. The xo-1 design has factored in technological issues such as local language support, as well as environmental conditions such as high heat and humidity. [16] It has no movable parts (*e.g.*, no hard disk or fan), and it features special antennas to support mesh networking. OLPC has continued to improve the xo-1's design and specifications since its initial introduction.

The xo-1 is backed by a large ecosystem of system designers, education experts and development specialists. The educational theories are tied into the operating system and software included with the xo-1 and the way it should be used. Dozens of nations are piloting or carrying out large-scale xo-1 implementations. Some of the most significant are Uruguay, where the government has provided xo-1 laptops to all public school primary students, and Rwanda, which, in addition to distributing xo-1 s to schools, is also emerging as a research and training center for the xo-1.

- Classmate – A laptop developed by semiconductor manufacturer Intel as a "mobile personal learning device for primary students in emerging markets." [17] Originally introduced in 2006, the Classmate is built around an Intel processor and has a rugged, "kid-friendly" design. Features include hardware-based theft protection, Wi-Fi and a battery life of between 3.5 to 5 hours. [18] The Classmate runs Windows or Linux and is available in clamshell or convertible designs. Intel has licensed the technology to various manufacturers.

According to press reports, more than 7 million Classmate Convertibles (which can be used as a laptop or a touch-optimized tablet) have been deployed across 70 countries. One of the largest deployments of the Classmate is in Portugal, which has contracted for around half a million of these laptops. [19] The Classmate is used for the country's *Magalhães* initiative ("Magellan" in English, named after the Portuguese navigator). [20] Local company JP Sá Couto manufactures the computers. Portugal is leveraging the program to spread Magellan Classmates to developing countries. In September 2008, it signed a deal with the Venezuelan government to supply 1 million Portuguese-manufactured Classmates. [21] The country's incumbent telecommunications operator, Portugal Telecom, has targeted the Magellan for overseas social responsibility programs, with plans to distribute the laptop in Lusophone Africa [22] and Namibia. [23]

- Netbooks -- Encouraged by the LCCD movement for students, computer makers have been downsizing laptops to also tap into the market (*e.g.*, netbooks). A noteworthy example in terms of price and entry into the educational market is the Asus Eee. [24] Asustek, a Taiwanese computer manufacturer, has developed rugged portable computers for use in space, off-car road races, Mount Everest and the North and South Poles. [25] It introduced the Eee PC notebook in October 2007. The Eee, like the xo-1 and Classmate, is a portable laptop that uses flash storage, and the entry-level models are price competitive. But the Eee was not strictly designed for the educational environment as were some other devices. As with other commercial computers, it comes in a much wider range of configurations and models than the Classmate or xo-1. Since 2007, Asus has expanded the Eee line, but still offers Eee PC laptops that sell for less than $300.

One of the largest Eee educational deployments is in Russia, where it is being used in schools following an order for approximately USD 200 million from the Free Deed Foundation, a philanthropic organization. Some 1 million Eee PC 700 models were to be delivered between 2007 and 2012. [26] The Eee has also been deployed in various school projects in the United States. [27] It also emerged as the preferred LCCD in testing done at three African universities (it should be noted, however, that some LCCDs such as the OLPC xo-1 or Intel Classmate are not designed for university students). [28]

- Mobilis -- Another LCCD that has been the focus of some attention is the Mobilis, manufactured by the Indian company Encore. [29] The Mobilis was selected in a tender for school laptops in Brazil. [30] Yet another is the Israeli-designed ITP-C, which is being used in school projects in Argentina and Chile. [31] However, while these devices were part of early LCCD pilot projects, there has been no further known development of the devices or any additional deployments.

Figure 2-1: Low-Cost Laptops Used in Schools

Manufacturer and Model	**OLPC xo-1** [32]	**Intel Classmate** [33]	**Asus Eee**
Representative Image			
Representative Deployments for Education	Afghanistan, Bhutan, Brazil, Cambodia, Colombia, Ghana, Guatemala, Haiti, India, Iraq, Lebanon, Mali, Mexico, Mongolia, Mozambique, Nepal, Nigeria, Niue, Pakistan, Papua New Guinea, Paraguay, Peru, Rwanda, Solomon Islands, South Africa, Thailand, Uruguay	Argentina, Brazil, Chile, China, Egypt, India, Indonesia, Lebanon, Libya, Malaysia, Mexico, Nigeria, Pakistan, Philippines, Russia, South Africa, Sri Lanka, Thailand, Uganda, Vietnam	Russia

Note: The list of countries where the devices are used in schools excludes developed nations.

[6] The unveiling occurred during the “Phase II” conference and trade show, held in Tunis, 16-18 November 2005.

[7] http://news.bbc.co.uk/2/hi/technology/4445060.stm

[8] http://www.aptsec.org:8080/program/ict/webhrdict/batch-5/osol-cap.pdf

[9] Ministerio de Educación de Chile. *15 Años Integrando TIC a la Educación Chilena*. Mayo 2008.

[10] http://web.archive.org/web/20110504063019/http://www.laptopfoundation.org/en/program/

[11] http://pcworld.about.com/od/notebooks/Intel-s-Classmate-PC-Enrolls.htm

[12] http://202.70.77.73/downloads/olpc-english.pdf {DEAD LINK}

[13] http://wiki.laptop.org/images/c/ca/Solomons_OLPC_Deployment_Report_Aug08.pdf

[14] http://www.desktoplinux.com/news/NS2824724304.html

[15] http://ewasteguide.info/system/files/Streicher_2009_JEnvMgmt.pdf

[16] http://laptop.org/en/laptop/hardware/index.shtml

[17] http://www.intel.com/intel/worldahead/pdf/CMPCbrochure.pdf

[18] The theft protection links the Classmate to a school server. If the Classmate loses connection to the server for a certain period of time, it is rendered unusable and can only be reactivated if returned to the school. See: http://blogs.intel.com/technology/2009/08/classmate_pc_as_a_one-to-one_l.php

[19] http://www.intel.com/pressroom/archive/releases/20080730corp.htm

[20] http://www.magalhaes.gov.pt

[21] http://www.eweek.com/c/a/Desktops-and-Notebooks/Venezuela-to-Receive-1-Million-Intel-Classmate-PCs/

[22] http://www.africanidade.com/articles/2607/1/Computador-quotMagalhAesquot-chega-As-escolas-de-STomA-e-Principe/Paacutegina1.html and http://archive-pt.com/page/107245/2012-07-10/

http://www.telecom.pt/InternetResource/PTSite/UK/Canais/Media/DestaquesHP/Highlights_2009/ptlaunchessapomozambique.htm

[23] http://tv1.rtp.pt/noticias/?article=96746&visual=3&layout=10

[24] For a comparison of different commercially available low-cost laptops see: http://blog.laptopmag.com/low-cost-laptop-cheat-sheet

[25] http://www.asus.com/ContentPage.aspx?Content_Type=AboutASUS&Content_Id=9

[26] http://www.kommersant.com/p814940/philanthropy/

[27] http://www.olpcnews.com/commentary/academia/asus_eee_pcs_in_usa_schools_a.html

[28] http://www.computeraid.org/uploads/Report-on-Low-Power-PC-Research-Project-April-2009.pdf

[29] http://www.ncoretech.com/products/ia/mobilis/index.html

[30] http://www.olpcnews.com/countries/brazil/olpc_classmate_mobilis.html

[31] http://www.itp-c.info/

[32] The xo-1 (previously known as the XO) was the first-generation OLPC laptop. It has subsequently been produced in upgraded forms, known as xo-1.5 and xo-1.75. Unless otherwise noted, all references in this module are to the first-generation xo-1.

[33] Convertible model pictured

2.2 Emerging LCCDs in education: leveraging mobile devices

The growing ubiquity of mobile devices creates new opportunities to change how students are educated and to change the relationships between student and teacher and between student and content. Mobile devices allow teachers and schools to make content available to students in a format that is portable and interactive, particularly if the format is optimized for mobile handsets. Because mobile devices are typically carried at all times, individuals can have immediate and constant access to current content, regardless of their physical locations. This has special relevance in developing countries and rural areas where traveling to a school can be long, expensive and inconvenient. [34]

As tablet computers have entered the mainstream technology marketplace (primarily in developed countries), they are increasingly included in discussions of LCCDs, alongside smartphones. Apple's iPad may be the most well-known mainstream tablet, but several devices have been released at various price points, including some tailored specifically for the educational market and for developing countries. The expected advantages of deploying tablets in educational settings include lower costs compared with traditional laptop or desktop computers, as well as potential ease-of-use improvements due to their touch-screen user interfaces. [35] Education-oriented tablets have been developed, or are being developed, by some of the same players involved in the low-cost laptop market, including Intel (with its Studybook [36]) and OLPC (with the xo-3). [37] In addition, e-readers, such as Amazon's Kindle, offer an opportunity to make various types of content available to students, while also serving as literacy-improvement tools. E-readers, therefore, have been used in several pilot projects.

[34] *Op cit* , p. 6.

[35] For example, Hewlett Packard announced in February 2013 that it would begin selling a tablet for $169. Although it is not specifically designed for educational use, its relatively low cost could drive adoption in the education market. See http://www.nytimes.com/2013/02/25/technology/hp-offers-a-new-consumer-tablet.html?_r=0 .

[36] http://www.intel.com/content/www/us/en/intel-learning-series/learning-series-studybook-prod-brief.html?wapkw=intel+studybook

[37] http://one.laptop.org/about/xo-3

2.2.1 Mobile devices for e-learning

Examples of low-cost tablets and e-readers include:

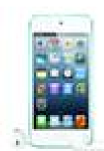
- xo-3 – OLPC's follow-up to the xo-1 is the planned xo-3 tablet computer. The xo-3 features an all-plastic design that is semi-flexible and extremely durable. It has a display that can be optimized in both transmitting and reflective modes for indoor and outdoor lighting conditions. The xo-3 also can be recharged in several ways, including by solar power or a hand crank. Working prototypes were unveiled in January 2012, and the company expected to begin shipping xo-3 tablets that year for a price below USD 100. The xo-3 can run either OLPC's Sugar operating system or Android.
- Studybook – Intel followed up its Classmate laptop with the Studybook tablet design. [38] The Studybook is a ruggedized, purpose-built tablet specifically intended for educational use, as indicated by inclusion of Intel's Learning Series Software Suite. The 7-inch tablets can run Windows 7 or Android, and may be updated to use Windows 8. As a reference design, Studybook will not be manufactured or sold by Intel, but the design will be licensed at no cost to any company interested in producing the device. Intel believes Studybooks can be produced at a cost of less than USD 200.
- I-slate – This tablet was developed by the I-slate Consortium, which includes hardware and software experts at Rice University in the United States, Nanyang Technological University (NTU) in Singapore, social outreach partners from the Indian non-profit Villages for Development and Learning Foundation (ViDAL), and a Los Angeles-based design team. The I-slate is billed as a "low-cost learning tool designed for classrooms with no electricity and too few teachers." [39] The I-slate was first introduced in 2011, using custom-designed hardware and software intended to focus on usability and energy efficiency. It is meant to serve as an electronic notepad to replace the manual slates and chalk used by many rural Indian schoolchildren. The current I-slate is targeted as a self-education tool for fifth and sixth grade students in rural communities. [40]
- Aakash/Ubislate – The Indian government, through the Ministry of Human Resource Development (MHRD), spearheaded a project to develop a computer specifically for college students. Initially envisioned as a laptop, over the course of its development the Aakash evolved into a tablet computer running the Android operating system. At its release in October 2011, the 7-inch Aakash tablet for Indian university students cost approximately USD 35 and featured Wi-Fi connectivity. [41] A commercial version intended for wider distribution was known as the UbiSlate 7 and priced at approximately USD 50. In March 2012, MHRD reassigned responsibility for procuring and testing the device to the Indian Institute of Technology,

Bombay. IIT Bombay has selected a vendor and is in the process of developing the Aakash 2 tablet, which will remain at a subsidized price of approximately USD 35 and was expected to be deployed before the end of 2012.

- Kindle – First introduced in 2007, Amazon's Kindle family of e-readers comprises models with either an e-ink or LCD display and options for Wi-Fi or mobile network connectivity. The e-ink models run on a purpose-built operating system, while the LCD models use a modified version of the Android operating system. All Kindles are designed to provide easy access to electronic books and other content from Amazon's own ecosystem, but they can also display content obtained from third parties, including textbook publishers. Kindle Fire devices can run compatible Android applications and can easily access the Internet. There have been several pilot projects in the developing world involving distribution of Kindles to individual students or to classrooms. These include projects by Worldreader, a non-profit organization devoted to expanding access to digital books in developing countries. [42] Kindle's prices currently range from USD 69 to USD 499. These projects have provided devices preloaded with a selection of local and international reading material, as well as the ability to download additional material (as discussed in the case study on a Worldreader project in Kenya in Section 5.8 of the Module).
- iPod Touch – Introduced in September 2007, the iPod Touch is a device with the same form factor as many smartphones. It runs the iOS operating system that is shared by the iPhone and the iPad. In general, the iPod Touch has most of the functionality of an iPhone with Wi-Fi connectivity, but without mobile network connectivity and associated communication applications. The Touch has access to all compatible applications in Apple's App Store, including applications intended for educational use. Apple notes that the App Store has more than 20,000 educational applications, including iTunes U, which is a platform for teachers to distribute classroom material directly to students' devices. [43]

Figure 2-2: Low-cost tablets/e-readers used in schools

Manufacturer and Model	**OLPC xo-3**	**Intel Studybook**	**I-Slate**

Representative Image			
Representative Deployments for Education	Expected availability in 2012	None known [44]	India
Manufacturer and Model	**Aakash/Ubislate**	**Kindle**	**iPod Touch**
Representative Image			
Representative Deployments for Education	India	Ghana, Kenya, Tanzania, Uganda	None known

Note: The list of countries where the devices are used in schools excludes developed nations.

[38] http://www.intel.com/content/www/us/en/intel-learning-series/learning-series-studybook-prod-brief.html .

[39] “Indian district plans to adopt 50,000 I-slate tablets,” (March 19, 2012), available at http://www.vidal.org.in/sites/default/files/jb-ISLATE-March19-Full-Press-Release.pdf .

[40] “I-slate educational tablet: optimizing tech-brain interface,” (March 19, 2012), available at http://www.youtube.com/watch?v=DBFNyGwICQw&feature=youtu.be.

41 Tripti Lahiri, India Announces World's Cheapest Tablet, Wall Street Journal, October 5, 2011 http://blogs.wsj.com/digits/2011/10/05/india-announces-worlds-cheapest-tablet/?KEYWORDS=datawind

42 http://www.worldreader.org/learnings/

43 See http://www.apple.com/education/ipodtouch-iphone/.

44 Reference design released in mid-2012.

2.2.2 Mobile communications growth

Mobile subscriptions continue to exhibit tremendous growth, especially in developing countries. Global mobile penetration is now 87 per cent in the developed world and 79 per cent in the developing world. [45] Meanwhile, mobile broadband subscriptions grew at an annual rate of 45 per cent between 2007 and 2011, resulting in twice as many mobile broadband subscriptions as fixed broadband subscriptions. [46] In the developing world, mobile broadband is often the only broadband access option available, given the generally low penetration of fixed broadband infrastructure. Even so, mobile broadband penetration in the developing world (8 per cent) lags significantly behind the developed world (51 per cent). [47]

There is significant variation in mobile penetration across and within regions. For example, within Africa, 25 countries were responsible for 91 per cent of mobile subscriptions. [48] And although Africa represents the fastest growing and second-largest mobile phone market in the world, it has the lowest mobile broadband penetration of any region; the mobile broadband penetration rate is below 5 per cent, while all other regions exceed 10 per cent. [49] The Asia-Pacific region continues to be the largest mobile market in the world, with 3 billion subscribers as of 2011, and an expectation that a further 1.5 billion subscribers will be added by 2015. [50]

By comparison, Latin America is now the third-largest mobile market, with more than 630 million mobile connections as of the end of 2011. [51] The market is beginning to mature, and its 13 per cent annual growth between 2007 and 2011 is expected to slow to 5 per cent by 2015.

However, the fact that mobile broadband penetration rates average only 51 per cent even in the developed world means that there is still significant room for growth. In 2011, mobile broadband saw 40 per cent annual subscription growth. [52] As mobile broadband penetration increases, especially in the developing world, there will be increased potential for delivery of educational services over mobile devices.

[45] ITU, "The World in 2011: ICT Facts and Figures," available at http://www.itu.int/ITU-D/ict/facts/2011/material/ICTFactsFigures2011.pdf .

[46] *Ibid.*

[47] ITU, "Key statistical highlights: ITU data release June 2012," (June 2012), available at http://www.itu.int/ITU-D/ict/statistics/material/pdf/2011%20Statistical%20highlights_June_2012.pdf .

[48] GSMA, "African Mobile Observatory 2011," (2011) at 1, available at http://www.gsma.com/publicpolicy/wp-content/uploads/2012/04/africamobileobservatory2011-1.pdf .

[49] ITU, "Key statistical highlights: ITU data release June 2012," (June 2012), available at http://www.itu.int/ITU-D/ict/statistics/material/pdf/2011%20Statistical%20highlights_June_2012.pdf .

[50] GSMA, "Asia Pacific Mobile Observatory 2011," (2011) at 3, available at http://www.gsma.com/publicpolicy/wp-content/uploads/2012/04/amofullwebfinal.pdf .

[51] GSMA, "Latin American Mobile Observatory 2011," (2011) at 5, available at http://www.gsma.com/publicpolicy/wp-content/uploads/2012/04/latammoeng.pdf .

[52] ITU, "Key statistical highlights: ITU data release June 2012," (June 2012), available at http://www.itu.int/ITU-D/ict/statistics/material/pdf/2011%20Statistical%20highlights_June_2012.pdf .

2.2.3 Use of mobile handsets in education

There have been several pilot projects to incorporate mobile handsets into classroom learning environments. Such projects have focused on engaging students with their current lessons, as well as activities like conducting student assessments.

One such project is called Seeds of Empowerment. An outgrowth of a research project at Stanford University in the United States, it aims to increase access to basic education for children living in extremely marginalized communities around the world. [53] Researchers partner with local organizations to provide mobile devices to students and schools. Seeds of Empowerment projects were launched in 2008 in Argentina, Mexico, and El Salvador, and additional projects were anticipated in Bolivia, Brazil and Uruguay in 2012. Early Seeds of Empowerment projects provided students with a purpose-designed device called a TeacherMate, but later projects have used smartphones with Android or iOS operating systems. The smartphones provide access to an educational platform called the Stanford Mobile Inquiry-based Learning Environment (SMILE), which allows students to perform self-evaluations and peer assessments.

In 2011, Paraguay's Ministry of Education launched the Learning Assessment through Mobile Phones (LAMP) pilot project to explore how to administer standardized tests through mobile phones. [54] The project, which focused on mathematics and Spanish language and literature, addressed key content areas of the national curriculum for secondary school students. The project also included training for teachers and school directors to help students prepare and to provide them with technical support. The use of text messaging as the medium for students to receive and respond to multiple-choice questions enabled the responses to be uploaded directly to the Ministry of Education's database, increasing the speed for processing test results. The results of the project, as well as an evaluation of its methods, will be included in a future report to be published by the Ministry of Education.

[53] UNESCO, "Turning on Mobile Learning in Latin America," (2012), at 23, available at http://unesdoc.unesco.org/images/0021/002160/216080E.pdf .

[54] *Op cit* , 21.

2.2.4 Educational benefits of mobile devices

Increasingly ubiquitous mobile devices, including feature phones, smartphones, and tablets, can help achieve a number of macro-level educational goals. Mobile phones have a 79 per cent penetration rate in the developing world (with a growing adoption rate for smartphones), [55] compared with the percentage of homes that have computers (only 25 per cent). [56]

Mobile devices can provide a level of reach, scope and immediacy that is largely unattainable through traditional classroom environments. The most up-to-date content can be accessible immediately -- from anywhere -- and it can be repeatedly reviewed for better comprehension and understanding. The typical mobile learning (m-learning) student saves 86.7 per cent of the money spent for a student taking the same training through a traditional classroom. [57] Among the goals that can be addressed through the use of mobile devices are:

- **Access to education** : By increasing access to education for all children, mobile devices can help achieve universal primary education and promote gender equality. According to the Global Campaign for Education, 69 million children worldwide still have no formal education, and 774 million adults cannot read or write. In addition, many young people considered educated have significant gaps in the quality of education they have received. Using mobile devices to increase access to education can help address each of these needs. Increased accessibility can provide rich educational opportunities for students who have traditionally lacked access to high-quality schooling. [58] Such students often include girls -- who may not be offered the same educational opportunities as their brothers or male neighbors -- as well as the disabled.

- **Skills instruction** : Mobile devices can improve access to training and instruction, which can have a long-term, sustainable and positive impact by helping people attain decent and productive jobs.
- **Health education** : Mobile devices can provide access to information necessary for preventing diseases and making informed health decisions. An e-learning initiative in Kenya, for example, upgraded nurses' skills and increased the amount of registered nurses from 100 trained per year under traditional programmes to more than 1,300 per year in a short period of time. However, while only 20 per cent of those nurses had access to a computer, all had mobile devices. With a global shortage of 3.4 million health workers, m-learning seems like a logical tool to employ in addressing this gap. [59]

[55] Gaudry-Perkins, Florence and Lauren Dawes, "mLearning: A powerful tool for addressing MDGs," *MDG Review* (April 2012), available at http://www.meducationalliance.org/sites/default/files/mlearning_article-mdg_review-alcatel-lucent-gsma-april_2012.pdf .

[56] ITU, “The World in 2011: ICT Facts and Figures,” available at http://www.itu.int/ITU-D/ict/facts/2011/material/ICTFactsFigures2011.pdf .

[57] Dr. David Ngaruiya. Kenyan Faculty member of NIST, in an interview with David Rogers, University of Central Florida.

[58] World Bank, “Surveying Mobile Learning Around the World (part one),” (May 29, 2012), available at http://blogs.worldbank.org/edutech/unesco-mobile-learning-series.

[59] Gaudry-Perkins, Florence and Lauren Dawes, “mLearning: A powerful tool for addressing MDGs,” *MDG Review* (April 2012), available at http://www.meducationalliance.org/sites/default/files/mlearning_article-mdg_review-alcatel-lucent-gsma-april_2012.pdf .

2.2.4.1 Benefits for students

Mobile devices are not a panacea for replacing or radically redesigning existing curricula. In fact, many educators who have incorporated them into their classrooms use them to support and enhance existing curricula. For example, mobile technologies can enable peer-to-peer learning and remote tutoring through social networking services. This is the goal of the Mixable application, launched at Purdue University in the United States. [60] Mixable – a web and mobile application – enables students to leverage the social media and sharing tools they already use, such as Facebook, Twitter and Dropbox, to discuss and share information relevant to their coursework. Even without a purpose-built application, mobile devices that enable access to social networking sites can be used by teachers and students to share resources, as well as to provide a forum for support, discussion and collaboration.

Mobile devices also allow educators to personalize educational content for students. Rather than using a static textbook, teachers can incorporate applications or mobile-accessible content tailored to each student’s skill level or progress. Similarly, small-scale m-learning programmes can promote development of curriculum at the local level to suit the cultural idiosyncrasies and particular needs of local children or the continuing education of the populace. [61]

The rapid adoption of mobile phones, along with the increasing availability of other mobile devices, can also provide literacy benefits. Particularly in developing countries, investments in mobile applications or devices can be more cost-effective than procuring and distributing physical textbooks and other printed resources, especially in rural areas. In many countries, mobile devices may be the only channel for effectively distributing reading material. As e-readers continue to proliferate and decrease in price, they offer a new avenue for lowering the cost of providing educational materials to students worldwide.

Literacy is often a key goal of m-learning initiatives. Colombia's Ministry of Education, together with the Ministry of ICT, and the Organization of Ibero-American States, has designed the largest mobile learning initiative in Latin America. With 1.67 million illiterate people aged 15 and older, the government plans to distribute 250,000 mobile devices and accompanying SIM cards in the project's first stage. These will be pre-loaded with six modules of interactive and self-directed educational content designed to increase users' literacy and basic skills. The devices and cards will be delivered for free, and no internet connection will be necessary to access the content. The first stage of the project was expected to be implemented in 2012. [62]

Even the ubiquitous mobile feature phone (not a smartphone) can be a powerful medium to distribute reading material. Worldreader, a non-governmental organization (NGO) best known for its distribution of e-readers to improve literacy in Sub-Saharan Africa, also offers an application for feature phones and smartphones that provides access to public domain books, as well as contemporary fiction and non-fiction. [63] Yoza Cellphone Stories is a project to support reading and writing by South Africa's youth by making a variety of reading material available over mobile phones. [64] The literature available over Yoza – including mobile novels ("m-novels"), Shakespeare plays, and poetry – resulted in 300,000 reads over its first year, as well as generating 40,000 comments in social media. [65]

In addition, mobile devices provide a medium for developing "information literacy," or the ability to find, use, and communicate information effectively and ethically. [66] By providing expanded access to information sources and improved ability to communicate with other students, teachers and subject-matter experts, mobile devices can greatly expand students' ability to grow into sophisticated researchers and critical thinkers.

Developers are producing an ever-increasing number of educational applications for mobile devices intended to address a wide range of subjects, skill sets and demographic groups. One Chilean application, for example, is intended to increase access to higher education. Chile has one of the highest graduation rates for secondary education in the region, but enrollment in post-secondary education shows significant gaps among different socio-economic groups. One of the reasons for this disparity is that students from lower-income groups perform poorer on the Prueba de Selección Universitaria (PSU) -- the national university admissions test -- compared with students from higher-income groups. This gap has been partially attributed to a lack of access to test preparation materials. PSU Móvil is an application developed to provide free access to packs of exercises, games, and podcasts, sorted by topic. It also contains a calendar of important PSU dates, deadlines, and diagnostic results for completed practice exercises. [67]

In rural and remote communities, the connectivity offered by mobile devices can substantially strengthen educational efforts. For example, SMS messaging can be used as a one-to-many tool for teachers to distribute information, assignments, or assistance to widely dispersed students. Students and educators can take advantage of social media platforms and other collaboration tools to form virtual communities that support, assist and challenge each other. Social networking is not limited to one or two platforms. While Facebook may have 1 billion or more active users worldwide, [68] other networks also are highly active. MXit, a social network based in South Africa, boasts nearly 50 million users, who send an average of 750 million messages daily. [69] MXit users are primarily African, with only 10 per cent located elsewhere.

While this section has focused on the use of mobile devices for delivery of educational content and services primarily in a classroom setting, m-learning can be targeted at learners outside the traditional school system. For example, mobile learning services can be oriented toward vocational education and training, as well as professional learning and development. The lessons learned in the provision of mobile education services to primary, secondary and post-secondary schools can be applied to other scenarios, and vice versa.

[60] See http://www.itap.purdue.edu/studio/mixable/.

[61] Gaudry-Perkins, Florence and Lauren Dawes, “mLearning: A powerful tool for addressing MDGs,” *MDG Review* (April 2012) at 9, available at http://www.meducationalliance.org/sites/default/files/mlearning_article-mdg_review-alcatel-lucent-gsma-april_2012.pdf .

[62] UNESCO, “Turning on Mobile Learning in Latin America,” (2012), at 19, available at http://unesdoc.unesco.org/images/0021/002160/216080E.pdf .

63 Worldreader, "Worldreader Mobile," available at http://www.worldreader.org/what-we-do/worldreader-mobile/ .

64 http://www.yoza.mobi

65 Yoza Project, "Yoza Cellphone Stories: Quick Overview," (August 2011), available at http://m4lit.files.wordpress.com/2012/05/3_yoza-cellphone-stories_082010_to_082011.pdf .

66 EDUCAUSE, "Information Literacy: A Neglected Core Competency," (March 3, 2010), available at http://www.educause.edu/ero/article/information-literacy-neglected-core-competency .

67 UNESCO, "Turning on Mobile Learning in Latin America," (2012), at 19-20, available at http://unesdoc.unesco.org/images/0021/002160/216080E.pdf .

68 Facebook, "Key Facts," (October 2012), available at http://newsroom.fb.com/content/default.aspx?NewsAreaId=22.

69 MXit, "MXit Statistics," (March 2012), available at http://site.mxit.com/files/MxitStatisticsMarch2012.pdf.

2.2.4.2 Benefits for teachers and administrators

Mobile devices and associated training can also be used to develop the human capital of teachers. There is a global shortage of teachers, primarily in areas with high poverty rates. [70] In addition, many teachers around the world are unqualified or underprepared to meet the educational demands of the 21st century. [71] Mobile devices can facilitate faculty mentoring and participation in online professional communities, making it easier for teachers to share best practices within their schools and with counterparts at other institutions, as well as to collaborate and motivate one another. [72] Mobile devices increase teachers' accessibility to rich repositories of free online lesson plans and educational content that can be downloaded, reviewed, and even projected or printed. [73]

For example, Mozambique's Ministry of Education has adapted curricular materials for mobile phones and created multiple versions to accommodate particular cultural and linguistic contexts. The United

States Department of Education has worked to make its online resources easily searchable. [74] Many such databases seeking to freely disseminate content already exist, including projects by universities such as Stanford, Harvard, and MIT. These platforms contain systems for testing, grading, providing student-to-student assistance, and awarding certificates of completion. [75]

Further, leveraging the ubiquity of mobile phones allows teachers and schools to improve communication with parents and students. Without the need for complicated applications or even smartphones, educators can call or text students and parents to keep them apprised of information ranging from assignments or attendance to the availability of new resources or important news about school facilities. Similarly, mobile technology can be used to improve communications between school administrators and teachers. The SMS for Better Schooling in Sindh (Pakistan) initiative involves 400 schools and uses text messages to inform schools and communities about such developments as the planned delivery of new textbooks – and to check in to make sure that the textbooks have actually arrived and are in use. Other services being monitored include the state of lighting in classrooms and the quality of drinking water in schools. [76]

[70] UNESCO, "Mobile Learning for Teachers: Global Themes," (2012), available at http://www.meducationalliance.org/sites/default/files/mobile_learning_for_teachers_global_themes_2012.pdf .

[71] *Ibid.*

[72] *Ibid.*

[73] *Ibid.*

[74] See, for example, Federal Resources for Educational Excellence at http://free.ed.gov/.

[75] UNESCO, "Mobile Learning for Teachers: Global Themes," (2012), available at http://www.meducationalliance.org/sites/default/files/mobile_learning_for_teachers_global_themes_2012.pdf .

[76] World Bank, "More on SMS Use in Education in Pakistan," (June 7, 2011), available at http://blogs.worldbank.org/edutech/sms-pakistan-2.

2.2.5 M-learning initiatives: characteristics and challenges

M-learning initiatives are relatively new and can vary tremendously in a number of respects. So, it is difficult to definitively identify the key factors in designing or implementing a successful programme. However, the emerging body of literature on ICTs in education and the growing number of m-learning programmes and pilot projects enable the identification of a few potential best practices.

2.2.5.1 Characteristics of successful m-learning initiatives

Several examples of m-learning programmes have been developed to meet the specific needs of a community or in response to a government request. For example, the BBC World Service Trust developed its Janala program to roll out English lessons in Bangladesh after the government identified the need for improved English skills. Students dial “3000” to access hundreds of three-minute audio lessons. They can then assess their progress with interactive audio quizzes. Nine months after launch, this service had attracted 3 million calls with a high rate of repeat users. [77]

It may make good business sense to mass produce content whenever feasible in order to spread the cost of content over a larger user base. But it is essential to develop local content and keep it relevant. [78] M-learning projects should have a clear sense of the mix of local, regional or international content that would be most useful to the target population.

To the extent possible, implementation of device-agnostic solutions should help to make m-learning programmes available to the widest possible audience without needing to customize them for a variety of mobile handsets or other devices. [79] For example, SMS-based services are accessible to nearly any mobile handset, while content delivered over mobile-optimized websites should be accessible to any Internet-connected device with a web browser, including smartphones, tablets and even some feature phones.

[77] Gaudry-Perkins, Florence and Lauren Dawes, “mLearning: A powerful tool for addressing MDGs,” *MDG Review* (April 2012) at 12, available at http://www.meducationalliance.org/sites/default/files/mlearning_article-mdg_review-alcatel-lucent-gsma-april_2012.pdf .

[78] *Ibid.*

[79] *Ibid.*

2.2.5.2 Challenges to mobile learning initiatives

There are certainly challenges and obstacles to mobile learning initiatives:

- Currently, most of the projects testing m-learning are either small-scale pilots or isolated initiatives not built with scale and sustainability in mind. [80] The scale aspect is unfortunate because of the great advantage educators and governments could leverage in using mobile devices on a larger scale to reach students who are unreachable by traditional teaching methods.
- Many projects are informal or have not been formally studied or researched, making it difficult to understand the “big picture” of m-learning initiatives globally. [81]
- M-learning does not eliminate the need for face-to-face training for teachers and other educators. Teachers often require face-to-face support to really change their behaviour and adopt plans that use mobile and other new technologies. [82]
- Although mobile devices offer access to new resources and teaching or learning methods, they remain only one of many tools available to educators and policymakers. Professional development should show teachers how to integrate mobile technologies with other tools. [83]
- Due to the dynamic nature of the mobile landscape, it is challenging to integrate mobile technologies into educational practices in a timely fashion. [84] When the primary goal of many initiatives is to ensure that every child receives an elementary education, leveraging up-to-the-second technology often does not seem necessary.
- There is a lack of educators developing content. [85]

The chancellor of the largest teacher training institute in Mexico, for example, noted that her country offers a case study of some of the obstacles and challenges involved in using technology, including mobile technology, to improve teaching and learning: [86]

- Mexico made substantial investments in education that yielded very poor results.

- Students often receive CDs in lieu of textbooks, but do not have devices to play the CDs.
- Many teachers did not know how to use technological materials, so the materials failed to promote learning. Ultimately, the large investment was wasted because of teachers' low user skills. [87]

It is also worth noting that there is tremendous variety with respect to m-learning initiatives within and across regions. This is due to the perceived gaps or opportunities that m-learning can address, as well as the resources available to implement such programmes. The challenge – and benefit – of this variety is that there is no single preferred approach to incorporating mobile devices into classroom curricula or other educational settings.

m-learning is still in an early stage, with significant additional research, trials and support necessary to more fully evaluate its effects and identify best practices. To that end, UNESCO was expected to release guidelines on m-learning by the end of 2012, as part of its M-Learning Policy Guidelines Project. [88] The goals of the project are to "guide national governments and education institutions on policy choices that can support and enable education delivery through the safe, affordable and sustainable use of mobile technologies," as well as to develop the future of mobile learning beyond the Education for All goal year of 2015. Draft guidelines were in circulation as of August 2012. [89]

[80] *Op cit* , at 9.

[81] UNESCO, "Mobile Learning Week Report," (December 12-16, 2011), at 15, available at http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/ED/ICT/pdf/UNESCO%20MLW%20report%20final%2019jan.pdf .

[82] *Ibid.*

[83] *Ibid.*

[84] *Op cit* , at 11.

[85] *Op cit* , at 12.

[86] *Op cit* , at 16.

87 *Ibid.*

88 See http://www.unesco.org/new/en/unesco/themes/icts/m4ed/policy-research-and-advocacy/m-learning-policy-guidelines-project/ .

89 See *http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/ED/pdf/UNESCO_Policy_Guidelines_on_Mobile_Learning_DRAFT_v2_1_FINAL__2_.pdf* .

2.2.6 Potential negative effects of mobile devices in classrooms

While there are important opportunities and possibilities for the use of mobile devices in educational settings, there are certainly potential negative effects as well, including the following:

- Without proper training and planning, the introduction of new technology into the classroom can distract from the core educational missions of schools and educational institutions.
- Without some combination of training, enforcement, or access restrictions, mobile devices run a significant risk of distracting students – and teachers – from educational pursuits.
- Similarly, access to mobile devices in the classroom creates additional opportunities for students to cheat, whether by researching test answers or sharing work with other students.
- If mobile devices are tightly integrated into lesson plans and curricula, the lack of a mobile device – whether due to affordability, loss, damage or other reasons – can put students at a disadvantage relative to their peers.

While these effects are not limited to mobile devices, the fact that mobile devices are, almost by definition, relatively small, can make it more difficult for educators to monitor their use.

3 Low-cost computing device cost elements

There are a variety of direct and ancillary costs involved in the implementation of a low-cost computing program. The initial costs include the LCCD, software licences (if not included with the LCCD itself), as well as certain peripherals (printers, additional memory, etc.), network access, and development of content specifically for the LCCD program.

Other costs involve taxes, as well as the transport and distribution costs related to the deployment of the LCCDs. The size of the country can have an impact on distribution and transport costs. A smaller, more urbanized, country will have lower costs than a large, rural one. The training of pupils and teachers on the LCCD is another initial, ancillary cost.

There are also a variety of ongoing costs related to an LCCD program. These include costs related to the maintenance of devices, software upgrades, security, ongoing network access costs, electricity, and staff costs, if applicable.

The above-mentioned initial and ongoing costs will vary substantially, depending on the scope of the program. Some projects are national (*e.g.*, hundreds of thousands of LCCDs for a nationwide implementation in Uruguay) whereas others are more localized (*e.g.*, a 30 LCCD pilot in Mali). The magnitude of the LCCD implementation has economy-of-scale implications for various elements, such as the price of the LCCD.

The software that comes with the LCCD, along with government policies for applications and educational content, affects software costs. Some countries may find that the applications that come with the LCCD are sufficient for their needs while others may want to use applications that can be downloaded at no cost via the Internet or purchased commercially. In terms of educational content, there are hundreds of free packages and applications.

Content is already available in some countries, even if it sometime must be modified to run on the LCCDs. Brand-new content may need to be developed in other countries. Some costs can be internalized, such as training or content development. In other words, rather than requiring additional government educational expenditures, elements of the LCCD project may have no impact on budgets if the activities already exist in government school systems. For example, there may already be a content development centre for computers. Governments might be able to transfer funds from educational activities that are no longer a priority to new LCCD projects.

Given this diversity in scope, it is possible to anticipate the necessary cost elements, but difficult to provide specific costs associated with these cost elements, since this will vary significantly based on the scope of the program and the country in which the program is being deployed.

Figure 3 -1: LCCD cost elements

3.1 Infrastructure

Infrastructure refers to the ICT hardware and other infrastructure components typically required for an LCCD program. Apart from the cost of the LCCD itself, other physical elements need to be factored into an LCCD program, including peripheral components for the LCCD, networking, servers and electricity.

3.1.1 The low-cost computing device

Although one of the goals of the one-to-one computing movement was a USD 100 laptop, this has yet to be achieved on a widespread basis, although some tablet devices have (or are expected to have) costs below the USD 100 threshold. LCCD costs vary depending on brand, configuration and the number purchased. The unit prices of various LCCDs are shown in the table below. This assumes purchase of a single unit with default configuration and does not reflect volume discounts.

Table 3-1: Unit Price of Various LCCDs

Type of LCCD	**Price (USD)**	**Remark**
OLPC xo-1	199.99	Price for donating a new OLPC to a child in a developing country. [90]
Classmate PC (convertible)	429.00	Manufacturer’s retail price for the following model: CTL 2go Classmate PC E12 Value Netbook (1.6 GHz Intel Atom Dual Core Processor, 2 GB RAM, 250 GB Hard Drive, Windows 7)
ASUS Eee PC	211.68	Price on Google Product Search for following model: 10" X101CH Eee PC
Studybook	579.00	Manufacturer’s retail price for CTL 2go Studybook L7
I-Slate	45	Estimated price as per I-Slate creator Krishna Palem, assuming sufficient volume is reached.
Aakash/Ubislate	35/65	Aakash is subsidized by the Indian government, while the essentially identical Ubislate is a commercial product.

Amazon Kindle	69	Price for 6” Kindle with e-ink display and Wi-Fi connectivity.
iPod Touch	299	Price for 5th-generation iPod Touch as of Oct. 2012

Note: The list excludes upcoming devices without firm pricing information.

Furthermore, because many LCCD projects are still pilots using donated equipment, it is difficult to get a firm figure about the price of LCCDs. At the same time, large-scale implementations have typically involved many other cost elements, also making it difficult to isolate just the LCCD cost.

Another perspective on the costs of the LCCDs is to look at project costs in various implementations around the world. One difficulty is that they typically include other items besides just the device itself. However, the resulting price per LCCD is still cheaper than average per unit prices and thus provides an insight into the impact of volume discounts.

Table 3-2: Cost of LCCD Programs in Various Countries

Country	**Date**	**# of LCCDs**	**Total (USD million)**	**Price per LCCD (USD)**	**Note**
Brazil	Dec-08	150,000 (Mobilis)	35.2	235	Including delivery to schools, taxes, 12-month guarantee, maintenance and equipment configuration.
Haiti	Feb-08	13,700 (XO)	5.1	372	Including training, electricity, content development and networking. LCCDs valued at USD 146.
Kenya	Jun-11	65 (Kindle)	0.019		Included 3G-capable e-readers

Malaysia	Jun-09	93,000 [91] (Intel)	9.9 per year		Budget includes hardware as well as software and training
Russia	Sep-08	1,000,000 (Eee)	200	200	Information is not available about what this amount covers.
Thailand	Jul-12	900,000	59 [92]	81	7-inch Android tablet from a Chinese supplier
Uruguay	Oct-07	100,000 (XO)	19.9	199	Including servers, guarantee, delivery to Montevideo and network-ready

In addition, cost information is not made public in some cases. For example, Colombia's Ministry of Education in October 2007 launched a pilot project to evaluate one-to-one computing models in school settings. [93] The project began with a donation of 300 Intel Classmate PCs, but will expand to include 1,500 computers. No project cost information has been released to date, and the description of a "donation" of computers from Intel indicates that per-unit cost information is likely to be unavailable.

LCCD pricing information is also sometimes speculative as projects move from concept to production and deployment. As noted, India's government has driven the development of the Aakash tablet, intended for educational use, with a target of distributing approximately 230 million devices to urban university students. The development process has been delayed, but the government still expects to provide the devices at a subsidized cost of approximately USD 35 per unit. Also in India, the consortium behind the I-Slate announced an agreement to provide 50,000 devices to middle school and high school classrooms in one district over the next three years. The consortium expects the price to be approximately USD 45; however, such pricing is contingent upon reaching target production volumes.

[90] http://laptop.org/en/participate/ways-to-give.shtml

[91] As of 2012.

[92] Amount available from 2012 government budget, reported as enough to cover the cost of the first 750,000 tablets.

[93] Ministerio de Educación Nacional, “Ministerio de Educación recibe donación de computadores Classmate PC de Intel,” (October 23, 2007), available at http://www.mineducacion.gov.co/cvn/1665/article-136688.html.

3.1.2 Additional hardware components

The LCCDs described in Section 2 are ready to use as-is and come with a number of features that may include Wi-Fi network capability, integrated cameras and microphones. Additional components for the LCCDs might be needed, depending on what each country or community deems necessary. These primarily revolve around storage, connectivity and peripherals.

- Storage : Most LCCDs used for education come with flash memory-based storage rather than hard disks. The storage capacity varies. If the storage is deemed insufficient, then the cost of obtaining additional higher capacity would need to be factored into the unit cost. Extra storage could also be supported through a school server.
- Connectivity : All of the LCCDs come with Wi-Fi connectivity and/or mobile network connections. However, in order to connect Wi-Fi-only devices to the Internet, access points need to be provided. [94] This is discussed under servers below. In addition, most LCCDs do not include Bluetooth connectivity, so if that is deemed important, then the cost of Bluetooth adapters would need to be included.
- Peripherals : Printers and scanners might also be needed.

The table below provides some indicative prices for additional hardware that might be needed.

Table 3-3: Prices for additional hardware

Product	Brand	Price (USD)

Bluetooth adapter	Bluetooth USB 2.0 Micro Adapter Dongle	1.32
USB Flash Drive	SanDisk Cruzer 4/8/16	5.73/1.71/9.83
Printer/Scanner	Canon PIXMA MG2120 all-in-one Printer	44.95

Note: Lowest price brands (excluding tax) for each product according to Amazon USA (accessed October 2012).

[94] In the case of devices with mobile network connectivity, a subscription may be required (or a user can pre-pay), although this is not a hardware item.

3.1.3 Taxes

Import duties, Value-Added Taxes (VAT) and other taxes add to the cost of the LCCD and peripherals. Policies vary widely regarding the extent to which these taxes are applied.

The World Trade Organization Ministerial Declaration on Trade in Information Technology Products (ITA) was agreed to by 29 participants in 1996. The number of participants has grown to 74, representing about 97 per cent of world trade in information technology products. The ITA calls for the total removal of import duties on ICT goods. Many developing countries, the targeted group for most LCCD projects, have not signed the ITA. Nonetheless, some countries have eliminated import duties on computers even though they are not ITA signatories. In May 2012, many signatories signaled that they would begin informal bilateral and multilateral consultations on expanding the list of products covered by the ITA. [95]

Import duties are sometimes used to encourage local assembly, refurbishment or manufacturing. In Brazil’s government auction for LCCDs, one of the alleged reasons OLPC had higher costs than its competitors was because it had to include the cost of import duties. Some other bidders were offering domestically produced computers. In Colombia, imported LCCDs have been rejected as the lowest-cost solution for schools because they do not add as much to the economy as domestically refurbished computers.

Therefore, the impact of taxes on the LCCD program will vary from country to country. As noted, import duties are not an issue in countries that have abolished duties on information technology equipment. VAT also may not be applicable if the computers are shipped directly to the government instead of going through a third party.

[95] World Trade Organisation, “Informal talks set to begin on expanding the Information Technology Agreement,” (May 15, 2012), available at http://www.wto.org/english/news_e/news12_e/ita_15may12_e.htm.

3.1.4 Security

Security costs must be contemplated to minimize the theft of the LCCDs. For example, both the xo-1 and the Classmate have built-in security features, reducing the need for additional expenditures. The Classmate has hard-wired anti-theft features, [96] while the xo-1 uses software-based security. [97] While these systems will generally render the LCCD unusable for unauthorized users, they may not be sufficient to reduce physical thefts, particularly if the thief is not aware of these features. Having students take the LCCD home at night can reduce security costs. Conversely, having a locked or guarded location to store the LCCDs should be considered. As tablets and smartphones are increasingly included in LCCD deployments or projects, there may be increased potential for theft given the devices’ smaller sizes.

[96] http://www.intel.com/content/dam/www/public/us/en/documents/product-briefs/learning-series_clamshell_classmate_AtomN2600_brief.pdf

[97] http://wiki.laptop.org/go/Bitfrost#Current_Status

3.1.5 Transport

Transport can form a significant part of the costs of providing low-cost computing devices. LCCDs need to be transported from the manufacturing location to the destination country. Each country’s costs for distribution of LCCDs will vary tremendously, depending on the distance from the LCCD manufacturing locations and the breadth of deployment, as well as the shipping method. Once in the country, the LCCDs then must be transported to different schools.

Priorities will dictate whether to use air or surface transportation. The former is more expensive (items are typically priced by weight) but quicker, whereas the latter is less expensive (items typically are priced by volume). There may additional costs if the LCCDs need to be assembled or reassembled once in the country. All of these factors make it difficult to provide a common figure for transport costs.

Transportation problems affect the LCCD program. For example, in the Solomon Islands, laptops could not be distributed to some schools because of logistics, and some teachers could not be briefed on the project because of a lack of fuel to transport them. [98]

[98] http://wiki.laptop.org/images/c/ca/Solomons_OLPC_Deployment_Report_Aug08.pdf

3.1.6 Adaptation for the disabled

Since most LCCD projects are still pilots with few large-scale deployments, limited resources have been directed at making them usable by disabled children. Nonetheless, certain countries, such as Portugal, Russia and Uruguay, have introduced measures to make LCCDs accessible for those individuals.

For example, an online forum exists for using the xo-1 laptop as an assistive technology for disabled persons. [99] The Portugal Telecom Foundation has also carried out numerous projects to modify computers for use by disabled persons, including children. [100] In Russia, a project was initiated to provide LCCDs for blind students.

At this stage, it is too early to determine the costs of making adaptations in each country. However, various groups are working on projects that will provide a track record, through shared experiences, to identify ways to reduce costs. In addition, charitable organizations, whose donations are often targeted for the disabled, could provide a funding resource to defray the costs of making computing devices accessible to disabled children.

With respect to mobile handsets, a number of design or hardware features have become widely available to assist the disabled. [101] For example, individuals with impaired hearing can benefit from text and multimedia messaging, visual or vibrating alerts and hearing aid compatibility. Similarly, blind individuals or those with impaired vision can take advantage of tactile markers on buttons or controls, audible or tactile feedback, adjustable brightness and contrast controls, and a backlit display. All of these features can be used by students with disabilities to help them access educational materials.

[99] http://www.olpcnews.com/forum/index.php?topic=65.0

[100] http://www.fundacao.telecom.pt/Default.aspx?tabid=359

[101] ITU and G3ict, "Making mobile phones and services accessible for persons with disabilities," (August 2012), available at http://www.itu.int/ITU-D/sis/PwDs/Documents/Mobile_Report.pdf.

3.1.7 Servers

LCCD programs can be significantly enhanced through the inclusion of computer servers. These computers are generally more powerful than the LCCDs and provide a range of services, including Internet connectivity, printer sharing, file downloading and disk storage. Assuming such services are desirable, then the cost of the servers, peripheral devices such as printers and networking costs must be factored into the LCCD project.

Since LCCDs do not have sufficient capability to function as servers, most countries use more powerful computers. The price of the servers varies by the amount of RAM, processor speed, disk capacity and computer brand. In some projects, one server is purchased per school. In addition, the purchase of printers and scanners needs to be contemplated, along with consumables such as paper and ink cartridges or laser toners.

Most LCCDs have Wi-Fi capability but require connectivity through an access point to the Internet if there is no mobile network connectivity, which requires both included hardware and an active subscription. Although a server is not needed for Internet connectivity, it can provide additional features such as better network security and management. In addition, performance can be enhanced by storing applications and content on the server for distribution to the LCCDs instead of each student accessing the Internet to download files.

Other costs associated with Internet access include the cost of routers and monthly subscription fees. Depending on the type of Internet access, additional adapters may be required. For example, if the connectivity is through a mobile network, then a wireless network adapter will need to be purchased. Given the added complexity of computer servers and Internet access, some countries have outsourced the support and maintenance of their equipment.

3.1.8 Electricity

The availability of electrical power has a major impact on the scope of an LCCD program. Some form of electrical current is needed to recharge the LCCD devices and power servers for supporting the program. Power costs can be divided into three areas:

1. Existing electricity at schools slated for LCCDs;

2. The charging aspects of the LCCD itself; and

3. On-going electrical costs.

If electricity does not exist at the school, the cost of providing some type of power to recharge LCCDs needs to be factored into the project costs. The type of power option will depend on whether the school is close to the electrical grid. If so, then the cost of connecting the school to the electrical grid must be contemplated. If not, then off-grid options need to be explored.

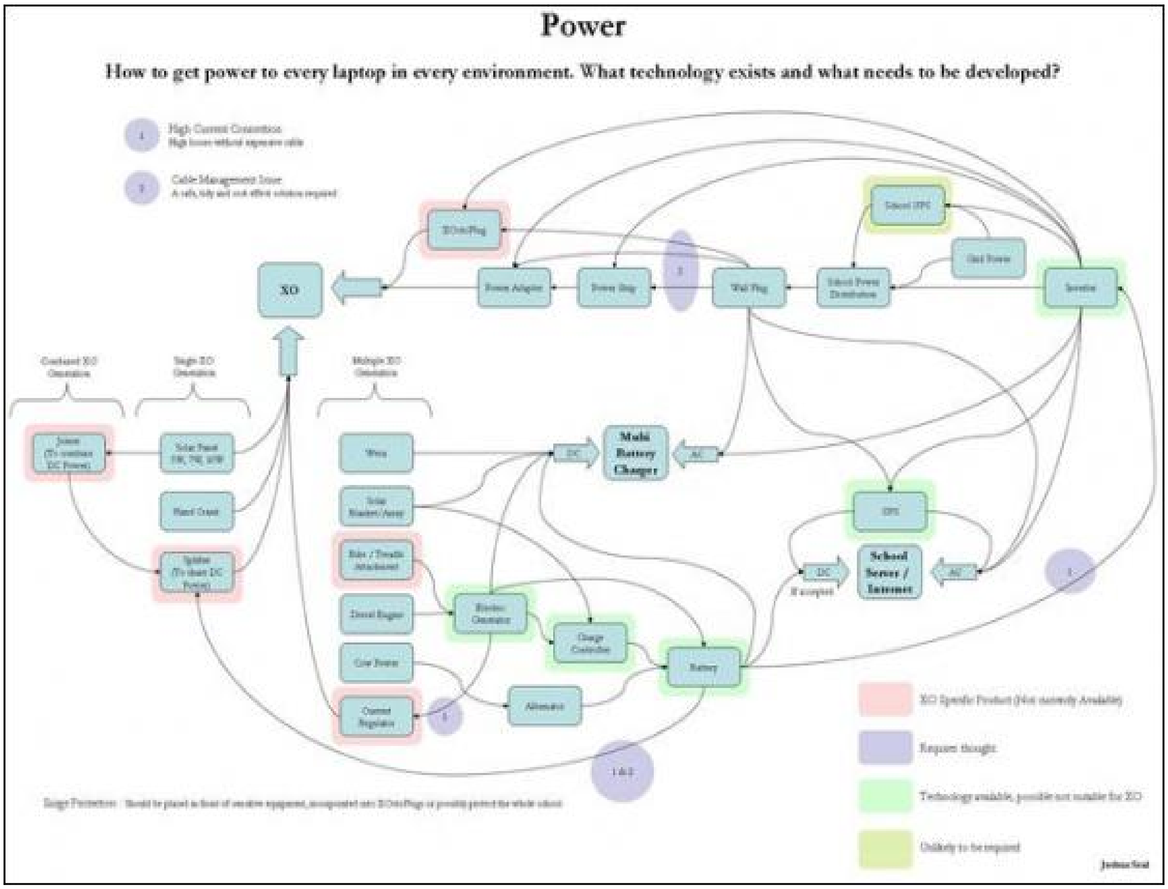
One solution would be to use a generator, typically powered by diesel fuel. This can be a costly proposition, because it requires purchase of a generator, payment for the diesel and an on-going supply of fuel.

Another option is solar or wind power. Both involve hardware costs, but there are no recurring electricity or fuel costs. In Uganda, for example, a project run by an NGO has been using solar power to recharge LCCD batteries.

The type of LCCD selected has an impact on power needs since some have self-charging options, such as solar panels or hand cranks. There may not be an immediate need for electricity, but the scope of any program will be limited without having a reliable energy source. Networking options inevitably would be constrained, because there would be no power to run a server.

If a school does not have electricity, some households may have power at home, so the LCCDs could be taken home and recharged. The battery power of the device itself varies among brands, as do the charging options. The figure below illustrates a variety of different options for charging the battery. One consideration is a charger and plug. Although most, if not all, LCCDs supply dual voltage chargers, plugs can be problematic, because they vary widely from country to country. This was an issue in the Solomon Islands where the plugs that came with the laptops did not match the outlets used in that country.

Figure 3-2: Power options for LCCDs



Source: http://wiki.laptop.org/index.php?title=Battery_and_power&oldid=213071

Since its initial introduction, OLPC's xo-1 has been modified to successfully re-charge through the use of a hand crank, while the planned xo-3 tablet can be charged via hand crank, solar panel, or even a bicycle or waterwheel fitted with the appropriate connection. [102]

Another consideration with respect to electricity is employing LCCDs with low power consumption. For example, the I-slate being developed in India is intended to minimize power consumption, including through the use of a low-power processor. [103]

[102] Johnston, Casey, “Crank, bicycle, and waterwheel: hands-on with the OLPC XO 3.0 tablet,” *Ars Technica* (January 10, 2012), available at http://arstechnica.com/gadgets/2012/01/charging-by-crank-bicycle-waterwheel-hands-on-with-the-olpc-xo-30-tablet/ .

[103] “Indian district plans to adopt 50,000 I-slate tablets,” (March 19, 2012), available at http://www.vidal.org.in/sites/default/files/jb-ISLATE-March19-Full-Press-Release.pdf .

3.2 Software

Software refers to the LCCD’s operating system and applications, as well as to the educational content delivered to the LCCD.

3.2.1 Applications

Applications refer to programs such as word processors, spreadsheets, databases and Internet browsers, as well as applications that also include content such as exercises or other learning tools. Basic applications are not necessarily a significant cost item depending on: (i) the type of LCCD; (ii) the operating system; and (iii) software applications desired.

All low-cost computing devices come with some application software along with the operating system. One consideration is whether commercial software such as the Microsoft Office suite of applications is necessary. If so, this software will need to be purchased; however, software manufacturers often give significant discounts for educational use of their software in many countries. [104]

Many software applications are available at no cost. For example, popular Internet browsers (*e.g.*, Firefox, Chrome, and Opera) are free and run on different operating systems. Likewise, the Adobe Reader document reader is also a free download and runs on various operating systems. The *OpenOffice* suite can be downloaded for free and includes word processing, spreadsheet, presentation, graphic and database software. [105] It is available in various languages, runs on a number of operating systems (*e.g.*, Windows, Linux) and can read and write files from other common office software packages.

In some countries, LCCDs must be usable with open-source software, because of the high cost of commercial applications. There is also a philosophical argument that commercial applications are not really necessary for primary school children:

“Children—especially young children—need the opportunity to learn far more than Word Excel, and Powerpoint. Of course, picking up these skills, having grown up with a laptop, will be readily accomplished.” [106]

Applications specifically intended for LCCDs continue to proliferate. The OLPC xo-1 runs a Linux-based operating system called Sugar that was initially developed for OLPC products. Sugar has since been made available for other devices, including those running Windows, MacOS and Linux. [107] Programs that can be used in the Sugar platform currently number nearly 450, including content related to math and science, media creation, games, maps and geography, search and discovery, games and teacher tools, among others. [108] The planned xo-3 tablet will run Sugar or Android, providing access to applications developed for those operating systems.

So, smartphones and tablets running widely adopted operating systems, such as Android or iOS, have increasingly been considered or deployed as LCCDs in educational settings. Such devices can take advantage of a variety of applications – both free and paid – that provide educational content or utility. The use of tablets in educational settings is still an emerging trend, but as such deployments expand, the variety of available applications is also likely to grow. Major device vendors already have made efforts to develop education-focused applications for tablet devices.

For example, in June 2012, Apple agreed to make iPads available to 600 students in 20 Thai schools. Apple also will develop education applications for marketing in its App Store. [109] Intel, in conjunction with its Classmate and Studybook devices, has developed its Learning Series Software Suite, which includes tools for classroom management, note-taking, e-reading, and painting/drawing, among others. [110] The I-Slate being developed for the Indian market runs a custom-developed operating system specifically intended for use in educational settings. [111]

In addition, feature phones can be used as educational and literacy tools. Worldreader, which has conducted pilot projects involving e-readers in Africa, has also developed an application (in conjunction with an Australian application developer) that runs on any Java-enabled handset and provides access to approximately 500 public domain books, as well as contemporary fiction and non-fiction from a number of developing markets. [112] The Worldreader app is also available for smartphones running Android or BlackBerry OS.

[104] Microsoft offers a Windows/Office bundle to Chinese students for $3. See: http://blogs.techrepublic.com.com/hiner/?p=525 . It also has the same deal for Russian students: http://www.silicontaiga.org/home.asp?artId=7535

[105] http://www.openoffice.org/

[106] http://laptop.org/en/laptop/software/index.shtml

[107] See http://sugarlabs.org/.

[108] See http://activities.sugarlabs.org.

[109] Leesa-nguansuk, Suchit, “Apple to let students test iPad tablets,” *Bangkok Post,* (June 22, 2012), available at http://www.bangkokpost.com/tech/computer/299161/apple-to-let-students-test-ipad-tablets .

[110] Intel Learning Series Software Suite, available at http://www.intel.com/content/www/us/en/intel-learning-series/software-suite.html .

[111] “I-slate educational tablet: optimizing tech-brain interface,” (March 19, 2012), available at http://www.youtube.com/watch?v=DBFNyGwlCQw&feature=youtu.be.

[112] Worldreader, “Worldreader Mobile,” available at http://www.worldreader.org/what-we-do/worldreader-mobile/

3.2.2 Content

The term *content* covers the educational materials developed for use on computers and other LCCDs. Content will have to be developed that is specific to the educational system of each country. Development costs vary, depending on:

- The complexity of the content that needs to be created;
- Whether content already exists that can be modified for the LCCD that is being distributed;
- Whether content from other sources can be utilized;
- Whether the languages used in the country are specific to that country, or whether developers can draw on content developed in countries where the same language is spoken; and
- How much of the content development is done “in-house” and how much is contracted to third parties.

One of the consequences of conducting technology trials, or starting pilot projects, is that content development will initially consume a larger portion of up-front costs. In Haiti, for example, the development of Creole language content accounts for 2.6 per cent of total pilot project costs. But this content can continue to be used if the pilot is scaled-up to a full program, so the total cost will be lower over time.

The availability of free content can help to alleviate these costs. The One Laptop Per Child (OLPC) effort works with “Wikieducator,” a site for open sharing of curricular materials. In the Solomon Islands OLPC pilot, primary schools are using free biology lessons downloaded from the Wikieducator site. [113] The pilot project was also able to draw on content developed for an earlier distance-learning project covering teacher training in local languages, as well as agricultural content on beekeeping, turtle conservation and chicken farming.

Worldreader, which has conducted pilot projects that provide e-readers to African schoolchildren, has worked with local publishers in Ghana to digitize local content. The goal is to give students content that may be more culturally relevant and engaging than the Western books that comprise the vast majority of digitized content. [114]

LCCDs that have Internet connectivity also have access to a wealth of free educational information online. For example, the Massachusetts Institute of Technology (MIT) offers MIT OpenCourseWare

(MIT OCW), which it describes as "a web-based publication of virtually all MIT course content." [115] The Khan Academy offers approximately 3,400 online videos with instruction in mathematics, science, computer science, finance and economics, and humanities, as well as standardized test preparation. [116]

113 http://wiki.laptop.org/images/c/ca/Solomons_OLPC_Deployment_Report_Aug08.pdf

114 iREAD Ghana Study: Final Evaluation Report, available at http://www.worldreader.org/uploads/Worldreader%20ILC%20USAID%20iREAD%20Final%20Report%20Jan-2012.pdf .

115 See http://ocw.mit.edu/about/.

116 See http://www.khanacademy.org/.

3.2.3 Adaptive technologies

As smartphones and tablets have proliferated, there has been increasing development of software intended to assist those with disabilities. Such software is not necessarily targeted at the academic sector, and it may even be included as a core operating system feature. For example, smartphones running current versions of iOS or Android have voice recognition and text-to-speech capabilities, which can be enhanced by third-party applications.

Other functionalities, such as magnification and more advanced speech recognition, can be easily installed as third-party applications on smartphones and tablets running the major mobile operating systems (including Android, BlackBerry, iOS, Symbian and Windows Phone). For example, the Mobile Accessibility suite (for Android) provides replacements for several components of the basic operating system with versions that were specifically designed for people with visual impairments; it also includes a screen reader. [117] ClearCaptions (for Android and iOS) provides near-real-time captions of telephone calls on smartphones (as well as computers). [118] Nuance offers applications for Android, iOS, and Blackberry that enable search, dictation, email and simplified text entry. [119] Other applications make use of mobile device cameras to read barcodes and identify objects and colors. As with any hardware or design feature that benefits disabled users, all of these features can be used by students with disabilities to help them access educational materials.

In addition, there is a growing body of mobile applications designed specifically to assist students with disabilities in a classroom or educational setting. For example, the ITU and G3ict identified several applications for Android and iOS devices that are geared toward students with developmental disabilities and speech therapy requirements, including tools intended to assist with such skills as sharing, letter recognition, conversation skills and sentence building. [120]

Governments have encountered certain obstacles, however, in modifying LCCDs for use by disabled persons. In Russia and Uruguay, the governments were unable to install the accessibility applications on their low-cost computers because of hardware limitations, so they instead had to use regular computers. [121] Uruguay also plans to provide adapted computers for deaf and physically challenged children; however, the cost of the adaptive software is expected to be more than the price of the computers (USD 150). [122]

[117] Code Factory, “Mobile Accessibility and other Android apps,” available at http://www.codefactory.es/en/products.asp?id=415.

[118] See http://www.clearcaptions.com .

[119] See http://www.nuance.com/for-business/by-solution/mobile-application/index.htm .

[120] ITU and G3ict, “Making mobile phones and services accessible for persons with disabilities,” (August 2012), available at http://www.itu.int/ITU-D/sis/PwDs/Documents/Mobile_Report.pdf.

[121] http://wiki.laptop.org/images/0/03/Evaluation_report_OLPC_Russia.pdf and http://web.archive.org/web/20090612193050/http://latu21.latu.org.uy/es/index.php?option=com_content&view=article&id=460:plan-ceibal-brinda-laptops-a-ninos-ciegos-entre-mayo-y-junio&catid=36:noticias-de-ceibal&Itemid=262

[122] http://www.presidencia.gub.uy/_Web/noticias/2009/05/2009050509.htm

3.3 Training

Teachers and students require training on how to use LCCDs. Beyond that, teachers will need to understand how to use LCCDs in the classroom environment and incorporate them into their teaching methods.

Training in basic maintenance and repair may also be necessary in order to keep LCCDs operational. Some LCCD projects have an extensive support system of volunteers that can help defray training costs. Techniques such as "training the trainers," where initial teachers or students are formally trained and they pass on what they learned to others, can also help to lower costs.

Training costs can also be internalized and incorporated into existing training frameworks. ICT learning is also different in that there is a significant amount of free training material provided with LCCDs or available online. Once initial skills have been taught, further advancement often depends on self-initiative and making use of the large amount of free training materials.

3.3.1 Teachers

Teacher training involves a number of steps, which are generally sequenced. The initial group to receive LCCDs requires training in integrating the LCCD in the classroom environment and routine trouble-shooting and maintenance. Those teachers, in turn, generally pass their experience on to the next group to receive LCCDs.

The LCCD project plan for Paraguay, for example, illustrates how the "training the trainers" scheme is used. Four consultants were hired to train 20 teacher trainers who in turn will train the 146 teachers from the participating schools. [123]

Training programs and materials continue to evolve, with vendors and sponsors increasingly integrating training with their marketing and outreach efforts. Intel, for example, offers face-to-face, online and hybrid options to train educators on the use of technology in the classroom, among other topics. [124] Intel's resources are offered in 24 languages, and through partnerships with government ministries and teacher education institutions, the company has reached more than 9 million teachers in 60 countries since 1999. In addition, Intel offers "Teacher PC" reference designs that are meant to meet teachers' needs, including access to content, professional development and digital literacy resources. [125] On a much smaller scale -- but tightly integrated with its pilot projects -- Worldreader provides training materials for project managers and teachers, including material on how to train students and, if appropriate, how to introduce the project to the larger community.

[123] http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=1801223

[124] See http://download.intel.com/education/teach/public/IntelTeach_Brochure_Global.pdf .

[125] See http://www.intel.com/content/www/us/en/intel-learning-series/learning-series-studybook-prod-brief.html

3.3.2 Students

Student training is typically not a cost item since it is part of the educational process. In other words, students learn how to use the LCCDs in the classroom, just as they would learn mathematics or science. Training to use LCCDs is not a primary goal, but rather a tool to enhance or reinforce other subject matter.

While student training may not be broken out as a cost item, students still must be educated on how to use the LCCDs available to them. The amount of training necessary will depend on a number of factors, including the LCCDs available, how familiar teachers and students are with the LCCDs and their capabilities, and the expected uses of the devices in the classroom.

3.4 Sustainability

Sustainability costs revolve around elements for maintaining and monitoring the LCCD program. This includes equipment maintenance, repair, replacement and disposal, as well as monitoring and evaluating the impact of the project.

3.4.1 Maintenance

LCCDs and other supporting equipment, such as servers and networking components, may require maintenance and repair. In addition, support staff—including new personnel to be hired or contracted—need to receive LCCD maintenance training.

One way of managing maintenance and support costs is to introduce a tiered system. This involves providing adequate training at the local level, where the LCCDs are installed, to handle routine software and hardware fixes. This ensures that basic repairs can be made without having to send the equipment somewhere else, avoiding long periods when students have no access to their LCCDs. A more sophisticated level of maintenance and repair can then be provided at regional or national levels for more serious problems. One aspect of tablets and e-readers is that they are generally self-contained devices with few, if any, user-serviceable components. Thus, they should result in a reduced maintenance burden compared with laptop or desktop computers. If they are damaged or fail, though, it may be more difficult to repair them.

Maintenance costs depend on how the program is designed. Costs can be internalized if existing students and staff are trained in basic repair and maintenance and in turn, pass their knowledge on to others ("training the trainers"). Specialized staff will require training for more sophisticated repair activities.

In some cases, maintenance and repair support has been included as part of the bidding requirements for government tenders. Project administrators should obtain performance guarantees and equipment warranties from vendors whenever possible. They should also scope out the logistics for getting LCCDs repaired or replaced.

Any LCCD program should also maintain a stock of new components and replacement LCCDs. In the case of Haiti, for example, 5 per cent of project costs were set aside for replacement stock-piling.

3.4.2 Mobile access costs and m-learning

The cost of access and data packages, as well as insufficient connectivity or coverage, are the biggest factors limiting the growth and adoption of m-learning. [126] The high price of handsets (particularly smartphones) and service packages can limit access to m-learning tools and services. Although mobile service costs continue to decline – decreasing 22 per cent between 2008 and 2010 in the developing world, and 19.1 percent in the developed world [127] – service prices remain an obstacle to higher adoption rates.

There are both public-sector and private-sector approaches that can be employed to lower affordability barriers. For example, governments could subsidize or otherwise contribute funding to increase the accessibility of devices and/or services when used for educational purposes. Such initiatives could be driven by ministries responsible for education and ICTs, among others. In the private sector, businesses can work to build business cases for providing devices, services or both for mobile learners.

For example, operators could partner with educational institutions to offer discounted or tailored service plans targeted at students and educators. A 2012 McKinsey & Co./GSMA report estimated that educational connectivity revenue alone would total USD 4 billion globally in 2020. [128] Operators can also partner with other service providers in the education sector to offer product/service bundles and business-to-business offerings.

In addition, efforts to lower device costs in the developing world could have a positive impact on adoption of devices capable of delivering educational content. While smartphones powered by the Android, BlackBerry, iOS and Windows operating systems may garner much attention in the developed world, there also are efforts under way to develop lower-cost smartphones that would be more affordable in the developing world. For example, the Mozilla Foundation – the organization best known for the Firefox web browser – is developing a mobile operating system for smartphones intended for release in 2013. Mozilla and its partners, which include Telefónica, Deutsche Telekom and Qualcomm, aim to make smartphones using the Firefox OS available in Latin America at a price between USD 100 and USD 115. [129] Mozilla is working with other operator partners in regions around the world to develop and deploy such low-cost smartphones.

[126] Gaudry-Perkins, Florence and Lauren Dawes, “mLearning: A powerful tool for addressing MDGs,” *MDG Review* (April 2012) at 11, available at http://www.meducationalliance.org/sites/default/files/mlearning_article-mdg_review-alcatel-lucent-gsma-april_2012.pdf .

[127] ITU, "The World in 2011: ICT Facts and Figures," available at http://www.itu.int/ITU-D/ict/facts/2011/material/ICTFactsFigures2011.pdf .

[128] McKinsey & Company, "Transforming learning through mEducation," (April 2012) at 22, available at http://www.gsma.com/connectedliving/wp-content/uploads/2012/04/gsmamckinseytransforminglearningthroughmeducation.pdf .

[129] Hardy, Quentin, "A Firefox Smartphone for the Developing World," (September 7, 2012), available at http://bits.blogs.nytimes.com/2012/09/07/a-firefox-smartphone-for-the-poor/ .

3.4.3 Recycling

Policies must be established for the environmentally sound disposal of LCCDs and other equipment. The movement to distribute LCCDs in schools is a relatively recent phenomenon, so experience in this area is still evolving. Furthermore, many LCCDs have yet to reach the end of their lifetimes, with some of the earliest just beginning to reach the end of their expected usable lives. For example, the estimated lifetime of the xo-1 is five years. [130] One step governments could take is to raise this issue with vendors and see if they would be willing to recycle the equipment.

[130] http://wiki.laptop.org/go/XO

3.4.4 Monitoring

The purpose of most pilots is to test the suitability of a particular LCCD for the learning environment. So it is vital to establish a monitoring and evaluation process. This involves testing students prior to the introduction of the devices, and then later evaluating the impact of the devices on the students' learning. The evaluation should also include testing the suitability of the LCCD, as well as the utility of the supporting infrastructure and environment.

Costs for evaluation might include the monetary compensation for personnel to carry out the evaluation, as well as the development of "before" and "after" tests. Monitoring and evaluation costs vary by country, depending on the detail and complexity of the evaluation. In Haiti, 3.9 per cent of project costs were set aside for monitoring and evaluating the project. Part of the evaluation in Haiti was based on a standardized test administered by UNESCO throughout Latin America and the Caribbean.

3.5 Managing costs effectively

LCCD programs have significant costs, and successful management of those costs is critical to the process of generating funding. One decision is whether the national government should adopt a national plan to minimize cost elements through economies of scale or whether local school administrations should adopt their own plans.

The scope of the project informs this decision. If the LCCD initiative is still in a pilot phase, then procurement may not require centralized intervention. Indeed, most pilots are small-scale efforts, often largely financed through development assistance and donations from equipment vendors. Therefore, they do not require a significant initial outlay from the government. Furthermore, local administrations might be better placed to form partnerships and more able to get the project off the ground quickly.

A large-scale implementation through the government's education ministry, however, can aggregate purchases to achieve lower costs. The national government is also more likely to have procurement expertise and the capability to evaluate rival offers. One method of selection is to use a tender process, in which the project's requirements are laid out in detail. In Brazil, for example, a tender process was integrated into the country's "e-procurement" system.

4 Implementing a sustainable LCCD programme

This section of the toolkit identifies elements necessary to achieve a sustainable low-cost computing device (LCCD) programme.

4.1 Project coordination

The implementation of an LCCD programme is a complex undertaking. LCCDs can have significant impacts on classrooms, teachers, training methods, distribution of educational materials and curriculum. They can also affect school funding and infrastructure requirements (*e.g.*, electricity and networking). Given the complexity of such programs, many countries have chosen to implement LCCD projects with various partners.

The decision to implement an LCCD programme is sometimes made at the highest level of government. If the government changes, then there may no longer be support for the program. This was the case in Ghana and Nigeria, where new governments stopped LCCD programmes. One way to avoid this is to create a national coordinating committee, which adds legitimacy and sustainability to the project.

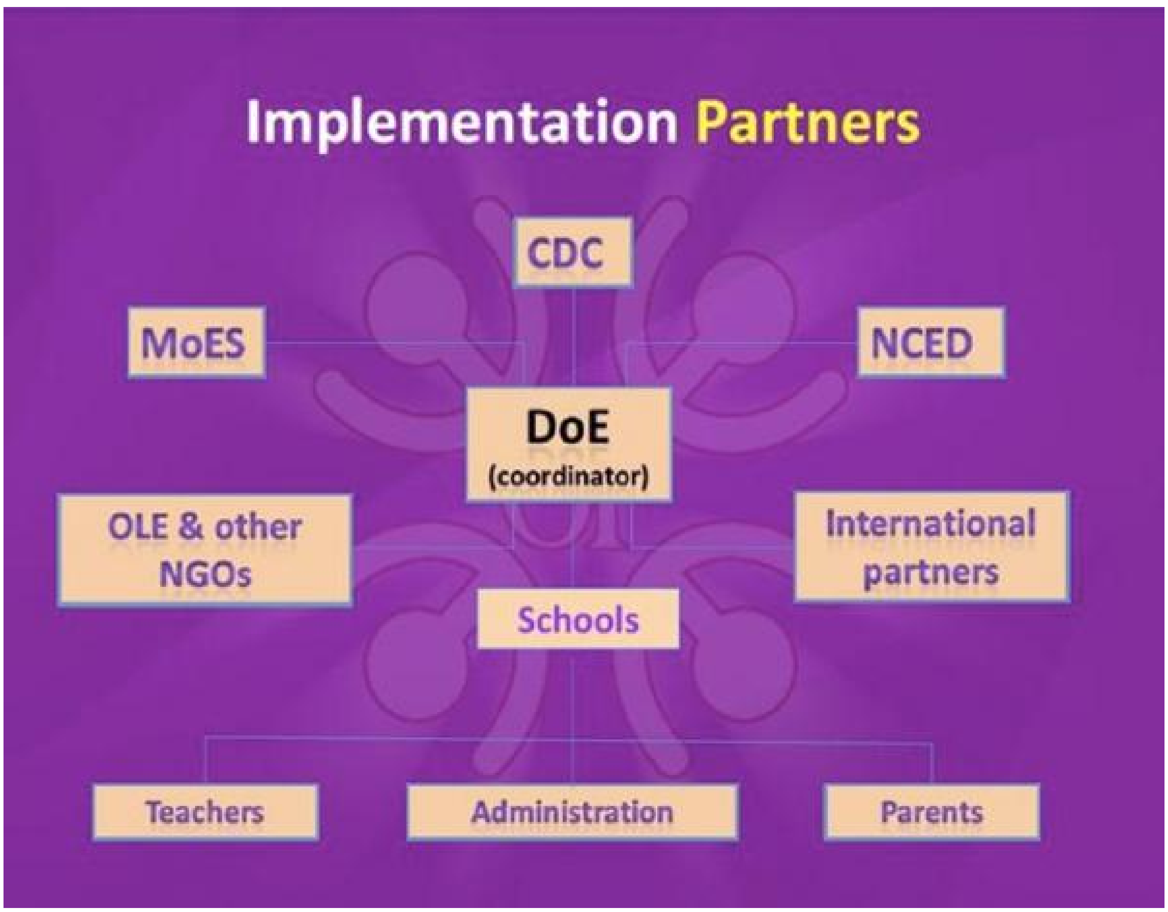
Once the decision is made to implement a low-cost computing device programme, it is generally coordinated through the ministry responsible for education. Furthermore, partners often insist on some kind of commitment from the education ministry before they will participate.

Although the education ministry may take overall responsibility for the programme, ongoing management is sometimes delegated to a technical branch of the ministry or agency of the government. In Uruguay, the Technological Laboratory of Uruguay (*Laboratorio Tecnológico del Uruguay* or LATU), a quasi-autonomous organization, coordinates the country's LCCD program. LATU is managed by a board of directors overseen by a government representative (from the Ministry of Industry, Energy and Mining), a representative from the Chamber of Industry, and a delegate from the central bank.

In Haiti, the Ministry of Education and Vocational Training (MENFP) is responsible for overall LCCD coordination. It chairs the ICT in Education Steering Committee, which consists of both public and private sector representatives that oversee the project. The pilot is implemented by the Project Coordinating Unit (PCU), located within the MENFP.

In Nepal, the LCCD project is coordinated by the Department of Education, with input from the Ministry of Education and Sports, the Curriculum Development Center and the National Center for Educational Development. Participants also include NGOs and international partners such as Danish development assistance (see figure below). School administrators, teachers and parents are also part of the implementation process. The Open Learning Exchange (OLE), a Nepalese NGO, has an agreement with the government of Nepal to help implement the project. Table 7-1 provides a list of project responsibilities among different partners.

Figure 4-1: LCCD project coordination and partners in Nepal



Note: DoE = Department of Education, MoES = Ministry of Education and Sports, NCED = National Centre for Educational Development, CDC = Curriculum Development Center, OLE = Open Learning Exchange.

Source: Open Learning Exchange Nepal.

Coordination across government and the private sector is a key factor in the success of m-learning programmes. The following sections describe the roles and responsibilities of different players.

4.1.1 Role of the ICT minister

The minister responsible for ICTs can play a key role in enabling an environment conducive to the introduction and success of m-learning initiatives. Specific approaches will, of course, need to be tailored to a country's particular circumstances. Among the tools available to the ICT minister are:

- Adopting and adapting related legislation: The ICT minister can, working within the legislative process, ensure that there is an enabling environment for the use of ICTs to deliver m-learning services to students and others. Such legislative efforts could address several factors, including decisions regarding service licences and conditions, universal access/universal service plans, and protection of children from online threats.
- Coordination: The ICT minister can and should coordinate with other government entities – notably the education ministry – to ensure a coordinated approach to supporting m-learning initiatives.
- Outreach: The ICT minister is likely responsible for national efforts to monitor and promote safe and productive use of mobile and online services. This can include spearheading campaigns intended to promote awareness of m-learning services and initiatives, as well as ensuring that such outreach is aimed at appropriate audiences.
- Online/mobile protection: The ICT minister is generally well-positioned to drive and encourage local industry initiatives to protect young people using mobile and online services from fraud, predators, and other threats.

4.1.2 The role of mobile operators and the private sector

Mobile operators serve a vital role in the provision of m-learning services by providing the connectivity that underpins such services. However, operators can take additional actions to further support increased access to educational content. For example, operators can offer discounted service fees for schools and educational institutions, or discounts for calling, SMS messages or data downloads of educational resources. Operators can also offer their expertise or network resources to assist in content aggregation and storage. Such resources can include webinars, podcasts, text recaps of lessons and educational video games. [131]

By developing or improving their managed services capabilities to cater to the m-learning market, operators can enable the development of robust mobile education platforms. In addition, operators can take steps to ensure that students and other young users are protected from malicious activity or content – not only by adhering to existing regulations but by offering protections beyond those required by law. Mobile operators also have expertise in areas that could support and strengthen m-learning initiatives, including customer care, technical support, and device management. [132]

For m-learning to positively affect education in a substantive way, educators and policymakers will need to forge new partnerships with industries and stakeholders that have not historically been involved in education, or whose core competency may lie outside educational fields. [133] For example, Qualcomm partnered with the ministries of education in Jordan and Singapore to bring 3G into the classroom.

The Jordan Education Initiative (JEI) is supporting a pilot project that in the fall of 2011 gave more than 200 students (grades 7-10) and 35 teachers at two schools 3G-enabled netbooks to conduct online research, complete multi-media presentations, and collaborate better. The netbooks have classroom management software allowing teachers to send and receive student assignments. Some teachers are creating their first email accounts and are learning how to communicate with other teachers and students using the Internet. [134] For this project, Qualcomm partnered with JEI, the Jordanian Ministry of Education, and the Ministry of Information Communications Technology.

Singapore's Ministry of Education promotes a framework for transforming the learning environment for students. To promote self-directed learning and a collaborative learning environment, 350 third-grade students and their teachers at Nan Chiau Primary School were given smartphones. This gave students anytime access to educational content, web-based resources and a broad range of learning tools that support self-directed and collaborative learning. [135] For this project, Qualcomm partnered with Microsoft, the National Institute of Education, Nokia, SingTel, and the University of Michigan.

[131] World Economic Forum, "Accelerating the Adoption of mLearning: A Call for Collective and Collaborative Action," (2012), at 4. Available at http://www3.weforum.org/docs/WEF_GAC_AcceleratingAdoptionMLearning_2012.pdf .

[132] GSMA, "The Mobile Proposition for Education," (March 2012) at 26, available at http://www.gsma.com/connectedliving/wp-content/uploads/2012/03/mobilepropositionforeducation1.pdf .

[133] World Bank, "Surveying Mobile Learning Around the World (part one)," (May 29, 2012), available at http://blogs.worldbank.org/edutech/unesco-mobile-learning-series.

[134] Qualcomm, "Wireless Reach Case Study: Jordan," (February 17, 2012), available at http://www.qualcomm.com/media/documents/case-study-jordan-eng-dec-2011 .

[135] Qualcomm, "Wireless Reach Case Study: Singapore," (June 8, 2012), available at http://www.qualcomm.com/media/documents/wireless-reach-case-study-singapore-we-learn-english .

4.2 Funding

A full-scale one-to-one LCCD program typically exceeds the resources of most developing nations. Consider Nepal, where the government drastically raised the education budget, planning to spend USD 609 million for the 2009/2010 school year. [136] Assuming a price of USD 150 for each LCCD, and with 4.4 million primary students, the cost of providing each Nepalese pupil with an LCCD would be USD 663 million -- exceeding the entire education budget.

In addition, if countries opt for the one-to-one model, they need to realize that this is a long-term commitment since each year there will be a new class of children that require their own new laptops.

Most LCCD programs are conceived as public-private partnerships so that costs can be spread among various parties. In addition, some vendors sponsor initial donations of computers for pilot projects. Somewhat surprisingly, development assistance has yet to be significant in this area despite the educational potential and economic importance of access to ICTs.

136 http://pustakalaya.org/eserv.php?pid=Pustakalaya:2362&dsID=MOE_NepalEducationInFigures2010At-a-Glance.pdf , using exchange rate from June 2010.

4.2.1 Government

Governments usually must cover some funding to demonstrate commitment and sustainability:

The OLPC Association focuses on designing, manufacturing, and distributing laptops to children in lesser-developed countries, initially concentrating on those governments that have made commitments for the funding and program support required to ensure that all of their children own and can effectively use a laptop. [137]

The extent of the government's financial support will depend on the scope of the program. A pilot project in a few schools will not entail significant government resources, whereas a full-scale national implementation would call for a government funding commitment.

In Haiti, the government is only financing USD 100,000 or 2 per cent of a pilot LCCD program, with the balance coming from the Inter-American Development Bank and the OLPC Foundation. A key government decision will be how much it can internalize costs by absorbing the resources required for a LCCD program into existing processes. This will require prioritization of educational goals to show commitment to LCCDs and one-to-one computing.

Some governments have made a serious commitment to LCCD for schools by providing significant funding. A few middle-income countries are largely funding LCCDs from their own education budgets. In the case of Uruguay, the government allocated 497 million Uruguayan pesos (USD 21 million) to its LCCD program in 2007, almost 3 per cent of its education budget. The Uruguayan government has attracted other partners to the program to help defray costs. This includes the incumbent telecommunication operator, which is providing Internet access. Meanwhile, a group of volunteer students has been set up to provide computer training.

In Brazil, the federal government funds equipment, Internet access, training and assessment, while state and municipal governments are expected to provide the necessary school infrastructure (*e.g.*, electricity) and logistical support, and to forge partnerships with other stakeholders and potential funding sources.

In addition, the United States Agency for International Development (USAID) provides funding for the Mobiles for Education Alliance, which is "is committed to reducing barriers to access appropriate, scalable, and low-cost mobile technologies to help improve learning outcomes in formal and non-formal education across all levels, especially in low-resource and developing country contexts." [138] Alliance members include organizations in Germany, the United Kingdom and the United States, as well as the World Bank, the Inter-American Development Bank, UNICEF and UNESCO, among others.

137 http://web.archive.org/web/20110504063019/ http://www.laptopfoundation.org/en/program/

138 mEducation Alliance, "The mEducation Alliance Mission," available at http://www.meducationalliance.org/page/alliance.

4.2.3 Non-governmental organizations (NGOs)

Non-governmental organizations (NGOs) are also supporting various LCCD programs. The Internet Society, for example, has provided funding to evaluate the LCCD project in the Solomon Islands. [143] In one of the world's largest non-governmental LCCD programs, the Volnoe Delo Educational Foundation is providing funding for implementing LCCDs in Russian schools. [144] In Uganda, the Maendeleo Foundation operates a Mobile Solar Computer Classroom. A jeep takes Classmate PCs to schools in different villages; the LCCDs are recharged using solar panels mounted on the roof of the jeep. [145] Worldreader, an NGO focused on expanding access to books in the developing world, has implemented several projects in sub-Saharan Africa.

143 http://web.archive.org/web/20110519015325/ http://www.picisoc.org/tiki-read_article.php?articleId=45

144 http://www.intel.com/content/dam/doc/case-study/learning-series-education-transformation-study.pdf

145 http://www.intelchallenge.com/mobilesolar

4.2.4 Development assistance

Some multi-lateral and bi-lateral development agencies are playing a significant role in the LCCD movement. For example, the Inter-American Development Bank (IDB) [146] is providing funding support for LCCD pilots in Haiti [147] and Paraguay. [148] In Uruguay, it has provided assistance for technical support and evaluation of the LCCD program [149] and its extension to secondary schools. [150] The IDB is also funding evaluation of LCCD pilots in Brazil.

In terms of bi-lateral assistance, the USAID provides assistance for Afghanistan's LCCD project. [151] USAID also contributed to a Worldreader program in Ghana as a Global Development Alliance project. [152] The Danish government is assisting with funding an LCCD pilot in Nepal. [153]

146 http://www.iadb.org/news/detail.cfm?language=English&ARTID=3668&ARTTYPE=pr&PARID=2&id=3668&CFID=1709965&CFTOKEN=5199

147 http://www.iadb.org/news/detail.cfm?artid=4413?uage=En&id=4413&CFID=1280276&CFTOKEN=76605445

148 http://www.iadb.org/Projects/project.cfm?id=PR-T1081?=en

149 http://www.iadb.org/projects/Project.cfm?lang=es&id=ur-m1029?oject=ur-m1029&query =

150 http://www.iadb.org/es/proyectos/project-information-page,1303.html?id=UR-L1058

151 http://afghanistan.usaid.gov/en/Article.540.aspx

152 iREAD Ghana Study: Final Evaluation Report, available at http://www.worldreader.org/uploads/Worldreader%20ILC%20USAID%20iREAD%20Final%20Report%20Jan-2012.pdf .

153 http://wiki.laptop.org/go/OLPC_Nepal/Background

4.2.5 Volunteers

Although volunteers do not usually provide direct funding, they can indirectly help defray training and logistical costs by providing free and often skilled labor. Volunteers have been used in various LCCD projects, particularly to assist with training activities.

In Uruguay, volunteers are organized under the *Support Network of the Plan Ceibal* (*Red De Apoyo al Plan Ceibal* or *RAP CEIBAL*). [154] University students, professionals and retirees from all over the country participate in local groups that offer assistance in areas such as equipment delivery, training children in using the LCCDs, developing learning exercises for students and parents and researching technical issues.

OLPC has an *OLPCorps Africa* project, whereby 30 college students have been trained to provide technical support for OLPC pilots throughout Africa. After a 10-day orientation course in Rwanda, volunteers were sent in teams of two to different African countries for up to 10 weeks. They were provided with 100 xo-1 laptops for deployment and USD 10,000 to cover costs. OLPC also organized an internship program for college students to work with local personnel in Peru and Uruguay, where they help to implement LCCD programs. [155]

[154] http://rapceibal.blogspot.com/

[155] http://one.laptop.org/action/volunteer#/intern-olpc

4.2.6 Parents

In some countries, parents are required to contribute towards defraying the cost of purchasing the low-cost devices. This can lead to reduced theft and damage, if parents and students assume ownership and responsibility for the equipment they have purchased.

In Rwanda, parents of students in private schools must purchase LCCDs. Arrangements are being made for long-term loans from banks to be repaid by parents of students. [156] Similarly, in Nigeria, parents of students from the private Corona Secondary School have purchased Classmate PCs for their children. [157] In Portugal, the Magellan program charges parents for LCCDs based on their economic situations. Those from low-income households do not have to pay, while medium-income families pay EUR 20 and those with higher incomes pay EUR 50. [158]

[156] http://web.archive.org/web/20090626073309/ http://allafrica.com/stories/200901080184.html

[157] http://www.intel.com/content/www/us/en/intel-learning-series/learning-series-bridging-digital-divide-nigeria-paper.html?wapkw=nigeria+case+study

[158] http://en.wikibooks.org/wiki/One-to-One_Laptop_Schools/Portugal A Portuguese mobile operator was also running a contest in early 2009 awarding one Magalhães PC per day for users who had topped-up their prepaid cards. http://web.archive.org/web/20091218084755/ http://www.telecom.pt/InternetResource/PTSite/UK/Canais/Media/DestaquesHP/uzomagalhaes.htm

4.2.7 National policies to promote LCCDs

4.2.7.1 Universal service funds

Universal service funds can be a source of financing in some countries. These funds, generally administered by the nation’s telecommunication regulator, are composed of contributions from operator revenues. They are normally designed to defray the costs of providing telecommunication services in remote or rural areas, or to subsidize services for low-income users. Universal service funds have been used in several countries to finance the acquisition of computers for schools:

- In **Colombia**, the *Computers for Education* project draws on the country’s universal service fund to distribute recycled computers to schools. [159] More than 14,000 schools have benefited from the project, which has distributed more than 200,000 computers.
- In **Morocco**, the universal service fund is used to finance the country’s *GENIE* program, which installs computer labs in schools. In 2006, the program financed the distribution of more than 27,000 computers in more than 1,800 schools, reaching some 1.4 million students. [160]

- In **Nigeria**, a tender was issued in 2009, inviting bids to install 100 PCs in each of 550 secondary schools across the country. The project will be financed by the Universal Service Provision Fund. [161]

[159] http://www.computadoresparaeducar.gov.co

[160] ANRT. 2008. *Rapport Annuel 2007*.

[161] http://www.inteleconresearch.com/pages/documents/UASFFunds2009update-Oct2009.pdf

4.2.7.2 Demand generation

In recent years, some countries have developed policies or plans related to broadband that include demand generation components intended to spur interest in broadband connectivity. Such programmes and policies often include approaches to support improved access to LCCDs. An important component of such efforts is political support from government ministries that are responsible for education, telecommunications, and human resource development.

For example, as part of legislation addressing universal broadband coverage, the Dominican Republic included financing mechanisms necessary for the acquisition and installation of computers, personal digital assistants (PDAs), smartphones, and other devices that provide access to a broadband connection. [162] Colombia's plan, Vive Digital, also addresses device cost issues by eliminating customs tariffs and making access to credit for the acquisition of terminals more flexible. [163]

[162] San Román, Edwin. 2009. "Bringing Broadband Access to Rural Areas: A Step by Step Approach for Regulators, Policymakers, and Universal Access Program Administrators; The Experience of the Dominican Republic." Paper prepared for the "Ninth Global Symposium for Regulators," Beirut, November 10–12, 2009, available at http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR09/doc/GSR09_Backgound-paper_UAS-broadband-DR-web.pdf .

[163] See http://www.vivedigital.gov.co/.

4.2.8 Student installment plans

One method to help students buy low-cost computers is to let them pay over time, on an installment plan. This makes the computers more affordable and allows the students to begin using them immediately.

Installment programs are generally aimed at secondary and, more often, tertiary-level students. One of the first countries to implement this type of program was France. The Ministry of National Education launched the *MIPE* (*Micro-Portable Étudiant*) program in 2004. The effort was undertaken in conjunction with almost all of the country's universities, as well as with private partnerships involving computer vendors and banks. [164] MIPE offers university students an opportunity to purchase a laptop with Wi-Fi capability and pay for it in installments. The payments are spread out over three years -- roughly the equivalent of paying EUR 1 per day [165] -- and the universities have agreed to provide free Wi-Fi access.

More recently, the Portuguese government has worked with mobile operators to give secondary students laptops, bundled with mobile broadband subscriptions (see the Portugal Case Study). In Namibia, mobile operator MTC offers university students a laptop for NAD 3,999 with a discount on monthly mobile broadband Internet access. [166]

[164] http://web.archive.org/web/20100723154319/ http://www.delegation.internet.gouv.fr/mipe/projet.htm

[165] http://www.atelier.fr/statistiques/10/30112004/operation--pc-1-euro-jour--40000-unites-vendues-28720-.html

[166] http://connected.mtc.com.na/

4.2.9 Donations

Contributions of money or used computers can help defray expenses. Used computer donations are a key component of recycled computer programs, and they can play a part in projects to spread computers to schools in developing countries. Computer Aid International accepts donations from both businesses and individuals. [167]

One example of a national program is *Colombian Computers for Education*, which accepts used computers from companies, the public sector and individuals. [168] OLPC accepts cash donations that are then used to purchase a laptop for a child in a developing country. [169]

[167] http://www.computeraid.org/

[168] http://www.computadoresparaeducar.gov.co/website/es/index.php?option=com_content&task=view&id=88&Itemid=228

[169] http://laptop.org/en/participate/ways-to-give.shtml

4.3 Distribution

Under the one-to-one LCCD philosophy, each child has his or her own device. In practice, however, this may be difficult for most developing nations to achieve, given the enormous expense of outfitting each child with a device -- particularly in countries with large populations of children.

Although one-to-one computing may be a long-term strategy, in the short term, governments may have to make choices about which schools and which students should benefit immediately from LCCDs, and which populations will have to wait. One of the first distribution choices is deciding which grades should benefit from the program. Many programs and most LCCD features are aimed at primary schools, but there have also been implementations in secondary and even tertiary-level institutions.

4.3.1 Pilot projects

One approach may be to establish initial pilot projects in different school environments. In a monitored environment, authorities can then test how LCCDs will be used in those different school situations. They can compare LCCD pilots in urban and rural settings, with public and private schools, and with younger and older students.

This was the approach taken in Haiti where a representative sample of different school environments was selected. [170] Determining a representative sample size will determine the number of LCCDs that will be needed for a pilot to ensure a scientifically accurate evaluation across a range of school environments.

170 "A preliminary sampling matrix has been identified to capture the following school characteristics: urban, rural, public, non-public, multi-grade and single-teacher schools. To accommodate these variables, allowing for variation in results the sample should contain a minimum of 13,200 beneficiaries. The TC will finance the further elaboration of this matrix, from which an estimated 60 public and non-public primary schools in three departments will be selected for the pilot. All beneficiary schools will belong to existing school networks structured around Basic Education Pedagogical Support Centers (EFACAP). Implementation of the pilot will be sequenced, allowing for ongoing evaluation and comparison between groups of schools receiving the XO laptops at the beginning and at the end of the pilot. An additional category will be created of schools offering the over-age accelerated program." http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=1364380

4.3.2 Saturation

Another distribution strategy is *saturation*. This involves selecting a small number of schools, but then providing LCCDs to all students, in all grades, in those schools. The benefit of this approach is that the pilot can be tested across a range of grades in one environment. Also, this often requires fewer LCCDs and minimizes resentment among children that might arise if some students have LCCDs and others do not. [171]

One way of achieving saturation with a wider school distribution is through *sharing the LCCDs*, particularly where schools are operated in shifts. For example, this was done in a few areas of Brazil. One drawback is that students cannot take the LCCDs home to share with parents. This can be an issue where the intent is to implicitly raise household computer and Internet connectivity by having parents and siblings use the devices. It may also be a problem if school administrators are counting on students to recharge the LCCDs' batteries at home.

Another factor influencing the distribution for testing would be school and community acceptance. In Afghanistan this was one of the reasons cited for the selection of the first pilot school:

“The parent's attitude, community acceptance, [and the] teacher's and school's representative overall attitude towards OLPC were the major factors for selection. Also the school size and the number of students in that school was the best match for our first pilot school.” [172]

[171] Schools in the Solomon Islands requested that they be saturated in the next phase of trials but the education ministry decided that evaluating the impact across different provinces was more important: “That the Ministry consider allocating 250 laptops from the next batch of laptops to complete (saturate) all grades in each of the three trials sites before expanding to other schools and provinces. This is to ensure that each whole school participates in the trials, providing more data for evaluation and allowing all teachers to collaborate and develop teaching ideas. The 75 initial laptops would be used for grade one at the three Marovo schools, and the Ministry would consider whether to use additional laptops via SPC for completing these schools or to expand single-class trials to other provinces. Laptops were distributed to Batuna and Patukae schools for all the grade one students and teachers, plus a few for key teachers in neighbouring secondary and vocational schools, fitting with the Ministry's requirement to evaluate impacts in each sub-sector.” http://wiki.laptop.org/images/c/ca/Solomons_OLPC_Deployment_Report_Aug08.pdf

[172] http://wiki.laptop.org/go/OLPC_Afghanistan/Deployment_News

4.3.3 Electricity

The goal of many LCCD programs is to provide computers in rural areas. The main factor affecting this is the availability of electricity. For example, Brazil’s *ProInfo* project established specific pre-qualification criteria for schools interested in obtaining computers. One of those prerequisites was the existence of electricity (see table below). Governments can install electricity in rural areas that are targeted for LCCD programs. However, the costs can be high, particularly if the area is a long distance from the electricity grid. Other options include providing stand-alone solutions, such as diesel-powered generators or solar energy. Another consideration for areas with a lack of electricity is the type of LCCD selected. Some offer a number of off-grid and human-powered solutions for charging the battery.

Table 4-1: School Selection Criteria for Brazilian ProInfo Project

	Rural	**Urban**
Type of school	Elementary	Elementary
Number of students	>50	>100
Electricity	Yes	Yes
Informatic lab	No	No

Source: http://portal.mec.gov.br/index.php?option=com_content&view=article&id=236&Itemid=471

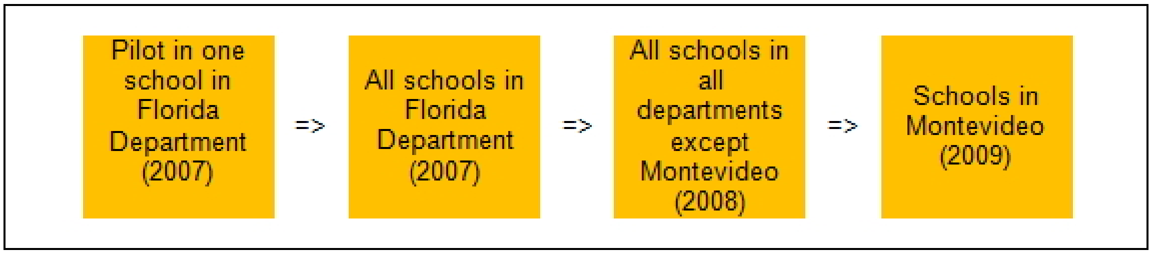
4.3.4 Distribution timetable

If the decision is taken to scale-up the program to incorporate the whole country, a timetable will be needed, since not all the devices can be distributed simultaneously. In Uruguay, LCCDs were distributed:

- First, to a pilot school in one province,
- Second, to all the schools in the same province, then
- Third, to all schools nationwide except for the capital, and finally
- Fourth, to the capital (see figure below).

The process will take approximately three years, but it will ensure that less-privileged schools outside the capital receive LCCDs first. In Brazil, the current phase of the LCCD program calls for distributing 150,000 LCCDs to 10 schools in each of its 27 provinces as well as five municipalities.

Figure 4-2: Sequencing LCCD Distribution in Uruguay



Note: Departments are the top level administrative unit in Uruguay, equivalent to a province or state. There are 19 departments in Uruguay.
Source: Plan Ceibal.

Another concern might be to prevent LCCDs from being distributed only to the most privileged elements of the population. Most of the trials and deployments to date, however, have adopted a conscious policy of distributing to public (rather than private) schools, generally outside urban areas. In order to avoid allegations of favoritism or corruption, the rationale and plan for LCCD distribution should be documented and made publicly available.

4.3.5 Gender issues

Explicit discrimination regarding gender has not been a significant issue in the on-going LCCD trials and implementations around the world.

The concept of one-to-one computing is inherently more equitable than a shared environment, in which some students could come to dominate access to the limited number of computers. Problems with equitable distribution are more likely to arise as a result of the existing socio-cultural environment in a country. For example, if schools are not integrated by gender, then there is more scope for a lack of transparency in LCCD distribution. In Afghanistan, where many primary schools are separated by gender, LCCDs were distributed to a girls' school and a "mixed" school in Kabul. In the mixed school, girls study in the morning and boys in the afternoon. [173]

LCCDs also have the potential to become devices for empowering and training mothers, if students are allowed to bring them home. OLPC has found this has a great influence on the entire family. Children often teach computer skills to their mothers and even grandmothers. For this reason, OLPC often insists that governments let children take the LCCDs home.

173 http://wiki.laptop.org/go/OLPC_Afghanistan/Deployment_News#Second_Phase_of_Deployments

5 National case studies

The following national case studies illustrate various aspects of the cost, coordination, logistical and management issues associated with implementing and sustaining a program to provide or support low-cost computing devices in schools.

5.1 Afghanistan

In September 2008, the Ministry of Education (MoE) and Ministry of Communication and Information Technology (MoCIT) launched an OLPC pilot in Afghanistan. [174] The project is a public-private partnership with the United States Agency for International Development (USAID), the Afghan mobile operator Roshan, and Paiwastoon, a local information technology company.

Each partner has a specific role in the project. The MoE and MoCIT are the government institutions tasked with improving education and the information technology (IT) sectors. Their collective goals are to embed communications technology into the education sector and to establish platforms to transform Afghanistan into an information society. To achieve this, MoE distributes the LCCDs to schools, along with digitized textbook content, the Quran and Web content. The MoCIT is responsible for ensuring the quality of the content, as well as the optimal functioning of the technology.

The private companies, Paiwastoon and Roshan, lend support in terms of content, software, training, connectivity, project management and implementation. Paiwastoon [175] develops content in the local Dari and Pashto languages, customizes software and trains teachers. Roshan [176] handles connectivity through its social responsibility program. [177] It also assists in facilitating the OLPC donation for the project and provides management support. In addition to supplying connectivity where it has existing infrastructure, Roshan supports and counsels installation teams responsible for the implementation of networking infrastructure.

USAID, through its small and medium enterprise development project, provides organizational support in connecting these partners to OLPC, as well as financial and logistical support for the creation of online Dari training. Other support products are a localized business creation toolkit and a marketing campaign to promote and expand the program's implementation as a tool for economic development. 178

The OLPC Foundation is contributing 5,000 XO laptops to Afghanistan. The OLPC technical implementation team began work in November 2008, preparing and translating teacher training materials into Dari and Pashto and carrying out power tests.

Almost half of the XO laptops have been distributed since the program was initiated. The first deployment of the XO laptops took place on 17 March 2009 to Estiqlal High School in Jalalabad, a city about 150 kilometers east of the capital Kabul. Some 400 laptops were distributed to 4th, 5th and 6th graders at the school. The second deployment of the laptops took place on 21 June 2009 in Kabul. Approximately 2,000 XO laptops were distributed during this phase to four schools in the capital city.

[174] http://moe.gov.af/news/Sanbullah/15September2008.htm

[175] http://svr1.paiwastoon.net/

[176] http://www.roshan.af

[177] http://www.roshan.af/Roshan/Roshan_Community/Roshan_Community.aspx

[178] http://afghanistan.usaid.gov/en/Article.540.aspx

5.2 Brazil

Brazil announced its *One Computer per Student* (*Um Computador por Aluno* or *UCA*) project in 2005. The project is coordinated by the President's office and implemented by the Ministry of Education. It has also been integrated into the country's educational development program.

The UCA project is being implemented in several phases, of which the first two have been completed. In the first phase, three types of LCCDs—Intel Classmates, Mobilis Encores and OLPC XOs— were donated by vendors and tested in five different elementary schools (see figure below). The federal and local governments covered other costs. One of the features of these pilots was to explore how the one-to-one model was implemented through sharing. This was possible because in some of the schools, students attend at different times of the day in order to maximize use of the school infrastructure. This allows the same laptops used by students at school in the morning to be used by those attending in the afternoon.

The second phase is a larger-scale implementation of 150,000 LCCDs to 10 elementary schools in each of Brazil’s 27 states, as well as five municipalities. The government issued a tender in December 2007, but it was subsequently cancelled because the government considered the LCCD prices submitted by bidders too high in comparison with prices in other countries. The higher LCCD costs actually stemmed from taxes imposed on LCCDs in Brazil, which added up to 71 per cent (60 per cent for customs duty and 11 per cent for a social tax). These taxes were much higher than in many countries and therefore significantly increased the price of the LCCD. [179] The tender eventually was reissued in 2008, and an Indian-manufactured LCCD, the Mobilis, was the winner. The ultimate outcome of the pilot is unclear, as development of the Mobilis devices appears to have ceased.

Brazil's local governments are co-funding the project. The federal government is responsible for covering the cost of the LCCDs and local governments are covering the costs of school infrastructure *(e.g.*, provision of electricity), as well as the training and content costs. Teacher training is implemented through a network of partners, including universities.

Figure 5-1: Brazil One Computer per Student Phase 1 deployments

- **INTEL CLASSMATE**

Palmas-TO

Colégio Estadual Dom Alano Maire Du Noday

Quantity: 400

Feature: share in different shifts

Piraí-RJ

CIEP No477 Prof Rosa Conceição Guedes

Quantity: 400

Feature: 1:1

- **ENCORE MOBILIS**

Brasilia-DF

Centro de Ensino Fundamental No 1 do Planalto

Quantity: 40

Feature: share in 3 different shifts

- **OLPC XO**

Sao Paulo

Escola Municipal Ens. Fund. Emani Silva Bruno

Quantity: 365

Feature: share in 3 different shifts

Porto Alegre

Escola Estadual Luciana de Abreu

Quantitiy: 395

Feautre: 1:1

Source: One Laptop Per Child Meeting – OLPC. MIT Media Laboratory, Cambridge, Massachusetts, May 20-23, 2008

[179] http://www.olpcnews.com/countries/brazil/david_cavallo_olpc_brazil.html and http://www.olpcnews.com/countries/brazil/uca_brazil_auction_canceled.html

5.3 Nigeria

In March 2007, the One Laptop Per Child (OLPC) Foundation provided XO laptops for primary school students and teachers in Galadima, a town near the capital Abuja. [180] The public school there had no electricity. As a result, the laptops were removed in December 2007. They were supposed to be replaced with new ones more suitable to the school environment. However, a change in government led to funding cuts and the replacement laptops were never procured.

Meanwhile, the Jabi Secondary School, also near Abuja, is the site of another pilot using Classmate PCs. The pilot is supported by the Ministry of Education and the government of the Federal Capital

Territory Authority. Intel has donated 40 computers and provided a full-time IT manager at the school, making it a showcase for Classmates in Africa. [181] The Jabi school has electrical power, as well as a WiMAX Internet connection that reportedly costs USD 10,000 per month. The Internet connectivity is available directly to the laptops (via wireless connection) without using a server.

Nigeria's government has reversed direction several times on technologies and scope of LCCD deployment. It had initially announced its intention to support a large LCCD deployment, but it later scaled back those plans. [182] In terms of operating systems, it has wavered between Windows and Linux. [183]

180 http://wiki.laptop.org/go/OLPC_Nigeria/Galadima

181 http://blog.wizzy.com/post/OLPC-and-Classmate-in-Nigeria

182 “The previous government of Nigeria had committed to buying one million laptops.” http://news.bbc.co.uk/2/hi/technology/7094695.stm

183 http://online.wsj.com/article/SB122332198757908625.html

5.4 Peru

In May 2007, Peru’s Minister of Education announced the country’s participation in OLPC, [184] stating that every school child would receive a laptop. The goal was to provide all primary school students with a laptop by 2011. [185] By mid-2008, some 40,000 computers had been distributed. Another 100,000 were installed by the end of that year, and there were plans to purchase an additional 150,000 in 2009. [186] With about 4 million primary school students, equipping each one with a LCCD at a cost of USD 150 would amount to approximately USD 600 million, or about 20 per cent of the country’s education budget.

In September 2008, Microsoft reported that Peru would become the first country in the world to have XOs with Windows software installed. [187]

Table 5-1: Education Indicators, Peru, 2007

	Total	Urban	Rural
Number of primary school students (000s)	3,947	2,620	1,326
Number of secondary school students (000s)	2,496	2,097	399
Percentage of public schools with electricity	48.1	79.7	34.5
Education budget (USD millions)	3,016		
As % of total government budget	16.7 per cent		
As % of GDP	2.7 per cent		

Source: Ministerio de Educación-Unidad de Estadística Educativa.

[184] http://one.laptop.org/map/peru

[185] http://www.minedu.gob.pe/noticias/index.php?id=6432

[186] http://www.livinginperu.com/news/7566

[187] http://web.archive.org/web/20081204023051/ http://www.microsoft.com/latam/prensa/2008/septiembre/peru.aspx

5.5 Portugal

Portugal's *e-escola* program was announced in June 2007. It calls for distributing 750,000 laptops (ASUS, ACER, Fujitsu, HP, Insys or Toshiba), along with broadband Internet access, to teachers and secondary students.

The laptops include Windows software and sell for EUR 150. Students from low-income households receive the laptop for free, but they have to pay for the broadband service subscription. The laptops are sold through telecommunication operators, which offer an EUR 5 discount off the monthly broadband price, with reduced monthly fees for low income students. [188] The program started in September 2007, and 250,000 laptops had been delivered by June 2008. [189] E-escola is subsidized from the fees mobile operators paid for UMTS (3G) licenses.

Table 5-2: The e-escola Mobile Broadband Offer

Income level	1st Scale	2nd Scale	3rd Scale
Laptop	€0	€0	€150
Monthly Internet price	€5	€15	€17.87

Note: Income level refers to the Portuguese system whereby households from 1st and 2nd scale are eligible for various government education subsidies. The broadband offer requires a 36-month commitment. The plan is capped at 1GB data transfer per month and offers speeds up to 2 Mbps. For the 3rd income level, the laptop is not bundled into a monthly price, requiring users to purchase it upfront.

Source: TMN.

Building on the e-escola experience, the Portuguese government in July 2008 formed a partnership with Intel to produce a Portuguese version of the Intel Classmate (the “Magalhães”). The *e-escolinha* project calls for distributing this computer to 500,000 primary school students. The program charges parents a fee for the computer, based on their economic situation. Those from low-income households do not have to pay, whereas those from medium-income households pay EUR 20 and those from upper-income homes pay EUR 50. [190] Some 370,000 Magalhães computers have been distributed.

[191] After a student has obtained a laptop through the program, Portuguese mobile operators offer an optional EUR 5 per month discount for broadband Internet access. [192]

[188] http://www.tmn.pt/portal/site/tmn/menuitem.0143d3546741f79ae8f48210751056a0/?vgnextoid=8823eb8b16c23110VgnVCM1000005401650aRCRD

[189] Carlos Zorrinho . "Bridging the Digital Divide to Connect People to Innovation." Presented at E-Skills 2008.

[190] http://en.wikibooks.org/wiki/One-to-One_Laptop_Schools/Portugal

[191] Jorge M. Pedreira. "Technological plan for education: The Portuguese framework for ICT in education and the Magellan initiative for primary school children." Presented at Inter-American Development Bank Seminar "Reinventing the Classroom", September 15, 2009. Washington D.C. http://events.iadb.org/calendar/eventDetail.aspx?lang=En&id=1444

[192] http://www.tmn.pt/portal/site/tmn/menuitem.0143d3546741f79ae8f48210751056a0/?vgnextoid=0584222fbfa8c110VgnVCM1000005401650aRCRD

5.6 Rwanda

ICT development is a main, cross-cutting issue in Rwanda's *Vision 2020*, the country's framework for economic and social development and conversion to a knowledge-based economy. Given the prominence of ICTs in Rwanda's development strategy, it is no surprise that its President, Paul Kagame, is a supporter of low-cost computing devices. Kagame is also a personal friend of Nicholas Negroponte, the developer of the One Laptop Per Child (OLPC) initiative.

Rwanda launched its OLPC programme in October 2008, with three schools receiving 5,000 laptops. Another 10,000 laptops were distributed in 2009 to schools in five districts (Gasabo, Kicukiro, Nyarugenge, Rwamagana and Rusizi). The programme in Rwanda called for an additional 100,000 XO laptops to be provided to at least half the primary schools in the country by 2012. [193]

Rwanda aims to be a major player in the OLPC movement. In June 2009, Rwanda established the headquarters for the Global Center for Excellence in Laptops and Learning, which is located in the Kigali Institute of Science and Technology (KIST). [194] Another initiative is dubbed "OLPCorps." It invites university students from around the world come to Rwanda for training. OLPCorps then deploys the trainees different African countries to support the OLPC projects in those nations. [195]

193 http://web.archive.org/web/20090626073309/ http://allafrica.com/stories/200901080184.html

194 http://www.reuters.com/article/pressRelease/idUS115902+09-Jun-2009+BW20090609

195 http://www.reuters.com/article/pressRelease/idUS233233+27-Feb-2009+BW20090227

5.8 Kenya

Worldreader is a U.S. and European non-profit whose mission is to make digital books available to children in the developing world. It has undertaken projects in several African nations using e-readers. As of June 2012, the organization’s projects have distributed more than 220,000 digital books to 1,000 children in sub-Saharan Africa. Worldreader works with sponsoring organizations to close the gap between the cost of e-readers and books and the prices local communities can pay. The organization also develops and digitizes local and international books, as well as managing logistics and support operations. It works in partnership with local governments, school systems, and related businesses. Further, Worldreader provides technical and pedagogical training for project managers and local teachers, as well as helping local businesses repair e-readers. [199]

In 2011, Worldreader and The Kilgoris Project [200] partnered to launch the first classroom e-reader project in East Africa. [201] The project was conducted at Ntimigom School in Kilgoris, the capital of the Trans Mara region of Kenya. It provided a total of 3,150 books, as well as capacity-building training, using Amazon Kindle e-readers. Ntimgom School’s four nursery-level teachers and three primary-level teachers serve more than 200 students in the Trans Mara region. The school is a sponsored public school, with funding coming from Kenya’s Ministry of Education and The Kilgoris Project.

This project was intended to provide a foundation for future efforts with schools and organizations all over the world. The two organizations shared two primary goals for the Ntimigom project:

1. Access to books: To increase the quality of education available to the Ntimigom students by providing access to a world of books. The organizations felt that increased access to books would broaden the way students thought and help to develop their creativity.

2. Capacity building: To use e-readers and teacher training as tools for teacher motivation, including for personal development, keeping abreast of educational research, or as resources for lesson planning.

The project began with a feasibility study conducted by Worldreader in January 2011. Worldreader sought to assess the school's environment and content needs, as well as meeting with representatives from The Kilgoris Project, the school and the community. That study led to a formal cooperation agreement between Worldreader and The Kilgoris Project.

A detailed implementation plan was developed for project execution. The plan included the following phases:

- Device set-up and transportation – This included shipping, labeling, and configuration of the e-readers, as well as inserting them into cases. Device set-up was carried out by representatives of Worldreader, The Kilgoris Project and Ntimigom School in space provided by a local start-up incubator.
- Content selection and distribution – Worldreader signed partnership agreements with two Kenyan publishers, allowing the organization to digitize selected books and make them available to students at no cost. The project also was able to add content from Ghanaian publishing partners, international publishing partners, and the public domain. Each of the 51 student devices was initially provisioned with 42 e-book titles, and each of the 14 teacher devices was provisioned with 72 titles. Plans were laid for future content provisioning, and training was conducted for teachers, the project coordinator, and students. The training was conducted as follows:
    - Teacher training – Eight three-hour modules, conducted over two weeks, addressed basic and advanced technical skills by utilizing leisure reading, mock sessions with actual students, book reports and reading incentives, lesson plans and e-reader keywords.

- Project coordinator training – The Ntimigom School principal was trained as the project coordinator, with skills such as how to delete and retrieve a book from the archive, inventory management, registration and deregistration.
- Student training – Teachers (with coaching support) provided training to students on basic technical skills related to the e-readers.

- Reading assessment – Worldreader and The Ntimigom School agreed upon a methodology for conducting student reading assessments and carried out the assessments.
- Community launch event – On 24 June 2011, several hundred teachers, students, parents, community leaders, local representatives of the Ministry of Education, local church leaders, school board members, local chiefs, councilors and government officials attended a launch event. Organizers described the value and uniqueness of the project, and the parents and community leaders were encouraged to use and care for the e-reader devices.
- Inventory management – The “classroom set” model, in which the set of e-readers is circulated from classroom to classroom, was adopted. If a device malfunctions, The Kilgoris Project is responsible for transporting it to Worldreader’s country representative, who will handle the remaining logistics.

In the October 2011 project report, Worldreader provided information on its monitoring and evaluation efforts. Given the scale of the project, it was deemed impractical and unnecessary to employ a randomized sample and a control group. The project was reported as having met its primary goals, including delivery of 3,150 e-book titles to Ntimigom classrooms and preparation of an additional 13 digitized titles from a Kenyan publisher. There were also “an abundance of capacity building activities,” consisting of the various training efforts. The project report also highlighted next steps for the project, including (1) scheduling periodic calls between Worldreader and the project coordinator to evaluate progress, and (2) planning for the next academic year (including content, assessment of the need for additional devices, and improving Internet connectivity at the school in order to facilitate content downloads).

In terms of project cost, The Kilgoris Project paid USD 19,000 for the package of 3G-enabled e-readers, which included the devices, content, shipping costs and technical support. [202]

In March 2012, Worldreader provided an update on the status of the project at Ntimigom School: [203]

- Since the initial launch of this project, the school had grown to 400 students and hired two new teachers.
- Worldreader had more than tripled its selection of available free or highly discounted book titles available to students and teachers.
- Although the mobile-enabled Kindles were unable to reliably obtain a network connection at project launch, they were now increasingly able to connect via EDGE and sometimes 3G.
- The Kilgoris Project was working to raise funds for an additional 100 e-readers and 5,000 digital books.

199 Worldreader, "What We Do," available at http://www.worldreader.org/what-we-do/.

200 The Kilgoris Project is a U.S. not-for-profit organization founded to support the development of the Kilgoris community.

201 Information from this case study is primarily drawn from the Worldreader report "Starting an E-Reader Program at Ntimigom School with The Kilgoris Project," (October 2011), available at www.worldreader.org/uploads/Worldreader Kilgoris Report Oct-2011.pdf .

202 Information supplied by Worldreader.

203 Worldreader, "An Update from Ntimigom School," (March 26, 2012), available at http://www.worldreader.org/blog/2012/03/26/an-update-from-ntimigom-school/ .

5.9 Malaysia

In June 2009, the Malaysian state of Terengganu embarked upon Project e-Book (*Projek Buku Elektronik*), an effort to improve education through the use of ICTs, training and support. [204] The state government took note of the work carried out by Intel with the Portuguese government's Magellan project and approached the company to develop a similar program. Project e-Book was intended to bring technology – including PCs, interactive whiteboards and servers – into schools. The ICT infrastructure and training, as well as Internet connectivity, digital curricula and teacher development, were focused on helping students, teachers and schools engage in interactive e-learning programs.

The initiative consisted of four primary elements:

- Educational content : Localized content and national school texts were digitized; the sole Malaysian government textbook publisher granted permission to the Terengganu government to pre-install the digital textbooks on Classmate PCs.
- Training : Intel Teach professional development was employed to enable teachers to integrate technology effectively into classroom teaching and learning activities. Working with a state government-owned private training agency, the project was expected to benefit more than 3,000 teachers.
- Technology : Intel agreed to provide hardware, software and services designed specifically for education, over the course of three phases.
- Connectivity : Internet access was provided to the schools via SchoolNet, a nation-wide collaboration between federal government ministries and local ISPs. The PCs provided by Intel were Wi-Fi enabled.

The project plan involved distributing PCs to students, who were allowed to take the computers home, providing the added benefit of giving low-income families access to ICTs. The teachers did not receive PCs until a year after students began using them. Two to three teachers per school received training in Intel Teach Essentials, with the expectation that these teachers would then train others at their schools. The program was planned and managed by a committee that included membership from the state government and other participating organizations.

At the project's outset, the Terengganu government allocated MYR 35 million annually to fund the project, with the laptops provided free to students. The state planned to increase the funding allocation to take greater advantage of the PCs and to enable one-to-one e-learning in the future.

The project was also designed to involve local industry, in order to foster a sense of community ownership in the project, as well as to generate local employment and economic development opportunities. Industry involvement included the following:

- The state government worked with Intel and a local assembler to open a factory capable of assembling 10,000 Classmate PCs per month.
- Digitized textbook content was provided by a local textbook publisher for pre-installation on to PCs.
- The State Education Department drove participation among district education offices and the Principals Board, and published general guidelines to help school administrators.

As of 2012, 93,000 PCs had been distributed to students in grades from primary Year 4 through secondary Form 2 (ages 10-14 years). They were pre-loaded with digitized versions of standard textbooks, test preparation software, Intel education bundles, the Koran and other religious resources, and a dictionary. [205]

The Malaysian government has worked with leading universities, SRI International and Intel to conduct research into the effectiveness of the project. Among the findings of that research were certain challenges:

- Teachers did not receive computers at the same time as students;
- The teachers trained on how to incorporate technology into their lessons but did not always pass along such training to other teachers at their schools;
- More interactive teaching materials were needed;
- Infrastructure challenges persisted, including a shortage of power outlets for charging computers and unreliable or slow Internet connections; and
- Students who received their computers in early grades continued to use them at home but lacked updated educational content consistent with their more advanced capabilities.

In response to the evaluations of the program, changes intended to address these challenges were implemented.

[204] Intel, “Education Program in Malaysia Gives Economy a Booster Shot,” (2010), available at http://www.intel.com/content/www/us/en/intel-learning-series/learning-series-education-program-malaysia-study.html .

[205] Intel, “Research Shows 1:1 eLearning Enriches Education in Malaysia,” (2012), available at http://www.intel.com/content/dam/www/program/education/us/en/documents/Intel%20Education%20Research%20Summary/intel-education-research-summary-malaysia.pdf .

5.10 Argentina

Seeds of Empowerment, an offshoot of a research project at Stanford University, aims to increase access to basic education for children living in extremely marginalized communities around the world. [206] Seeds of Empowerment is making use of the Stanford Mobile Inquiry-Based Learning Environment

(SMILE), a learning methodology that allows pupils to use mobile phones to generate and share their own educational materials in an interactive way.

The first Seeds of Empowerment project in Latin America to use the SMILE platform was launched in 2011 in the Argentine province of Misiones. It involved the support of the provincial government, telecommunications operator Telecom and a local NGO. The project was initially implemented in 10 rural and suburban primary and secondary schools, and was expected to expand to 20 schools in 2012. The overall objective of the project was to incorporate mobile technology in encouraging critical thinking, creativity, literacy and scientific thinking among students.

The pilot, which took place in August 2011, included training workshops using smartphones and tablets with the Android operating system. [207] Students and teachers were able to participate in various workshops with SMILE methodology, which allowed them to learn through innovative teaching methods and to generate dynamic content in real time using mobile devices. Every smartphone was pre-loaded with several applications associated with various subjects in the school's curriculum. Each mobile device served three children, and students used the applications to generate questions about lessons or curriculum, working individually or in groups to compose questions on a topic and search for multimedia support to illustrate their questions. [208] The application compiled the students' questions, allowing them to rank questions in addition to answering them. Results were generated in real time, allowing the teacher and students to see which questions were ranked the highest, which were the easiest, and which were giving students the most trouble.

According to Stanford's School of Education, one of the SMILE pilots, in August 2011, focused on civic engagement at an urban high school located in northern Argentina. [209] Students were challenged to use SMILE to think critically about what it means to be an engaged citizen in their community. Specifically, students were asked to generate questions for their peers relating to moral dilemmas that might arise in their community. Questions generated by the students addressed issues such as homelessness, suicide, stealing, school bullying, and violence. Each group staged a skit to represent the concepts and captured their skits with photos to generate multimedia questions on their handsets. They would take pictures of ambiguous civic circumstances and create questions for their peers, such as "What would you do in this situation?" or "Who do you think is responsible for this?" By rating each other's questions, students came to the realization that the best questions were those that divided the class in terms of responses, whereas less-complex questions would not highlight the differing views of their peers. According to the researchers, after three rounds of creating, answering and rating questions, the high school students were generating profound and challenging questions that were relevant to local concerns.

[206] UNESCO, "Turning on Mobile Learning in Latin America," (2012), at 23, available at http://unesdoc.unesco.org/images/0021/002160/216080E.pdf .

[207] Misiones Online, "Tecnología móvil para educar: aporte de Telecom a escuelas misioneras," (August 11, 2011), available at http://www.misionesonline.net/noticias/index?dia=11&mes=08&anio=2011&permalink=tecnologia-movil-para-educar-aporte-de-telecom-a-escuelas-misioneras .

[208] *Op cit* , 21.

[209] Stanford University School of Education, Office of Innovation & Technology, "SMILE Pilot Studies," available at http://suseit.stanford.edu/research/smile/pilot-studies. According to the website, the Stanford Mobile Inquiry-based Learning Environment (SMILE) is basically an assessment/inquiry maker which allows students to quickly create own inquiries or homework items based on their own learning for the day. For example, students can freely take a photo (Shown in Figure 1) of a diagram or any other object from their own textbooks or any phenomena discovered in their school garden or lab and create a homework item.

6 Conclusions

Greater government focus on ICTs for education, and ongoing reductions in the price of devices for students, are generating a lot of interest in the potential for boosting computer availability for students in developing countries. This module has examined various issues that should be considered in implementing an LCCD distribution program for schools. It also has presented a variety of country experiences. Based on the analysis, several conclusions can be drawn:

- The selection of a particular LCCD depends on a country's educational strategy and development status. Some LCCDs, such as the OLPC xo-1 and Intel Classmate, are expressly designed for children in developing countries, featuring special ergonomic and technical characteristics. Other laptops may not have these features and may not be as appropriate for young children. Some laptops may not be suitable for difficult environments, such as extreme temperatures or lack of electricity.
- The selection of a particular LCCD is also dependent on the pedagogical orientation of a country, as well as on government software policies and the age of the schoolchildren. The OLPC xo-1, for example, is specifically aimed at primary school children and may not be suitable for older students. At the same time, traditional mass-market laptops may not be as appropriate for primary school students. Some countries have policies to adopt or favor certain operating systems and software, which also affects LCCD selection.
- The immediate introduction of a one-to-one computing model is beyond the financial capability of most developing countries. Therefore, countries need to consider a phased approach involving a mixture of installing computer labs and distributing individual computers -- the two methods are complementary rather than inconsistent. One-to-one computing will radically affect the school environment. Governments and educational institutions must consider the positive and negative aspects. For example, one-to-one computing democratizes ICTs by making an LCCD widely available to all children regardless of income level, urban or rural location or gender. They can also be taken home, so that every household with a child also becomes a household with a computer. This may well be disruptive to the established learning environment.
- Objective studies about the costs and benefits of education-oriented LCCDs, commercially available laptops, recycled computers and thin clients are still lacking. The evidence to date is

not entirely convincing, because it is typically sponsored by organizations that have an interest in a particular solution. Countries also need to be aware that, although there is an altruistic element to many LCCD programs, private companies are profit-oriented. Governments must carefully evaluate LCCDs and plan programs that are driven by the educational sector's needs and resources, rather than driven by offers of donated computers for pilot projects.

- There must be a long-term commitment to one-to-one computing and LCCDs. Each year, new students enroll and need additional LCCDs. Governments need to ensure ongoing funding and sustainability to support this.
- Another financial challenge for developing countries is the need to balance the introduction of broadband Internet connectivity in schools with promoting one-to-one computing. The goals of one-to-one computing and broadband connectivity are both important, but with limited budgets, governments need to balance priorities. Therefore, it may be difficult to implement both one-to-one computing and broadband connectivity simultaneously. One-to-one deployment plans may need to be adjusted in order for schools to also attain Internet connectivity.
- Mobile education services and applications could allow countries to leapfrog over the computer lab and one-to-one computing models that have dominated discussions of ICT for education for at least the last decade. The potent combination of lower costs, increased computing power, and ubiquity of mobile devices could help overcome one of the biggest challenges to school connectivity: the high cost of buying computers. While mobile handsets, tablets and e-readers may not be able to completely replace more traditional desktop and laptop computers, they provide a new point of access for school-age children, university students and other learners to educational content and collaboration tools.
- In order to maximize accessibility, mobile learning initiatives should cater to the full range of technology contexts. Smartphones and tablets may have the flexibility and processing power to obtain and run a wide range of applications and services, but there is still a large base of feature phone users. A comprehensive mobile learning initiative should take into account the mix of mobile devices that is prevalent in a particular market and ensure maximum accessibility. For example, feature phone users with Nokia handsets in China, India, Indonesia and Nigeria can access Nokia Life Tools, which the company describes as a "mobile-based, life-improvement information services suite." Nokia Life Tools provides information targeted not only for education (such as English language learning resources), but also agriculture, healthcare and entertainment. The service had reached more than 30 million users as of August 2011, with the mix of available information and languages tailored to each market. [210]

- ITU members can take several steps to consider the potential benefits of mobile devices for their own educational programs and policies:
    - Review existing education (including e-education) policies, programs and plans to determine if they should be modified to reflect the rise of mobile devices and services suitable for education;
    - Consult with education, ICT, and other stakeholders to identify potential areas of agreement, cooperation and potential improvement for m-learning initiatives;
    - Identify the potential benefits and drawbacks to promoting m-learning initiatives;
    - Consider making any relevant revisions needed to create an enabling environment for mobile education tools;
    - Identify potential funding options for m-learning initiatives and pilot projects; and
    - Incorporate mobile devices and m-learning initiatives into education policies and plans in an appropriate manner, and with adequate mechanisms for monitoring their effects.

[210] Nokia, "Nokia Life Tools," available at http://press.nokia.com/wp-content/uploads/mediaplugin/doc/nokia-life-tools_data-sheet-for-kenya-event.pdf .

7 Checklist

Several useful steps, or decision-points, in implementing an LCCD distribution program can be summarized in the following “checklist.”

Coordination

LCCD projects are usually a collaboration between the ministry of education and other partners such as NGOs, international donors and the private sector. Who will participate in the project? Who will take overall implementation responsibility, including integration of pedagogical questions, dealing with LCCD vendors, handling technological issues, coordinating transport and delivery and liaising with schools and volunteer groups? This step involves answering these threshold questions.

School Designations

Which schools will participate? How many students and teachers will be involved? Do the schools have electricity? What languages are spoken? What is the transportation situation? Are parents supportive?

Finance

Where will funding come from? How much are import duties and taxes? Should a tendering process be used? How much of the project should be outsourced?

LCCD Selection

What are the requirements for the LCCD (*e.g.*, operating system, applications, battery life, national language interface, keyboard, etc.)? How much does it cost? What kinds of discounts are available? What kind of support network (*e.g.*, content, training manuals, etc.) are available? What kind of warranties can be obtained? What kind of battery re-charging and plug configurations are available? Should LCCD selection be tendered?

Networking

Is networking capability needed for the project? Do schools have access to the Internet? What kinds of connectivity options are available (*e.g.*, dial-up, DSL, WiMAX, 3G/4G mobile, VSAT)? Is mesh networking needed? What are the costs of networking (*e.g.*, installation of network adapters and routers, recurring service costs)? Can local telecommunication operators or ISPs assist with networking? Are firewalls needed for content control?

Transport and Distribution

How far is the country from the LCCD manufacturing location? What is the lead time for manufacturing the LCCDs? How will the LCCDs be transported (*e.g.*, by air, by ship, etc.)? What are customs formalities and how long is the delay? How will the LCCDs be distributed within the country? What is the deployment schedule?

Content

What education content is needed to support teaching? What content comes with the LCCD? What content is available through the LCCD support network? Is it free? How easy is it to convert existing national content for use on the LCCD? Will new, nationally developed content be needed? Is content documentation available? How will free content be downloaded from the Internet and distributed?

Servers and Peripherals

Will servers be used? What kind of computers will be used for the servers? How much additional disk space is needed? What kind of peripherals (and how many) will be needed (*e.g.*, printers, scanners)? Should servers be included in a tender? Should server support be outsourced?

Electricity

How will LCCDs be recharged (*e.g.*, on-grid or off-grid electricity)? Will universal power supply (UPS) backup be needed? What is the recurring electricity cost?

Training

How will teacher training be implemented? What will be taught? What are the logistics (*e.g.*, centralized training or training on-site)? What kind of documentation will be needed? Should training be outsourced and/or included in a tender? Do the LCCDs themselves have training modules? Is student training necessary? If so, the same questions apply.

Support and Maintenance

How will the project be technically supported? Should support be outsourced and/or included in a tender? What is the maintenance procedure? How will students and teachers be trained in routine maintenance and troubleshooting? What stock of inventory should be maintained for spare components or replacement? What is the procedure for sending LCCDs for repair? How will equipment be recycled?

Monitoring

How will the project be monitored and evaluated? Who will carry out the monitoring and evaluation?

Table 7-1: Project responsibility checklist

Government	Vendor	International agency
• Coordinate all the parties concerned within the country; • Nominate a national project coordinator responsible for coordination with the education ministry and all other partners; • Exempt duties and/or tax for the devices; • Identify schools to receive the devices; • Arrange for local transportation of the devices from the port of entry to the designated schools; • Provide supporting infrastructure (including electricity), Internet connectivity, as well as printers, scanners, additional memory devices and servers as	• Donate devices, including any necessary adaptations for use in beneficiary country (e.g., operating system, national language keyboard, pin configuration, etc.) and reasonable warranties; • Cover shipping costs of the devices, including packing for export, shipping charges, airfreight or vessel charge and insurance from the originating country to the port of entry; • Contribute human resources to provide training and support to teachers in the target areas where the devices will be delivered;	• Coordinate with other partners to identify applications and content-related requirements to be included in the devices; • Support local training by underwriting expenses, making arrangements for training at local/ regional training institutes, etc. • Negotiate, through the project coordinator, signed agreement with the beneficiary country to ensure its commitment to the project; • Conduct an evaluation of the pilot phase of the project and identify areas for improvement; • Following the evaluation of the pilot phase, assist

required at local sites and provide IT specialists to install networks in the targeted schools; • Create awareness and organize community learning and information exchange campaigns including meeting at all schools with teachers, students and parents to build their support for the project; • Keep other partners informed; • Translate donated training materials into local languages as required; • Identify a team of IT specialists to participate in the technical maintenance and support training to be provided by the vendor so that local IT specialists will be able to maintain and support the devices. • Assume responsibility for software upgrades as required.	• Provide an IT expert to provide service and support to each participating country for at least 6 months; • Provide initial trainer(s) and training materials on the maintenance of the devices so that each participating country can train national IT experts to repair and maintain the LCCDs; • Provide trainers, training materials and training sessions for teachers and students on use of the devices, peripherals and content.	the beneficiary country to design a comprehensive national LCCDs in schools program and assist the beneficiary country in launching public tenders for the provision of LCCDs;

Table 7-2: Feature Comparison of Low-Cost Computing Devices for Students - Laptops

	xo-1.75 (OLPC)	**Classmate (Intel)** [211]	**Eee (ASUS)**
Dimensions	245×230×30.5mm	10.6 x 8.2 x 1.2 "	262 x 180 x 22 mm
Weight	< 1. 5 Kg	3.5 pounds	1 Kg
Battery life	22.8 Watt-hours (LiFePO4) About 4.3-6 hours depending on battery and assuming 3.81 Watts [212]	Up to 10 hours (6-cell)	Up to 5 hours (3-cell)
CPU	Marvell 800 MHz	Intel 1.6 GHz	Intel 1.6 GHz
USB ports	3	2	2
Form factor	Convertible laptop with pivoting, reversible display	Clamshell	Clamshell
Random Access Memory	512 MB or 1 GB	Up to 2 GB	Up to 2 GB
Storage	4 GB	Up to 320 GB HD or up to 128 GB SSD	320 GB HDD
Operating system	Sugar (Linux-based)/ (Windows XP also available)	Windows 7 or Linux	Windows 7 Starter

	xo-1.75 (OLPC)	**Classmate (Intel) [211]**	**Eee (ASUS)**
Networking	802.11b/g; 802.11s (Mesh) networking;	10/100M Ethernet; 802.11 b/g/n; 3G capable	10/100M Ethernet; 802.11 b/g/n
Display	Liquid-crystal display (LCD): 7.5” 1200 × 900	10.1” 1024 x 600 color LCD	LCD 10.1” 1024 x 600 color LCD
Camera	Yes	Yes	Yes
External audio / video ports	Headphone and microphone	VGA, HDMI, headphone and microphone	VGA, HDMI, headphone and microphone
Warranty	30 days	1 year	1 year

Table 7-3: Feature Comparison of Low-Cost Computing Devices for Students - Tablets

	Ubislate 7+	**Studybook (Intel) [213]**	**Amazon Kindle**
Dimensions	190.5 x 118.5 x 15.7		6.5” x 4.5” x 0.34”
Weight	350 grams	1,2 lb.	5.98 oz.
Battery life	3 hours	6 hours	4 weeks (wireless off)

	Ubislate 7+	Studybook (Intel) [213]	Amazon Kindle
CPU	Cortex 800 MHz	Intel 1.2 GHz	
USB ports	1	1	0
Memory	256 MB	2 GB	
Storage	2 GB	32 GB SSD	2 GB
Operating system	Android 2.3	Windows 7 Professional or Android	proprietary
Networking	802.11 a/b/g and GPRS	Wi-Fi	802.11 b/g/n
Display	7” 800 x 480 resistive	7” 1024 x 600 color LCD	6” e-ink
Camera	No	Yes	No
External audio / video ports		Headphone	
Warranty	1 year	1 year	1 year

[211] Intel Classmate is a reference design licensed to vendors. Specifications here are for a representative sample of one such product.

212 http://news.cnet.com/8301-13512_3-9768920-23.html

213 Intel Studybook is a reference design licensed to vendors. Specifications here are for a representative sample of one such product.

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