School Connectivity
for the 21st Century

Table of Contents

Figures

Tables

Executive Summary

"Education is the most powerful tool which you can use to change the world."

- Nelson Mandela

Information and communication technologies (ICTs) no longer simply serve as convenient tools for interaction, but rather they have evolved into essential instruments for everything from government operations to business processes to individual activities. After decades of innovation, ICTs have become more affordable and have embedded themselves so effectively into daily activity that, according to one United Nations study, more people have access to mobile phones than they do to other basic services.[1] However, universal access to ICTs - Internet-enabled devices in particular – has not yet been achieved, nor has universal access to broadband. In an increasingly connected world, those who fall behind on the technology adoption curve are at a great disadvantage.

This sentiment is echoed most discernibly within the education sector. Education paves the way to opportunity and provides a path out of poverty. Given the proper resources, students have the chance to better themselves academically, personally, and professionally; yet, as advancements in educational technologies emerge, only those who have access to them benefit, widening the gap between achievement and economic stagnation.

To ensure that benefits of ICTs accrue to everyone, more needs to be done to increase broadband availability and adoption, specifically through policies that connect schools, libraries, and all classrooms to broadband Internet service. This report reviews five examples of national connectivity programs that have achieved high levels of Internet access in schools and that have prioritized upgrading connectivity to 21st century standards. These are the principal findings:

Vision. Successful programs are driven by a high-level political understanding of the importance of school connectivity as the foundation for developing knowledge-based societies and leveraging the economic potential of information and communication technologies. These top-level visions are typically supported by detailed plans and appropriate funding.

Feasibility. Once a commitment is made to connect or upgrade school connectivity, deployment can progress quickly. This is especially true when upgrading from narrowband to ultra-high-speed broadband. At the same time, rapidly falling costs and technological improvements provide an opportunity for schools in emerging countries to leapfrog over their developed world counterparts into the 21st century.

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1 For example, 6 billion people have access to mobile phones compared to 4.5 billion who have access to a working toilet. http://newsfeed.time.com/2013/03/25/more-people-have-cell-phones-than-toilets-u-n-study-shows/

Funding. A successful school connectivity program requires a sustainable mechanism to fund fixed and recurring costs over time. However, connectivity programs do not necessarily require very large sums of money. In several of the countries studied, the government has recognized the importance of ICTs in schools and has committed a portion of the education budget for the capital costs of modernizing school technology. Universal service funds (USFs) are also useful sources of financing. Unfortunately, despite the fact that a number of countries have USFs, many are not used effectively or have not begun to disburse money. This is a missed opportunity.

Technology Requirements. Several technological aspects of school connectivity programs work in concert to ensure a robust system is available for students and educators: bandwidth to the school, within-school connectivity, district-wide access, and complementary hardware and software. The experience of the programs reviewed here demonstrates that, over time, per-student bandwidth needs are regularly updated and that local area networks (LANs), which provide connectivity within schools, are essential, not only to extend connectivity throughout the campus, but also to achieve real outcomes by supporting collaboration and access to resources for every student and educator.

The good news is that the technology landscape has reached an inflection point that creates previously unimagined opportunities to impact education through technology. This inflection point can be best described with the now popular phrase "the Internet of Everything" (IoE). The IoE is the networked connection of people, processes, data and things. It is about capturing value for teachers, students, administrators and families by embracing the biggest transitions

in technology today: cloud, mobility, security, and big data analytics. While the technologies may be complex, deployment for a school is straightforward when deploying fast IT models, often cloud-based, that are simple, smart and secure.

Cisco estimates the worldwide value at stake of an IoE transformation in education to be $258 billion over the next ten years. Connectivity is the starting point for any government seeking to embrace these technologies, which is why the ideas in this paper are so critically important to countries endeavoring to drive value for education through the Internet of Everything.

Improving education should be a priority for all governments at every level, be it national, regional, local or otherwise. As this report demonstrates, impactful connectivity programs are financially feasible, can be implemented (and result in impact) in a relatively short time period, and do not necessarily require large capital budget expenditures. With the right design and political will, a successful program can be implemented quickly and can drive enhanced educational outcomes.

Introduction

Broadband access is a necessary component for many modern educational tools, though it is frequently lacking or insufficient in speed and capacity in primary and secondary schools around the globe. While many nations have prioritized access to affordable education, and some have made headway in doing so for access to broadband within schools, there is still work to be done. With 50 million more children enrolled in schools worldwide today than there were in 1999 and an extra $22 billion needed to ensure basic education at just the elementary level by 2030, more funding, educators, and resources are required if this demand is to be met.[1]

Research on the educational impacts of technology indicates that disparities in technology access within U.S. schools, for example, affect students' opportunities to access institutional resources and use technology effectively. The immediate benefits of connecting schools with broadband include, primarily, expanded and improved access to educational materials. When instructors are adequately equipped with the tools they need to teach, they are more effective, and may advance their own professional development supplementary to their students' academic growth. Internet connectivity allows classes to conduct online research and interact with external content. Additionally, broadband enhances the usefulness of ICTs already adopted by schools (such as desktop computers) and provides opportunity for students to learn how to use new technologies.

Beyond these immediate impacts, schools that implement sustainable broadband plans may observe improved student cognitive and non-cognitive functioning[2], increased student interest in the pursuit of ICT-related professions, and boosted morale amongst members of the school community. Broadband access also enables distance- and e-learning. This has the potential to tremendously impact rural areas in particular, as their schools are offered the option of creating and investing in these innovative programs. Finally, broadband-dependent technologies allow teachers and learners to collaborate across classroom, school and even national boundaries. This collaboration can include anything from "face-to-face" meetings, student sharing of teacher-generated content, or project work amongst students across different geographic regions.

Heightened student achievement, improved access to social services, enhanced capacity-building and knowledge creation, and opened channels to markets, goods, and services, are just a few of the long-term benefits that accompany broadband access. In the long run, when sustainable connectivity programs are developed and implemented in schools, an investment is made not only in education, but in the vitality of the surrounding community as well.

1 http://www.dw.de/two-thirds-of-countries-miss-un-education-goals/a-18371538

2 http://connectaschool.org/itu-module/21/517/en/schools/connectivity/reg/1.2.1/

School Connectivity
for the 21st Century

Overview

Many governments around the world have endorsed the *Education for All* goals, recognizing education as a fundamental human right and establishing the importance of empowering every citizen with the knowledge, skills and values necessary for a fulfilling and productive life.[1] Now, more than ever, technology is critical for delivering education. As the Broadband Commission for Digital Development notes:

> "In the twenty-first century, education cannot be separated from technology. Rapid advances in information and communication technology (ICT) and expanding connectivity to the Internet have made today's world increasingly complex, interconnected and knowledge-driven. Access to quality education for all – which includes access to ICT – is an imperative for building inclusive and participatory knowledge societies."[2]

Cognizant of the importance of school connectivity, the World Summit on the Information Society (WSIS) adopted a Plan of Action in 2003 calling on governments "to connect universities, colleges, secondary schools and primary schools with ICTs."[3] The educational ICT environment has evolved dramatically in the dozen years since WSIS. This change is driven by two major trends: i) a move towards greater availability of devices for students typified by 1:1 computer programs with a proliferation of mobile phones and tablets, and ii) the emergence of cloud computing for supporting online educational content and school administration software. These changes require considerable bandwidth and internal local area networks for their

benefits to be successfully maximized. Today, the fact that a school is connected to the Internet is not as important as how it is connected, what its connection speed is and whether it has sufficient in-school Internet access for laptops, tablets and other digital devices in classrooms.

This report reviews strategies undertaken in different countries to provide primary and secondary schools with access to the Internet. The focus is on Internet connectivity although availability of computers, integration of Internet into the learning environment, e-learning content and teacher training are all critical ingredients for the successful application of ICT in education.

Connectivity Options

21st century school connectivity requires attention across several areas. This includes the bandwidth required, the physical link to the Internet, the upstream service provider and downstream distribution throughout the school. An example from Ireland is used to illustrate these points (Figure 1). A wide area network (WAN) is used in Ireland to provide upstream Internet connectivity. The actual physical connection to the Internet consists of a variety of technologies (e.g., ADSL, wireless, satellite, etc.). Each school in turn has a router to support Internet distribution throughout the campus via local area networks (LANs). This kind of high-level design enables connectivity options like Wi-Fi to be available in every classroom on school campuses. Additionally, centrally managed services to schools, such as the provision of a firewall or content filtering, offered by the overarching WAN not only enhance security, but also reduce total cost.

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1 http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-all/

2 Broadband Commission 2013

3 http://www.itu.int/wsis/docs/geneva/official/poa.html

Figure 1: School Network

Source: National Centre for Technology in Education (NCTE). 2004. "The Schools Broadband Programme: Information and Guidance for Schools" p. 126. http://www.ncte.ie/documents/broadband/SchoolsBroadbandProgrammeInsert.pdf
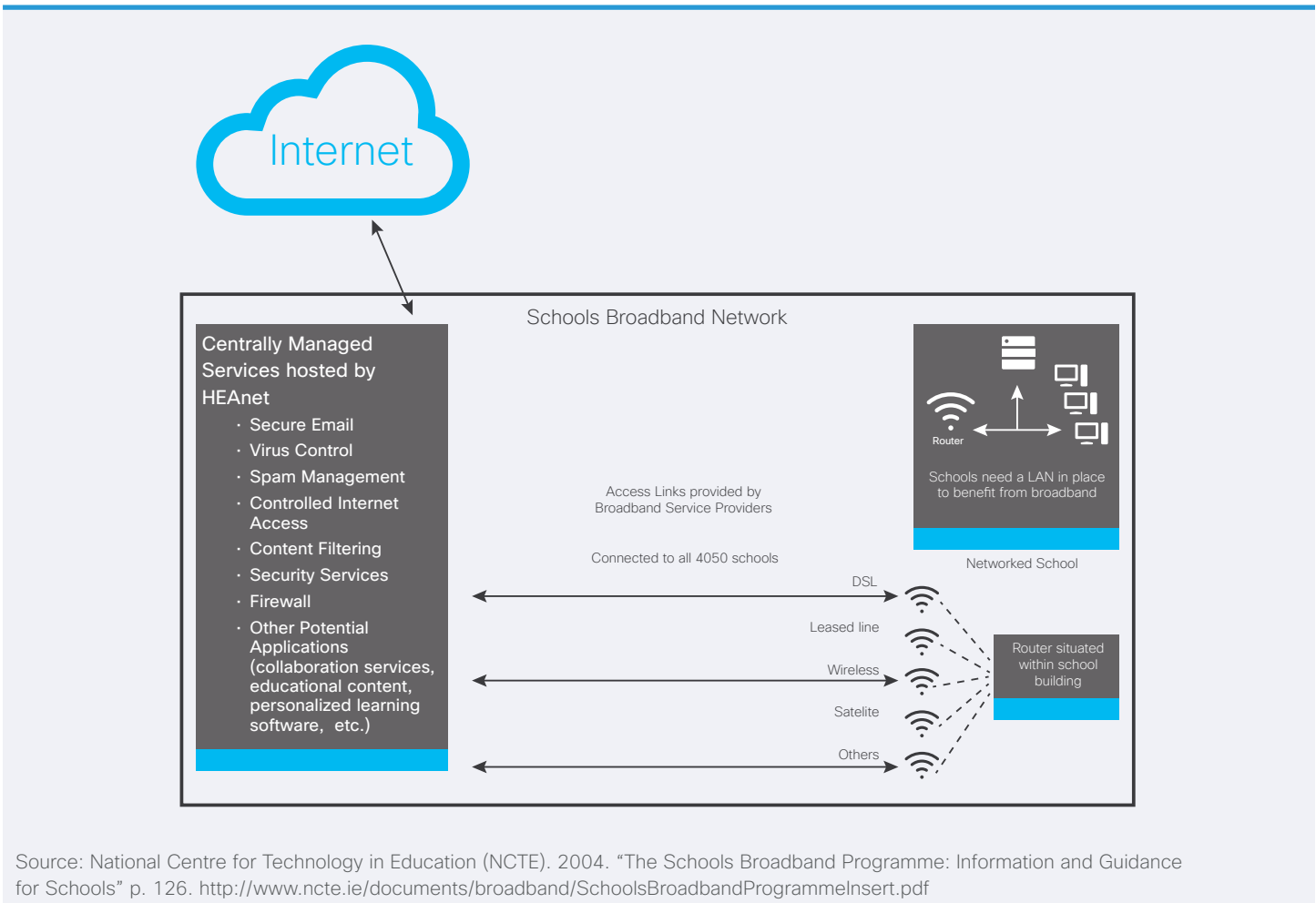
It is not realistic to propose a common broadband speed for schools. The amount of bandwidth required per school will vary depending on its size (i.e. number of students and teachers), the degree of e-learning integration and the number of connected devices. International definitions of broadband remain stuck on a speed of at least 256 kbps that has not been updated in years.[1] With this speed, it would be impossible to support 1:1 computing environments or e-learning platforms. Cognizant of this, many countries have adopted far higher speed standards for their schools. For example, Ireland has established a minimum speed of 100 Mbps for secondary institutions and Portugal a target of at least 48 Mbps for all schools. Others have targets that reflect the number of students in the school. A United States school technology group has proposed a short-term target of at least 100 Mbps per 1,000 students and teachers and later rising up to 1 Gbps[2], while New Zealand is rolling out fiber optic cable with four bandwidth options depending on the number

1 "ITU and the OECD have defined broadband as a capacity of at least 256 kbps in the uplink or downlink speed." See: http://www.broadbandcommission.org/documents/reports/bb-annualreport2014.pdf

2 See Fox et al 2012

of students in the school. These recent standards imply a minimum bandwidth requirement of 50 Mbps for smaller schools rising to 1 Gbps for larger schools.

A number of technologies exist that facilitate connection to the Internet. Ideally, schools will want a connection that matches bandwidth requirements based on the number of students. The location of the school is also a factor since the choice of technologies and/or speeds becomes more restricted the further the school is from urban areas. Wireless is often used in remote areas due to the unavailability of cabled technology. Relevant technologies for 21st century school connectivity are shown in the table below.

Table 1: Internet Connectivity Options

Physical link	Internet access technology	Details
Copper wire	VDSL (Very-high-bit-rate digital subscriber line)	VDSL operates over copper wire telephone line and is generally the most prevalent technology available for schools. VDSL can offer speeds up to 100 Mbps.
Coaxial cable	DOCSIS (Data Over Cable Service Interface Specification)	Used primarily over cable television networks, though Internet access over cable television networks is not available in a number of countries. Maximum speed is 200 Mbps.
Fiber optic cable	PON (Passive Optical Network)	Supports the highest commercial bandwidth available today. Speeds are dependent on the transmission equipment used. Some schools are using speeds of 1 Gbps.
3G mobile cellular	HSPA (High-Speed Packet Access)	HSPA features download speed of 42 Mbps.
4G mobile cellular	LTE (Long Term Evolution)	Standard specifies download of 100 Mbps that could be increased to 1 Gbps using multiple channels.
Wireless	WiMAX	Theoretical download speed on WiMAX is 46 Mbps.

Source: Adapted from World Bank. 2012. *Broadband Strategies Handbook*.

1 http://www.fcc.gov/measuring-broadband-america/2013/February

To maximize access to online resources, broadband needs to be available to every classroom and computer (including peripherals such as printers, scanners, monitors, white boards, etc.). Distributing high-speed Internet throughout the school in this way requires a robust LAN, which could be wired, wireless (i.e., Wi-Fi) or a mix of both. This type of network is critical to the support of a school's intended use of its broadband connectivity. In an environment of slow or inconsistent bandwidth, the LAN may be set up to upload and download content at night and store that data for use during the day. Local software in the LAN can also support cross-classroom collaboration and a wide range of personalized learning solutions. Additionally, while cybersecurity elements may be embedded across either a LAN or a WAN, it is the LAN that imposes safety controls, such as limiting the sites students may be permitted to visit, or controlling who may access what content on the network. With the proliferation of devices, Wi-Fi in particular has taken a predominant role.

Status of School Connectivity Around the World

European, high-income Asian and North American nations have virtually all of their schools connected to the Internet. Despite high Internet access in these countries, the quality of network connectivity varies. For example, in Europe, broadband is not ubiquitous, local area networks even less so and the majority of students have average broadband speeds of less than 30 Mbps.

Table 2: School Connectivity in Europe

	Grade 4		Grade 8		Grade 11 general		Grade 11 vocational	
	2006	2011	2006	2011	2006	2011	2006	2011
Computers connected to the internet per 100 students	8	15	10	19	12	23	14	31
% schools with broadband	65%	92%	71%	95%	75%	96%	75%	94%
% schools with broadband via ADSL	42%	53%	51%	52%	51%	52%	54%	51%
% schools with a local area network	50%	64%	68%	69%	75%	68%	72%	86%

Source: European Commission 2013.

In the rest of the world, school connectivity is uneven. According to a review of WSIS, progress in connecting schools has been limited with the result that many developing countries are constrained in their capability to use ICTs in education effectively:

"At the opposite end of the continuum, while some progress has been made in a number of developing countries, LCRs [Learner to Computer Ratio] frequently remain too high and school Internet connectivity rates too low to provide pupils with access to advanced forms of ICT in education. This is true of some countries in Latin America and the Caribbean, and especially so for many countries in Asia and Africa, where the minority of schools have Internet connections and where LCRs are too high to provide pupils with meaningful learning opportunities. Since LCRs can mask disparities between those schools with many computers, those with few, and those with none, it is difficult to shed light on the extent of disparity within countries." (ITU 2010)

The UNESCO Institute of Statistics has carried out surveys on ICT in education for Asia (2012) and Latin America and the Caribbean (2010–2011) (UIS 2012 and 2014). There is a wide global divide in school connectivity not only between developed and developing nations but also among developing nations. In countries for which data is available, Internet connectivity in public secondary schools ranges from 6% to 100%. Few countries provide broadband to all public secondary schools. The availability of local area networks in public secondary schools in developing countries is limited and there is no information on how widely they cover schools.

There is still much work to be done to lift schools around the world to connectivity appropriate for the 21st century. Chapter 4 reviews the outcomes of technology-enabled education and Chapter 5 looks at the experience of several countries that are modernizing their school connectivity.

Technology and Education Outcomes

Global rates of school enrollment for primary and secondary age children have increased since the turn of the century, bringing the world closer to achieving the Education for All (EFA), Millennium Development, and Sustainable Development Goals. A considerable amount of progress has been made in reaching universal access for primary education globally; between 2000 and 2012, the number of out-of-school primary age children fell by 42%.[1] However, despite substantial gains made over the last decade and a half in school enrollment, the rate of growth has stagnated since 2007. Fifty-eight million primary school-age children (9% of children this age) worldwide and sixty-three million adolescents of lower secondary school age (17% of children this age) have yet to gain access to education. Additionally, 793 million adults – almost 66% of whom are women – still lack basic reading and writing skills.

At the same time, over 40% of the global population – about 3.1 billion people – is online.[2] According to ITU estimates, at the end of 2014 there were 711 million fixed broadband subscriptions and 2.3 billion mobile broadband subscriptions (a mobile-to-fixed ratio of more than 3:1).[3] This rapid expansion of connectivity to the Internet, specifically through broadband subscriptions, has united more people than ever before. Rapid advances in the technology have facilitated the now-interconnected nature of global activity, and broadband access has become an essential cornerstone of learning in the 21st century.

The immediate benefits of connecting schools with broadband include, primarily, expanded and improved access to educational materials. When instructors are adequately prepared with the tools they need to teach, they are more effective, advancing their own professional development in addition to their students' academic growth. Internet connectivity allows classes to conduct online research and interact with external content. Additionally, broadband enhances the usefulness of ICTs already utilized by schools, such as computers, and provides new opportunities for students to learn how to use the technology.

Beyond these immediate impacts, schools implementing broadband connectivity may observe improved cognitive and non-cognitive skills of students, increased student interest in pursuing ICT-related professions, and boosted morale amongst members of the school community.[4] Broadband access also enables distance education and e-learning, giving schools the opportunity to utilize these programs, which would have a tremendous impact in rural areas. Broadband also improves school operations. As noted by

1 http://data.unicef.org/corecode/uploads/document6/uploaded_pdfs/corecode/Global-OO-SCreport-Full-web_217.pdf

2 http://blogs-images.forbes.com/niallmccarthy/files/2014/08/Internet-Usage.jpg

3 http://www.broadbandcommission.org/documents/reports/bb-annualreport2014.pdf

4 http://connectaschool.org/itu-module/21/517/en/schools/connectivity/reg/1.2.1/

the ITU, "school connectivity also helps enhance educational administration through electronic exchange of forms, data and other information. It also achieves cost efficiencies by automating manual tasks and reducing expenses associated with textbook printing and distribution."[5]

In the long run, when schools develop sustained broadband programs, they are making an investment in their students' and their own future success. Heightened student achievement, improved access to social services, enhanced capacity-building and knowledge creation are just a few of the long-term benefits that accompany broadband access.

Conversely, when schools lack access to broadband, they suffer. Technological disparities between school districts affect students' opportunities to access institutional resources and practice using technology, which hinders their chances of graduating from secondary schools or entering college. While these effects are confined to the short-term, early access to technology could impact a student's professional trajectory. Long-run inequities may persist due to diminished access to technology among low-income and minority groups. This trend can be mitigated if more countries, and more school districts, implement robust high-speed connectivity programs. Broadband connectivity serves as a catalyst for change by connecting the unconnected to new ideas, to engaging conversations, and to tools for economic, social, and political development that were previously out of reach.
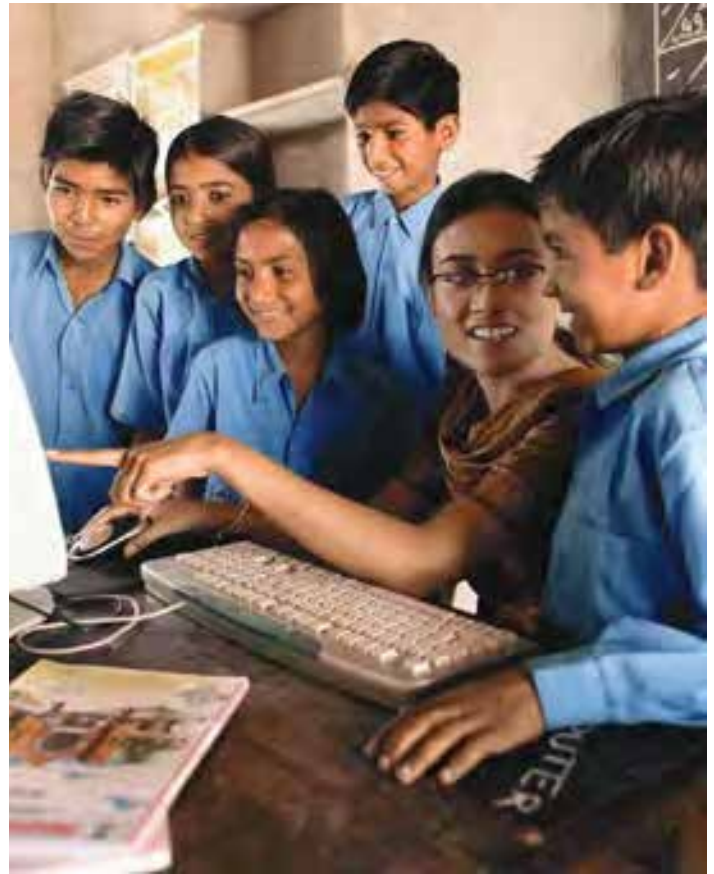
To ensure that benefits of ICT accrue to everyone, more needs to be done to increase broadband availability and adoption, particularly through policies that connect schools and libraries to broadband Internet service and ensure widespread connectivity within schools. With only 43% of the global population currently online, countries must commit to digital inclusion by connecting their schools and developing programs that benefit their students while meeting the global demand for a technologically literate workforce.

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5 http://connectaschool.org/itu-module/21/517/en/schools/connectivity/reg/1.2.1/

National School Connectivity Programs

This chapter documents experiences from five countries that have been successful in connecting their schools to the Internet through dedicated national programs. Each country is now in the process of moving to higher levels of connectivity characterized by faster speeds, pervasive in-school connectivity and educational WANs. The methods of implementation used in each case are diverse, ranging from enhanced Internet connectivity that serves as a complement to one-to-one computer programs (Portugal and Uruguay) to subsidized Internet pricing for schools (United States). All of the programs share a commitment to connect all schools regardless of location, and all are backed by sufficient financial support. Some of the programs are tied to high-level country strategies where school connectivity plays an important role in raising the nation's technological capability (Portugal) or democratizing access to ICTs (Uruguay). The diversity of approaches provides relevant examples for other countries desiring to achieve a high degree of school connectivity.

Ireland: 100 Mbps Post-Primary Schools Project

Education is compulsory for children in Ireland from the ages of six to sixteen or until completion of three years of post primary education. Primary education consists of grades 1-6 and most schools are state-funded. The post-primary education sector comprises secondary, vocational, community and comprehensive schools and consists of six years of schooling. There were 4,009 state aided primary and post-primary schools during the 2012/13 school year with just over 900,000 students (Table 3).

Ireland has gone through several phases of school connectivity. Its first policy on ICT in education, *Schools IT 2000*, was issued in 1997. Although a majority of schools were connected to the Internet, connections were predominantly low speed, often used for administrative purposes and a significant number of computers in schools were not connected to the Internet. This led to the *Technology Integration Initiative* (part of the *Schools IT 2000*) providing grants for schools to purchase computers and establish Internet connections. The program resulted in all schools having an Internet connection.

Table 3: Irish Public School System 2012–2013

Level	Schools	Students	Average students per school
Primary	3,286	536,317	163
Post-Primary	723	367,178	508
Secondary	373	189,446	508
Vocational	256	120,473	471
Community	80	49,449	618
Comprehensive	14	7,810	558
Total	**4,009**	**903,495**	**225**

Source: Adapted from Department of Education and Skills.

Despite the connection of all schools to the Internet by 2001, speeds were slow and there were challenges with maintenance and technical support. To address these issues, the *Schools Broadband Program* was launched in 2005.[1] Under this initiative, all primary and secondary schools would have an Internet connection of at least 512 kbps. Different access technologies including DSL, leased line, coaxial cable, satellite and wireless were used depending on school size, location, and availability. The Department of Education and Science contracted with Internet service providers to supply schools with routers installed with Internet links. Costs were lowered and technical support strengthened through the management of access to the Internet and other services (e.g., firewall, remote access, hosting, etc.) by Ireland's National Education and Research Network (HEAnet). This leveraged HEAnet's long experience providing connectivity to universities and other tertiary institutions. The program was a joint project between the government and the Telecommunications and Internet Federation of the Irish Business and Employers' Confederation. The total costs of the project, including the fixed and recurring costs through June 2008 were estimated to amount to around €30 million.[2]

1 http://www.ncte.ie/documents/broadband/SchoolsBroadbandProgrammeInsert.pdf

2 Department of Education and Science (2008)

Arising from the government's 2009 *Next Generation Broadband* report, the *100 Mbps Post Primary Schools Project* marked the next stage for Ireland's vision of developing its schools as world leading centers of digital education:

> "Connectivity to schools, in particular, will benefit from the Government's investment in broadband infrastructure. We aim to equip second-level schools in Ireland with 100 Mbps of broadband connectivity and Local Area Networks (LAN) on a phased basis. This will enable students to learn and collaborate online."[3]

The project called for the some 700 post-primary schools in Ireland to be provided with broadband at speeds of at least 100 Mbps. The project commenced in 2010 with a pilot that drew participation from 78 schools with each county in the country represented by at least one school. Following a positive evaluation of the first pilot, the remaining schools were connected from 2012 to 2014 (Figure 2).[4]

Figure 2: Ireland's 100 Mbps Broadband Schools Deployment

Source: Adapted from PDST. 2015. "High Speed 100Mbit/sec Broadband Schools Programme (Updated Jan 2015)." http://www.pdsttechnologyineducation.ie/en/Technology/Schools-Broadband/High-Speed-100Mbit-sec-Broadband-Schools-Programme/
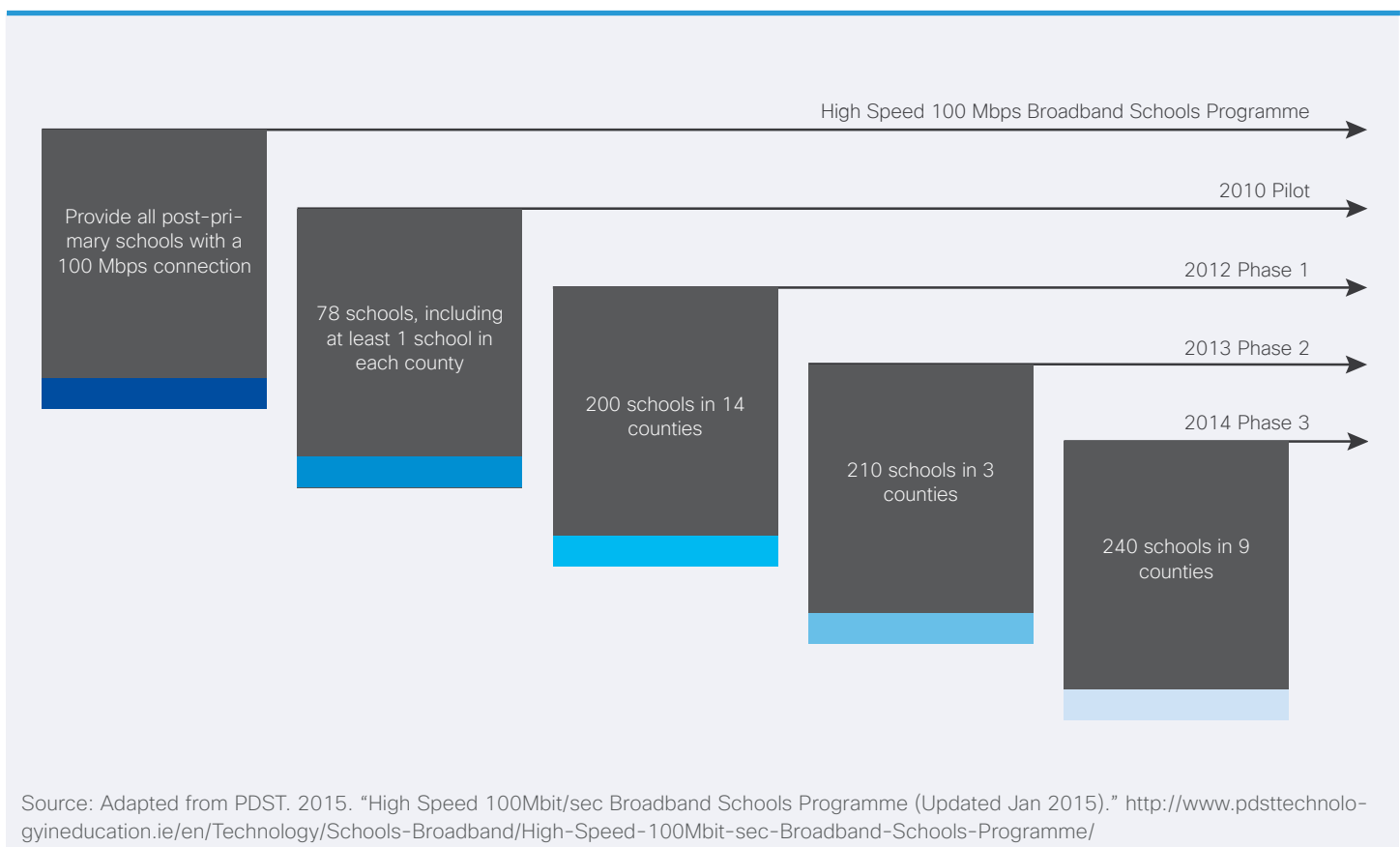
3 Department of Communications, Energy and Natural Resources. 2009. Next Generation Broadband: Gateway to a Knowledge Ireland. http://www.dcenr.gov.ie/NR/rdonlyres/F9B1D956-358D-4870-AA99-DD25A4417F59/0/NextGenerationBroadbandPaperGatewaytoaKnowledgeIreland.pdf.

4 http://www.pdsttechnologyineducation.ie/en/Technology/Schools-Broadband/High-Speed-100Mbit-sec-Broadband-Schools-Programme/

A team consisting of the Department of Education and Skills (DES), the Department of Communications, Energy and Natural Resources (DCENR), HEAnet and PDST Technology in Education manages both the *Schools Broadband Program* and the *100 Mbps Post Primary Schools Project.* The latter has been funded primarily by DCENR (capital costs of around €11 million and €11 million for current costs for the years 2012-2015), with additional backing from the European Regional Development Fund (ERDF) and DES (remaining current costs estimated to be some €16 million up to 2015 and responsible for ongoing annual costs into the future). Following the successful completion of the third and final phase of the project in 2014, HEAnet was appointed by the Government to oversee maintenance of the new network, supported by ESB Telecoms, which will continue to provide backhaul from regional locations to Dublin. As of September 2014, almost 750 post-primary schools were covered by the Schools 100 Mbit/s High-Speed Programme; those schools that have not yet reaped the benefits of 100 Mbps connections will do so gradually as they are transitioned off of the Broadband for Schools Programme.[1]

New Zealand: Ultra-Fast Broadband in Schools

New Zealand achieved a high level of school connectivity by the early 2000s. However, the government saw the need to upgrade connectivity to meet the learning requirements of the 21st century requirements. An ambitious program was launched to connect almost all schools to fiber optic cable between 2012 and 2015 covering 98% of schools and 99.9% of students. The few remaining remote schools are provided with fast wireless broadband connections of 10 Mbps. Schools can use their new ultra-fast broadband as anchor hubs to spread connectivity throughout the community. In fact, this is a feature of many successful school connectivity programs. A Wi-Fi network accessible from outside the school enables the community to access the Internet in the evenings or weekends when school is not in session. Here too, the LAN can be managed so as to ensure students have priority when they need it but neighbors get access too.

School is compulsory in New Zealand for all children aged six to 16. Primary school consists of grades 1-8 and secondary covers grades 9-13. A composite school provides both primary and secondary education. There are two types of public schools, both funded by the government: state and 'state-integrated'. State-integrated schools are associated with a religion or specific teaching technique (e.g., Montessori). As of July 2014, there were 2,438 public schools in New Zealand with 738,556 students (Table 4).

1 http://www.heanet.ie/schools/schools-100-mbits-project

Table 4: New Zealand Public Schools and Students, July 2014

	Schools	Students	Students per school
Primary	1,930	434,542	225
State: Not integrated	1,698	396,835	234
State: Integrated	232	37,707	163
Composite	126	36,386	289
State: Not integrated	98	25,026	255
State: Integrated	28	11,360	406
Secondary	345	264,624	767
State: Not integrated	274	225,672	824
State: Integrated	71	38,952	549
Special	37	3,004	81
Total	**2,438**	**738,556**	**303**

Source: Adapted from http://www.educationcounts.govt.nz/statistics

All New Zealand schools have been connected to the Internet for over a decade, moving from dial-up access to ADSL and wireless access in the mid-1990s (Figure 3, left). In 2012, speeds varied depending on the size of the school with an average broadband speed of 17 Mbps (Figure 3, right).

Figure 3: School Connectivity in New Zealand

Percentage of schools online

Primary — Secondary

85
94
99
100
100
55
83
96
98
100

1996 1998 1999 2001 2003

Bandwidth speed (Mbps), 2012

Speed — Average

97
15
8
19
20
32

Very small, Small, Medium, Large, Very large, Extra large
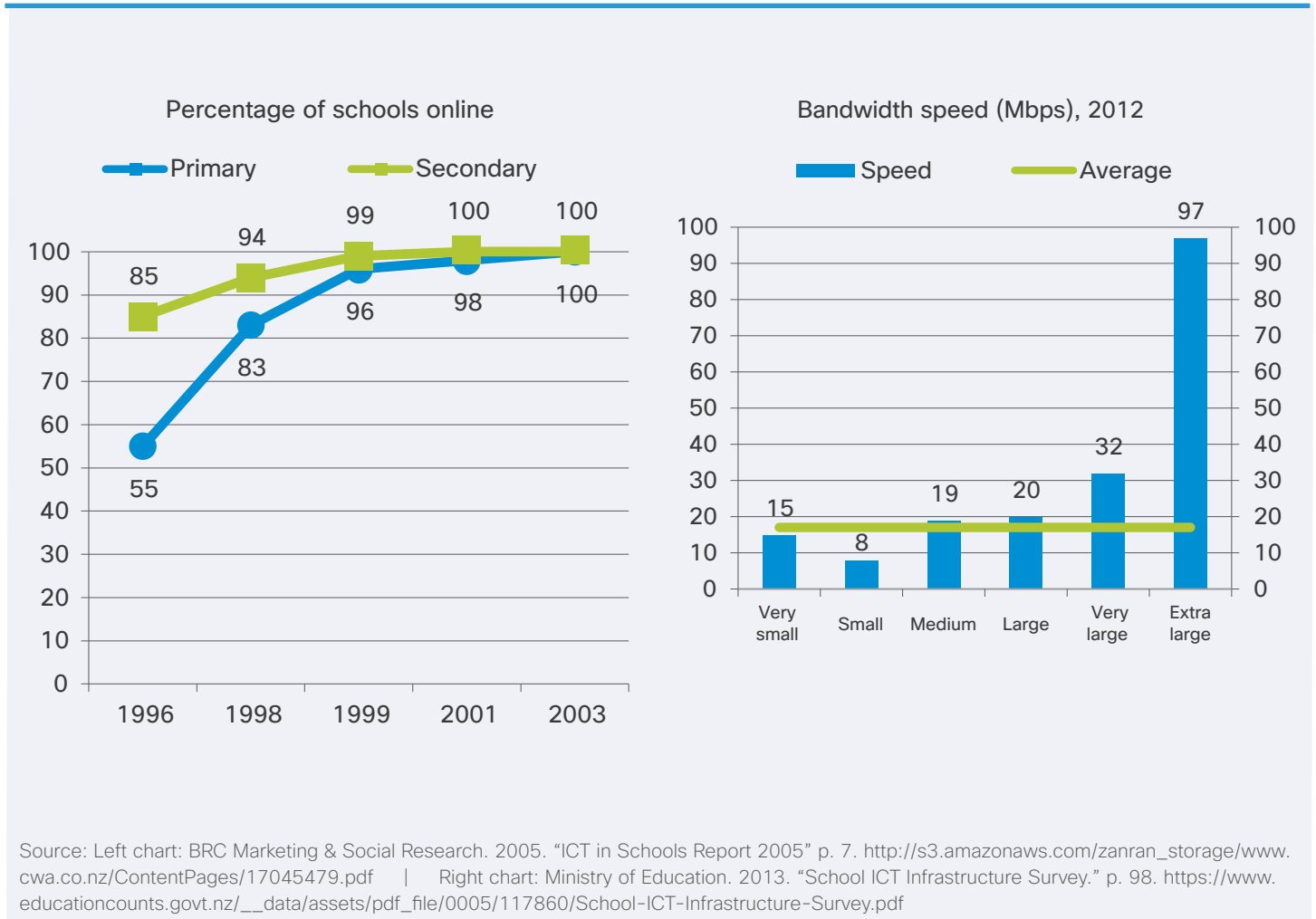
The Ultra-Fast Broadband (UFB) Initiative announced in 2011 is part of a government program to enhance New Zealand's broadband services in order to boost productivity and drive economic growth. The initiative calls for 75% of residents to be covered with high-speed broadband by 2019. UFB is being implemented through a NZ$1 billion government investment in a state-owned company, Crown Fiber Holdings, to deploy a fiber optic backbone and, more importantly, local access connections. Another program called the Rural Broadband Initiative (RBI) targets rural areas of the country.

Schools have been targeted as a top priority for UFB and RBI. Almost 98% of public schools (covering 99.9% of students) will receive a fiber optic line. The remaining 2.3% too remote for fiber access will receive wireless access (including three by satellite), with the connection from the school to the nearest fiber access point in the street covered by funding. NZ$28.2 million has been allocated by the government to fully fund the fiber optic connection from the street into the

school.[1] In the case of schools where fiber optic deployment would be uneconomical, funding is being provided by the government (Ministry of Economic Development) under the Remote Schools Broadband Initiative (RSBI) for point-to-point wireless connections.[2]

Figure 4: New Zealand Fiber Optic to School Roll-Out

Fiber access to schools

Provide 2,416 schools with fiber connection with at least 100 Mbit/s & 57 remote schools with wireless connection with at least 10 Mbps

1,252 schools with fiber connection

23 schools with high-speed wireless connection

2,028 schools with fiber connection

39 remote schools with high-speed wireless connection

2,241 schools with fiber connection

44 remote schools with high-speed wireless connection

All remaining schools connected

2012

2013

2014

2015

Source: Adapted from Ministry of Business, Innovation and Employment, Broadband Deployment Updates. http://www.med.govt.nz/sectors-in-dustries/technology-communication/fast-broadband/deployment-progress

Those with fiber will receive speeds of at least 100 Mbps while remote schools will have speeds up to 10 Mbps. Schools have normally been responsible for Internet access charges as well as supplementary services such as cloud computing, firewalls, remote backup, etc. The government created a state-owned company, Network for Learning (N4L), to operate a secure, managed network including access to the Internet and online learning content.

1 https://www.national.org.nz/news/news/media-releases/detail/2011/05/19/govt-delivers-$1b-for-broadband-commitment

2 https://www.national.org.nz/news/news/media-releases/detail/2014/04/15/rollout-of-faster-broadband-to-remote-east-cape-schools-complete

Most schools are opting for this solution, with some 80% having registered to use N4L.[1] Five speed options are offered depending on the size of the school. The Government has committed NZ$211 million through 2020-21 for N4L and will fund school connectivity to the company, citing the need for equitable access to not only higher quality Internet connections and uncapped data for schools, but also to enhanced learning opportunities for students that will equip them with relevant 21st century skills.[2]

Table 5: Speeds Available Through N4L

Roll size	N4L connection size	Total schools
1. N/A[1]	10 Mbps	<50
2. 1–250	50 Mbps	1,515
3. 250–750	100 Mbps	845
4. 750–3200	500 Mbps	180
5. 3200+	1 Gbps	0[2]

[1] Schools connecting via wireless or satellite will receive a 10Mbps connection
[2] Unless upgrade is offered to a school

Note: At the time of this report, 1 Gbps connections were not yet marketed.

Source: Network For Learning.

1 http://www.beehive.govt.nz/release/80-percent-schools-registered-managed-network

2 http://www.minedu.govt.nz/theMinistry/EducationInitiatives/UFBInSchools/QuestionsAndAnswers/NetworkForLearning.aspx

Internal networks are being updated through the Ministry of Education's School Network Upgrade Project (SNUP) so that schools can maximize the availability of faster broadband. The Ministry also partly subsidizes the equipment for internal connectivity.[1]

Schools in New Zealand have the opportunity to become "community hubs" by extending their fiber Internet access to surrounding areas. For example, arrangements can be made with a retail ISP to locate their equipment at the school and sell access within the local community. Schools could then charge rent to the ISP for colocation and access to its fiber, helping providing an extra source of revenue while simultaneously equipping students with the tools they need to learn in a 21st century learning environment.

Portugal: Education Technology Plan

The Portuguese government adopted the *Plano Tecnológico da Educação* (PTE, "Educational Technology Plan") in 2007 with the goal of placing the country's school digitization among the top five in Europe by 2010.[2] The eSchool initiative was one program of the PTE whose purpose was to provide laptop computers to elementary and secondary schools. Between 2008 and 2012, approximately 1.7 million laptops were distributed to students, adults in training programs, and educators. Every school in the country was provided with broadband access, up from 7% in 2005. A significant portion of the initial budget came from auctions for 3G frequencies with subsequent funding based on a shared model involving the government, beneficiaries and telecommunication operators.

The Portuguese primary and secondary educational system consists of nine years of primary ("básico") in three cycles and three years of secondary. Over 80% of all students attend public schools.

1 http://www.minedu.govt.nz/NZEducation/EducationPolicies/Schools/Initiatives/ICTInSchools/ICTInitiativesAndProgrammes/ICTInfrastructure/SNUP.aspx

2 See "Plano Tecnológico da Educação" at: http://www.drealg.min-edu.pt/content_01.asp?B-treeID=01/03/01

Table 6: Portuguese Public School System 2012–2013

Level	Schools	Students	Average number of students per school
Primary	6,289	959,942	153
Primary (Cycle 1)	4,207		
Primary (Cycle 2)	919		
Primary (Cycle 3)	1,163		
Secondary	575	315,014	548
Total	**6,864**	**1,274,956**	**186**

Note: Primary schools are counted for each cycle of school they teach.

Source: Adapted from DGEEC/MEC.

Portugal has gone through several phases of school connectivity (Figure 5). The first was connecting all schools to the Internet using ISDN technology[3], achieved in 2002. The second was carried out within the framework of the 2003 *National Initiative for Broadband* ("Iniciativa Nacional para a Banda Larga")[4] and called for providing all schools a basic broadband connection. This was accomplished in January 2006 when some 8,000 schools were provided with broadband (most using ADSL) over a period of just 18 months.[5]

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3 Integrated services digital network is a technology dating back to the early 1990s that implements data use over telephone networks.

4 http://purl.pt/268/1/

5 Ligação das escolas em banda larga concluída oficialmente (Actualizada). http://tek.sapo.pt/noticias/internet/ligacao_das_escolas_em_banda_larga_concluida_879515.html

Figure 5: Portugal: Schools Connected to the Internet, 1998-2008

Schools connected to the Internet (%)

■No connection   ■Narrowband connection   ■Broadband connection

Source: Adapted from UMIC - Agência para a Sociedade do Conhecimento.
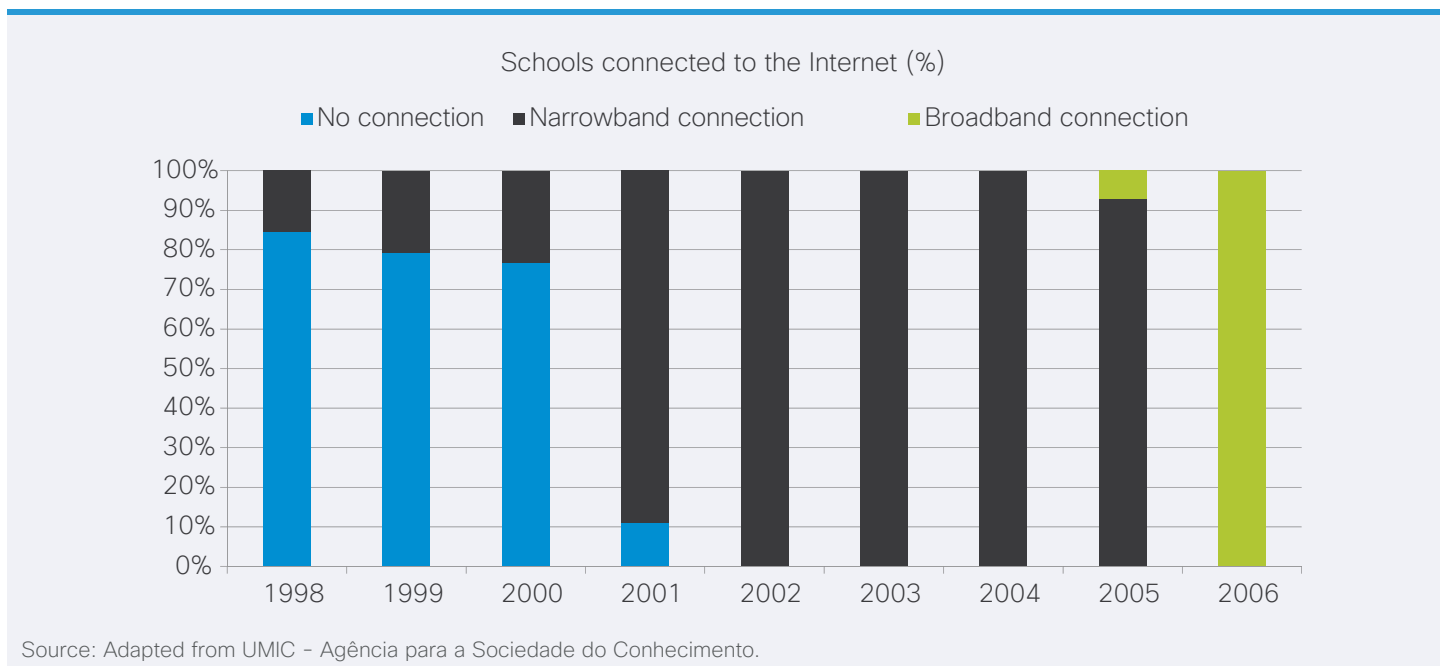
By 2007, the Portuguese government had adopted PTE. Its primary objectives were to raise the national computer-to-student ratio and to provide faster broadband to all schools (Table 7). This was complemented with projects to train teachers and develop e-learning content.

Table 7: Portugal Education Technology Plan Targets

Target	EU15 average (2006)	Portugal (2007)	Portugal (2010)
Connection to broadband Internet	6 Mbps	4 Mbps	≥ 48 Mbps
Number of students per PC with Internet connection	8.3	12.8	2
Percentage of teachers with ICT certification	25%	-	90%

Source: Education Technology Plan, 2007.

The PTE called for a drastic increase in the availability of devices for students and teachers. This was implemented through two initiatives to distribute laptops to users in second and third cycle primary and all secondary schools (eSchool) and the first cycle of primary schools (Magellan). Between 2008 and 2012, these initiatives provided laptop computers with 3G and Wi-Fi broadband access to 1.7 million elementary and secondary students, adults in training programs and educators. Recipients of the computers contributed to the cost of the laptop as well as 3G Internet access for use outside the schools. The number of students per Internet connected computer improved from 12.8 in 2007 to 2.1 by 2011 (Figure 6).

The PTE also resulted in an increase in broadband speeds from the average of 4 Mbps in 2007. In 2011, almost a third of students in grade 4 had access to broadband with speeds of over 30 Mbps compared to an average of 13% in the European Union. Almost 60% of Portuguese students in 11th grade general studies had access to broadband speeds over 30 Mbps compared to less than a quarter in the European Union.

Figure 6: Portugal: Students per Internet-Connected Computer and School Broadband Speeds, 2011

Note: In the left chart, schools refer to public primary ("ensino básico") and secondary ("secundário"). Years refer to school ending fiscal years.

Source: Adapted from Direção-Geral de Estatísticas da Educação e Ciência (left chart); European Schoolnet and University of Liège, 2012 (right chart).
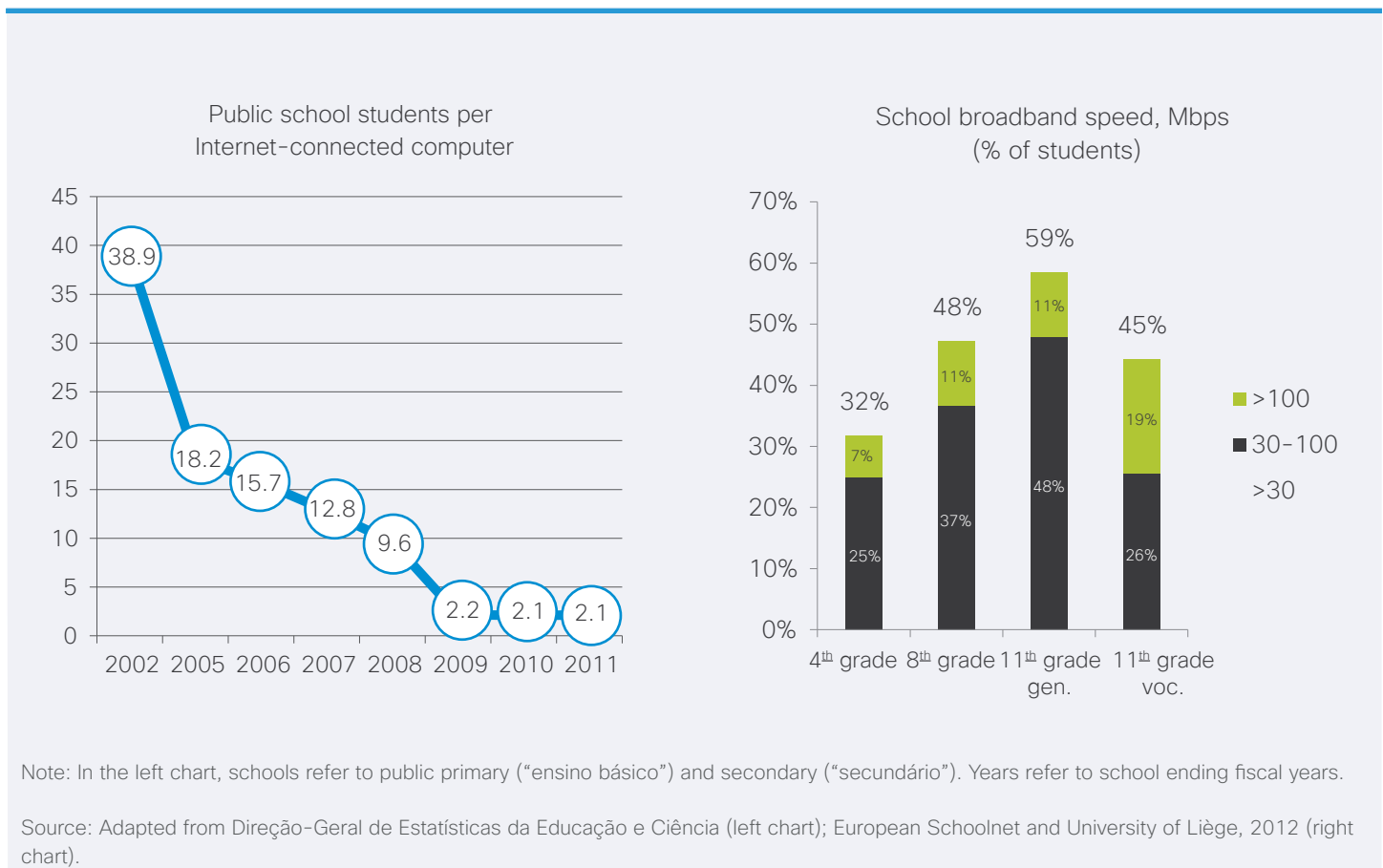
The Ministry of Education and Science (MEC) administers the PTE through a Management Board and Executive Coordination Team. All schools appointed one representative for coordinating the project. Other partners include municipalities (due to their local school responsibility), parents (who finance computer purchases) and the private sector (for providing telecom services and computers).

Funding for the PTE came from three sources. Most of the initial funding was from the fees operators paid for 3G spectrum in 2000. At the time, the operators agreed to make commitments for the information society. This was concretized in 2007 to fund "e-Initiatives" of the government outlined in the PTE to cover laptops, discounted broadband service, network investments and equipment. In addition to the operators, the government contributed from its budget with the remainder funded by parents and teachers for the laptops. Total investment was €1.1 billion between 2008 and 2010. The bulk of the funding was for computer purchases, training and development of digital content. Network costs are estimated to have accounted for less than a tenth of the figure and funded by the government through request for bids. This included a ceiling of €75 million for providing local area networks in schools and €14.5 million for three years of Internet service charges to schools.

United States: E-Rate

The 1996 Telecommunications Act called for establishing a mechanism to support connectivity in schools. The Federal Communications Commission (FCC) implemented this in 1997 through the Schools and Libraries Program (E-rate). The program is funded by universal service contributions made by telecommunication operators. Funding is made available to subsidize the cost of Internet access in public primary and secondary schools. The amount of the discount ranges from 20% to 90% depending on the income status and urban/rural location of the school. Since the introduction of the program, Internet access in US schools has gone from 65% to 100%. The FCC has modernized the program to promote access to high-speed broadband including support for wireless local access networks.

Education in the United States is compulsory with the age range defined by local school authorities. There are twelve years of schooling. Primary school generally consists of grades 1 through 8 and secondary school grades 9 through 12. There were approximately 100,000 public primary and secondary schools and close to 50 million students during the 2011-2012 school year (Table 8).

Table 8: United States Public School System, 2011-2012

	Schools	Students	Average number of students per school
Primary	66,689	31,724,573	476
Secondary	24,357	15,708,815	645
Combined elementary/secondary	6,311	1,818,020	288
Other*	971	4,712	5
Total	**98,328**	**49,256,120**	**501**

Note: * Includes special education, alternative, and other schools not reported by grade span.

Source: Adapted from U.S. Department of Education, National Center for Education Statistics.

The Telecommunications Act of 1996 made specific provisions for schools to receive support for connectivity. Relevant passages of the Act include:

"Elementary and secondary schools and classrooms... should have access to advanced telecommunications services … All telecommunications carriers serving a geographic area shall, upon a bona fide request for any of its services that are within the definition of universal service under subsection (c)(3), provide such services to elementary schools, secondary schools, and libraries for educational purposes at rates less than the amounts charged for similar services to other parties."

The national telecommunications regulator, the FCC, operationalized the requirements of the Telecommunications Act in the *Schools and Libraries Program* (E-rate). It is one of four programs drawing on the country's universal fund made up of contributions from telecommunications operators. The E-rate is used to subsidize telecommunications services for primary and secondary schools, specifically their network infrastructures and equipment. Individual schools can apply for funding, as can schools at the district or consortium level.

Subsidies may be requested under two categories of service: category one (telecommunications, telecommunications services and Internet access), and category two (Internet access within the schools such as internal connections, basic maintenance of internal connections, and managed internal broadband services). While these two service categories are equally important, it is the implementation of the latter that must be achieved for real impact to materialize.

The amount of the subsidy depends on the level of poverty (measured by the percentage of students eligible for the National School Lunch Program) and whether the school is located in an urban or rural area. The discounts range from 20% to 90% of the costs of eligible services.

The Universal Service Administrative Company (USAC), an independent, not-for-profit corporation designated by the FCC, administers the E-rate program. USAC is responsible for processing applications for subsidies, confirming eligibility, and reimbursing service providers and schools for the discounted services. The organization also ensures that all applicants and service providers comply with the E-rate rules and procedures established by the FCC.

Telecommunications operators pay a percentage of their long distance revenues to the Universal Service Fund, and the FCC calculates a contribution factor each quarter based on the projected requirements of the program. The somewhat complex formula incorporates various adjustments, including circularity and uncollectible contributions.

For the fourth quarter of 2014, the contribution amount was 2.2% of interstate and international telecommunications revenues.[1]

E-rate is one of four programs drawing upon universal service funds. In 2013, over a quarter of disbursed universal service funds or some US$2.2 billion went to schools and libraries for subsidizing telecommunications services. Between 1998 and 2013, US$27 billion has been disbursed for the E-rate program. The year before the E-rate program was established, 65% of schools in the United States had Internet access. Seven years later, all schools had Internet access.

1 FCC. 2014. "Proposed Fourth Quarter 2014 Universal Service Contribution Factor." Public Notice, September 11. http://www.fcc.gov/document/proposed-4th-quarter-usf-contribution-factor-161-percent.

Figure 7: Unites States: Schools with Internet Access and Broadband Speeds

Percentage of public schools with Internet access

School Internet Speed (% of schools), 2013
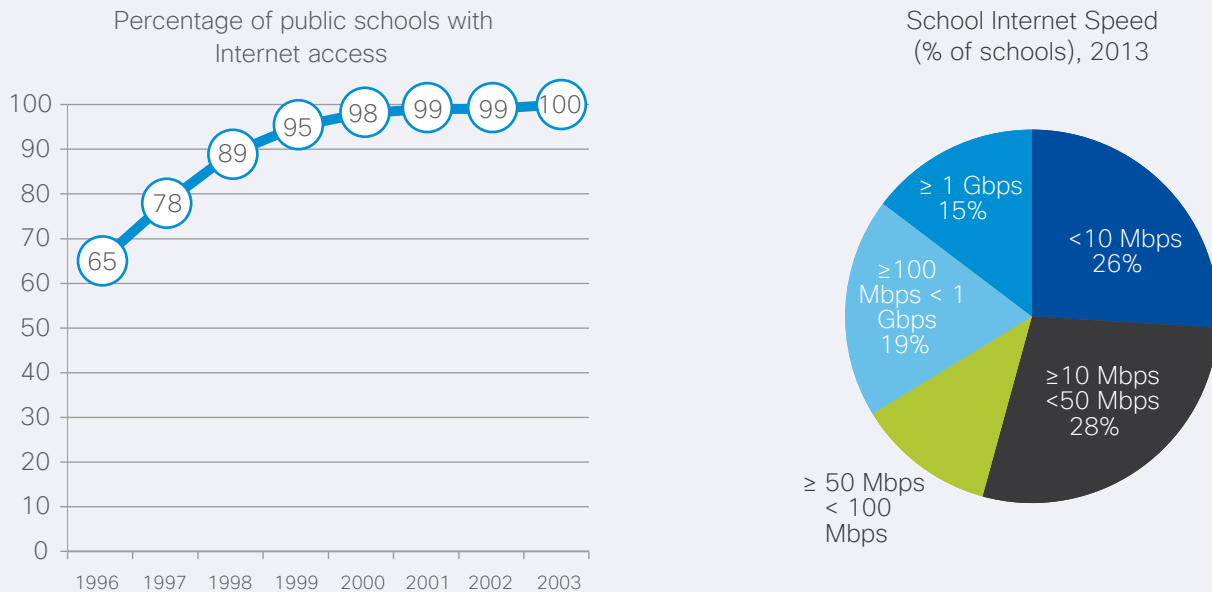
Source: Adapted from National Center for Education Statistics and US Dept. of Commerce, National Telecommunications and Information Administration (State Broadband Initiative, CSV format December 31, 2013).

In June 2013, President Barack Obama announced the ConnectED initiative aimed at upgrading connectivity in schools to meet the needs of the 21st century.[2] In support of this, the FCC modified the E-rate program in 2014.[3] It established bandwidth targets based on the number of users in a school with 100 Mbps per 1,000 users for the short run and 1 Gbps per 1,000 users in the longer term. Specific changes included phasing out subsidies for legacy service such as telephone service and increasing funding for high-speed Internet access and internal networks.

Education in the United States is decentralized and administered at the state and local levels. Aside from the federal E-rate program, many states supplement school Internet connectivity through other programs and initiatives. For example, California, home to the largest school system in the United States, connects 78% of all public schools to its statewide educational network. The state also provides broadband infrastructure grants for under-provisioned schools to upgrade their connectivity.

2 https://www.whitehouse.gov/issues/education/k-12/connected

3 http://www.fcc.gov/page/summary-e-rate-modernization-order

Uruguay: Educational Connectivity Program

Uruguay's Plan CEIBAL was launched by then President Tabaré Vázquez in 2006.[1] The impetus was as much to promote equal access to ICT as to modernize schools with technology.[2] The initial goal was to provide laptops to all primary school students starting with rural areas in order to democratize the process. At the time the program was launched, 43% of primary schools did not have a computer. Where they were available, there was a large discrepancy between poor and wealthy neighborhoods: one PC per 78 students in low-income schools compared to one per 37 in wealthier ones.[3] By the end of the first phase of the program, almost 400,000 laptops were distributed to all public primary school children and teachers, and the program extended to secondary and private schools. An Educational Connectivity Program resulted in the historical telecom operator ANTEL connecting over 90% of public schools to the Internet by 2013, up from less than half in 2006. A special initiative to provide electricity to rural elementary schools also supported Internet connectivity so that by the end of 2014, Uruguay became the first country in Latin America to connect all of its public schools to the Internet.[4]

Education is compulsory for children ages 6 to 14. Primary school is six years and secondary up to another six years. In 2013, there were 2,453 schools in the country and almost half a million students.

Table 9: Uruguay Public School System, 2013

	Schools	Students	Average Number of Students per School
Primary	2,158	268,001	124
Secondary	295	226,046	766
Total	**2,453**	**494,047**	**201**

Source: Adapted from Ministry of Education and Culture.

1 Conectividad Educativa de Informática Básica para el Aprendizaje en Línea (Basic Educational Connectivity for Online Learning). The acronym alludes to the country's national tree, the "ceibo."

2 Vázquez, Dr Tabaré. 2009. "Digital Democracy." Americas Quarterly. http://www.americasquarterly.org/node/370.

3 "Computer Use in Schools Strengthened and Extended beyond the Classroom." 2015. Inter-American Development Bank. http://www.iadb.org/en/mapamericas/uruguay/computer-use-in-schools-strengthened-and-extended-beyond-the-classroom,5839.html.

4 Presidencia del Uruguay. 2014. "A fines de 2014 todas las escuelas uruguayas dispondrán de energía eléctrica e Internet." Noticias, May 28. http://www.presidencia.gub.uy/comunicacion/comunicacionnoticias/luces-para-aprender-energia-electrica-conectividad-internet-todas-escuelas-uruguayas-2014.

The *Basic Educational Connectivity for Online Learning* plan ("Conectividad Educativa de Informática Básica para el Aprendizaje en Línea," CEIBAL), launched by then President Tabaré Vázquez in December 2006, aimed to provide each child with a laptop computer in order to promote equality of access to information technology.[1] By 2009, children and teachers in all primary schools had been provided with approximately 380,000 laptops. The computers connected wirelessly to each other and to the Internet. Each school had a server and the infrastructure necessary for network connectivity. An agreement was made between the state-owned telecommunication operator ANTEL and Laboratorio Tecnológico del Uruguay (LATU) to provide Internet connectivity and subsidize Internet access for the CEIBAL schools providing a discount of 75% on ADSL service for urban schools and 50% for wireless access for rural schools outside of ADSL coverage.[2]

The government funded the project through an increase in education funding. Between 2007 and 2013, 5,726 million Uruguayan pesos (US$238 million in 2006 constant prices) were allocated to the project, equivalent to 3.1% of the education budget over that time. The majority of the funding was allocated to the purchase of computers with connectivity accounting for US$11.6 million from 2007 to 2009, or 9% of total CEIBAL expenditures.[3]

While CEIBAL received significant attention, since 2001 the *Educational Connectivity Program* ("Programa de Conectividad Educativa," PCE) has led deployment of Internet access in schools. The program is based on agreements between the National Administration for Public Education ("Administración Nacional de Educación Pública," ANEP) and ANTEL. Under this program, ANTEL provides free Internet access to all schools under ANEP's domain. By the end of 2010, there were 1,838 institutions connected: 1,332 primary schools, 320 secondary schools, 141 in UTU (technical-professional education) and 45 in teacher training centers. This connects urban primary schools and all secondary schools, but only some of the 1,100 rural primary schools. ANTEL also provides other networking services to schools, including technical support and hosting servers with firewalls to filter appropriate content. The majority of the connections under the PCE program are ADSL followed by mobile wireless. A revision of the PCE agreement in 2011 calls for average speeds in schools to increase from 512 kbps to 10 Mbps.[4]

ANTEL's involvement with PCE and CEIBAL has resulted in the percentage of schools with Internet access rising from 1% in 2001 to 99% by 2011. It has been a challenge to connect the remaining few rural primary schools due to a lack of electricity. This constraint was addressed through "Lights for Learning"[5] a special initiative to install electricity in rural elementary schools. As a result, Uruguay became the first country in Latin America to provide all of its public schools with the Internet in 2014.[6]

1 http://archivo.presidencia.gub.uy/_Web/noticias/2006/12/2006121402.htm

2 http://www.latu.org.uy/index.php/inicio/1650-latu-y-antel-firman-acuerdo-que-subsidi-ara-conectividad-para-plan-ceibal

3 Rivoir et al 2012

4 Antel. 2011. "Antel y Anep: potenciar la conectividad educativa." Press Release, September 8. http://www.antel.com.uy/antel/institucional/sala-de-prensa/eventos/2011/antel-y-anep-po-tenciar-la-conectividad-educativa.

5 http://www.oei.org.uy/luces_aprender.php

6 Presidencia del Uruguay. 2014. "A fines de 2014 todas las escuelas uruguayas dispondrán de energía eléctrica e Internet." Noticias. May 28. http://www.presidencia.gub.uy/comunicacion/comunicacionnoticias/luces-para-aprender-energia-electrica-conectividad-internet-todas-es-cuelas-uruguayas-2014.

Figure 8: Schools Connected to the Internet and Type of Internet Connection, Uruguay

Percentage of schools with Internet

Type of Connection, 2010
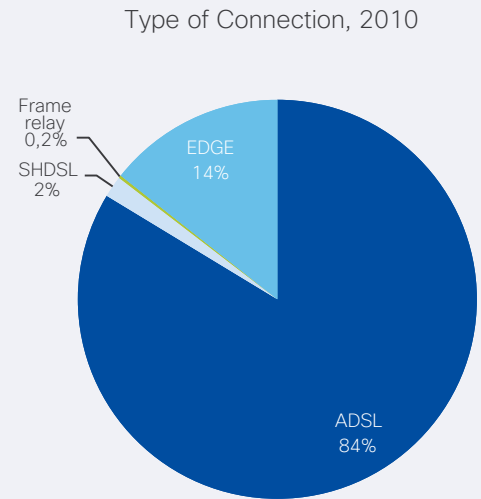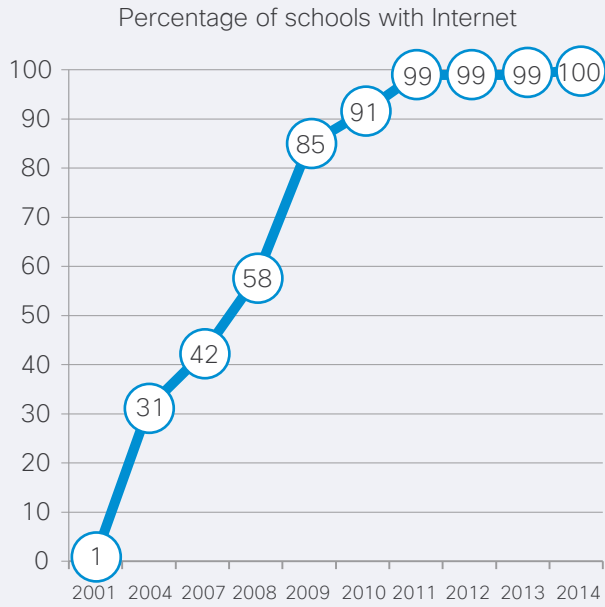
Source: Adapted from ANTEL and Rivoir and Lamschtein 2012.

Good Practices and Lessons Learned

Successful school connectivity programs consist of a sequence of components, all of which must function in harmony (Figure 9). Having a compelling reason or vision as to why connecting schools is necessary is the single most important factor. Top-level commitment is essential to ensuring the political will and funding is available to drive programs forward. An inclusive plan backed by measurable targets is essential for keeping the program focused and carried out on time. Additionally, stable and reliable sources of funding are crucial. The importance of a vision coupled with a plan and targets is emphasized by a review of WSIS school connectivity developments:

> "Typically, countries that have strong policies and set targets for ICT in education with high-level government and sector-wide support show the most rapid change" (ITU 2010).

The technology element of this relationship involves important connectivity building blocks such as bandwidth, local area networks and supporting hardware and services. Teacher training and content are also critical elements for a successful school connectivity program. Finally a monitoring and evaluation mechanism is indispensable to track progress as well as to determine if existing connectivity needs to be upgraded, resulting in a new program. Country experiences with each of these elements are described below.

Figure 9: Components of Successful National School Connectivity Programs

Source: Authors
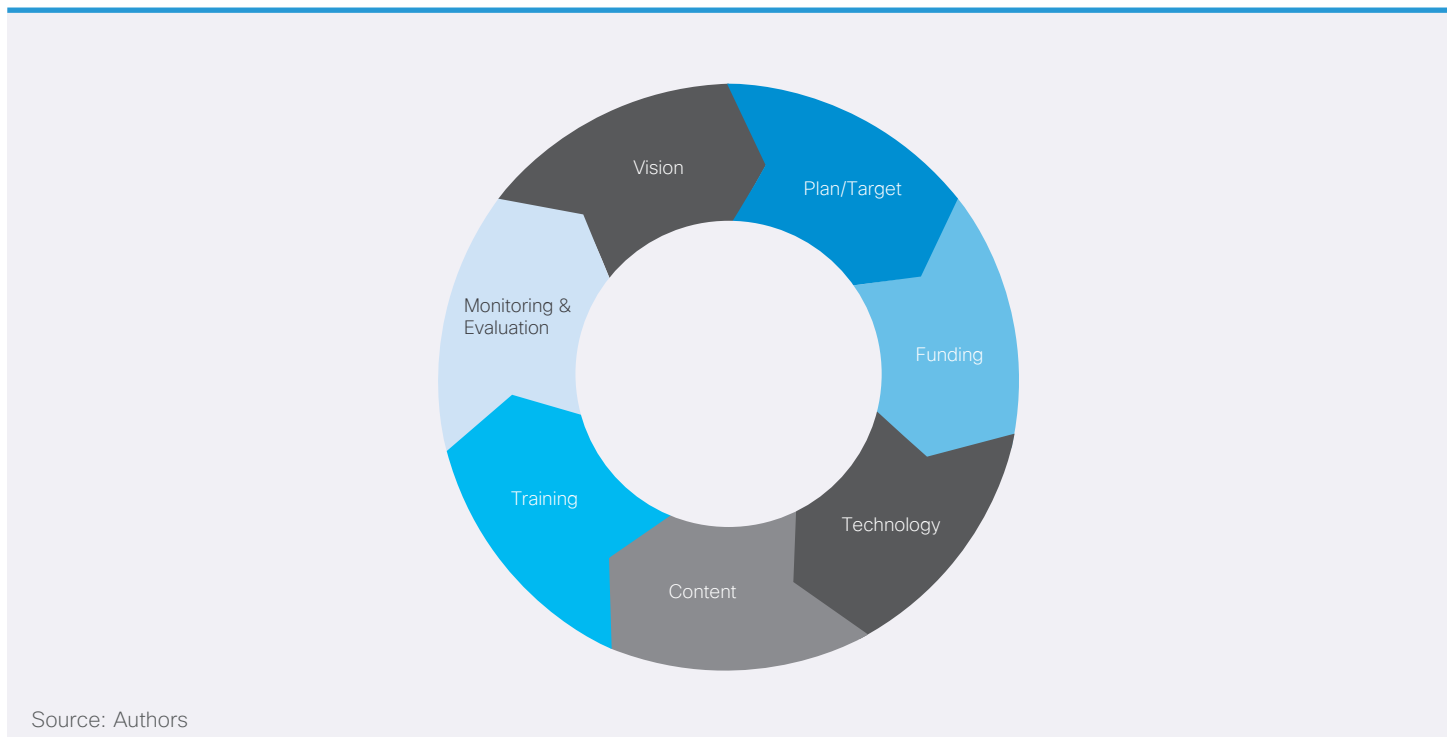
Vision

Each of the programs has been triggered by a high-level vision of what up-to-date school connectivity can offer. The education strategy of the governing National Party in New Zealand notes: "We can improve the education of all young New Zealanders by ensuring they are learning in modern classrooms with modern technology."[1] Such visions are also driven by a desire to democratize access to ICTs. Ireland and Uruguay deployed connectivity first to rural schools and the United States provides the largest subsidies to poor and rural schools. School connectivity is also critical for competitiveness. Portugal launched its school modernization program in part out of concern that it was falling behind other European countries. These top-level visions are typically backed up with appropriate funding and direction.

Table 10: Country Visions

Country	Vision
Ireland	"Connectivity to schools, in particular, will benefit from the Government's investment in broadband infrastructure... This will enable students to learn and collaborate online."
New Zealand	"Technology plays an increasingly important role in our children's education. Recognising this, the government has prioritised schools in its national fibre roll out through the Ultra-Fast Broadband an Rural Broadband initiatives."
Portugal	"The modernization deficit of techlogical education in Portugal justifies the adoption of an ambitious national strategy and action plan, enabling the country not only to catch up but also position it as the best in europe within a reasonably short time period: between five and seven years. The defined and shared vision by community agents the education community is clear: put portugal among the five most advanced European countries in terms of technological modernization of education."
United States	"Preparing America's students with the skills they need to get jobs and compete with other countries relies increasingly on interactive, personalized learning experiences driven by new technology."
Uruguay	"Universalize ....access to informatics and Internet..."

Source: Various; Authors; National Party "Policy 2014 Education: 21st Century Schools." https://www.national.org.nz/docs/default-source/PDF/2014/policy/education---21st-century-schools.pdf

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1 See National Party "Policy 2014 Education: 21st Century Schools" at: https://www.national.org.nz/docs/default-source/PDF/2014/policy/education---21st-century-schools.pdf

Plans and Targets

High-level national connectivity policies are typically behind school initiatives in all of the countries studied. Ireland's national broadband strategy called for high-speed coverage in schools. In Portugal, the government publically committed to the technological modernization of schools. The presidents of the United States and Uruguay have both articulated visions for ICT in education, and in New Zealand, the newly elected government has established the vision to dramatically increase high-speed broadband access throughout the country by deploying technologies such as WANs and by investing in infrastructure.

The key plans for connecting schools to the Internet are summarized in the table below. Every country had the clear objective of providing Internet connectivity to all primary and/or secondary schools with specific targets and timetables. Some countries have several plans. In some cases, the original plan was accomplished and a more ambitious project introduced to achieve a higher level of connectivity. In other cases, there are parallel plans, with some targeting different types of schools (e.g., urban or rural, primary or secondary). Other plans have even been updated to accommodate the need for faster connectivity in schools.

Inclusivity is another important consideration. All of the countries examined realize that remote schools face special connectivity challenges and have developed special policies and initiatives.

Table 11: School Connectivity Plans and Targets

Country	Connectivity Target	Inclusivity (i.e. Provision for rural/ remote schools)	Plan(s)
Ireland	All post-primary schools with 100 Mbps broadband by 2014 (achieved)	No exceptions (i.e., all schools with 100 Mbps)	100Mbps to Post-PrimarySchools Project
New Zealand	Fiber optic with speeds of at least 100 Mbps to 98% of schools covering 99.9% of students by 2016	Remote schools provided with broadband wireless connection of at least 10 Mbps	Ultra-Fast Broadband Rural Broadband Initiative
Portugal	At least 48 Mbps per school by 2010		Education Technology Plan (PTE)
United States	99% of American students will have access to next-generation broadband by 2018	Highest subsidy of 90%	E-rate Modernization Order
Uruguay	All primary students with a computer and network access by 2009 (achieved)	Provision of electricity	CEIBAL Educational Connectivity Program (PCE) Lights for Learning

Source: Various; Authors

Funding and Sustainability

There are various models for funding school connectivity. The most direct and transparent are ICT expenditures from the budget of the ministry responsible for education. However, education ministries sometimes lack the funding to absorb the full cost of ICT equipment purchases and service charges. In that case, the education budget could be increased or an allocation made from the central government. Another option is a universal service fund. Alternatively, in lieu of imposing a universal service levy, operators could agree to provide Internet access in schools as a universal service obligation.

The countries studied have adopted different mechanisms for funding Internet connections and access in schools. In most of the countries studied, the government has largely funded connection to the Internet and recurring service charges. The United States uses federal universal service funds to subsidize the price of Internet access in primary and secondary schools.

Sustainability of ongoing funding is difficult to predict. Unless the requirement for school connectivity is enshrined in law such as the United States, funding could be affected by a change in government direction or education ministry priorities. A next best strategy is assurance about medium-term funding such as Ireland and New Zealand where budget has been guaranteed through a certain number of years. This is similar to the case in Portugal, where contracts for school connectivity are awarded for two to three years. In Uruguay, multi-year agreements are made between the telecom operator and education authorities. Ideally, governments might consider establishing specific thresholds for school connectivity such as a percentage of the education budget or per school/per student amounts.

In reviewing funding for school connectivity, it is useful to understand different expenditure categories. These include capital outlays and recurring expenditures. The former category covers one-time charges for the physical connection to the Internet, installing local area networks and/or Wi-Fi. The latter covers recurring service charges and operational and maintenance charges.

One challenge in comparing school connectivity funding is that the periods covered and components of funding make it hard to assign to specific areas. For example, some of the program budgets include the entire amount of a program, involving computer provision, content development and training, plus the installation school wide connectivity, including Wi-Fi. Others incorporate additional aspects besides just connectivity, such as the inclusion of support services and access to educational portals with WANs. The information in the table below illustrates the extent to which countries devote funding to school connectivity.

Table 12: Funding

Country	Funding sources	Non-recurring Funding			Recurring Funding		
		Comment	Per school (PPP)	Per student (PPP)	Comment	Per school (PPP)	Per student (PPP)
Ireland	Government & European Union	Government funded capital costs of €11 million. The project also received funding from the European Union.	18,599	37	Government funded €27million in operating costs through 2015 and will fund ongoing operating costs.	7,609	15
New Zealand	Government	NZ$ 28 million for fiber optic connections and NZ$ 211 million for educational network. Also contributes to cost of local area networks (N4L).	7,721	25	Government covers cost of Internet access for schools using N4L.	7,273	24
Portugal	Government	€1,045 million for full program between 2008-2012	NA	NA	Multi-year contracts for providing Internet access funded by government	1,141	6
United States	Telecom operators	Not possible to distinguish. Most funding is recurring but money also available for LANs. Schools also finance non-recurring amounts.	NA	NA	Internet services subsidized ($471 million in 2013)	14,506	NA
Uruguay	Government & telecom operator	US$238 million (2006 constant prices) for Plan Ceibal; 3.1% of total education sector spending (2007-2013)	NA	NA	Incumbent telecom operator provides free Internet access as universal service obligation.	6,446	32

Note: PPP = Purchasing Power Parity (source PPP exchange rate: IMF). NA = Not available. Data for Portugal refer to a budgeted ceiling amount and actual contract award would likely be lower. Per school data for United States includes consortia consisting of a number of schools as well as libraries and it is likely actual per school ratio would be lower. Data for Uruguay include expenditures for public Internet access centers in addition to schools so actual per school/per student amounts would be lower.

Source: Various; Authors

Countries have different approaches for what central governments cover and what individual schools have to pay. In general, the government covers the full costs of network connections and service charges in Ireland and Portugal. In New Zealand, the government pays network connection costs as well as recurring Internet service charges if schools use the educational network. In the United States, the different categories are eligible for federal subsidies and some states have initiatives to fully cover the costs.

Table 13: Funding Policies for Different Connectivity Categories			
Category	Fully Subsidized*	Partly subsidized	Schools pay full amount
Internet service charge	Ireland, New Zealand †, Portugal	United States ‡, Uruguay #	New Zealand †
Local Area Networks	Ireland (post-primary), Portugal, Uruguay #	New Zealand, United States ‡	
Network connection	New Zealand, Ireland, Portugal, Uruguay	United States ‡	

Note: * All expenses paid by central government authority. † Free if school uses educational network; otherwise, they pay for commercial Internet service. ‡ Federal program; states may have initiatives to cover full costs. # CEIBAL schools are partly subsidized whereas other schools are fully subsidized.

Source: Various; Authors

Development assistance has been another source of funding for ICT in education in all of the countries studied, except for New Zealand and the United States. Though the amounts have generally been modest, the support has often been important for piloting, integrating e-learning, and evaluating, which collectively add to the success of the connectivity projects and enchance their impact.

Connectivity programs in all of the countries involve a number of partners, educational backbone networks, and the private sector. Close coordination amongst them has been crucial to success of the programs. While in some cases funding from Universal Service Fund programs has been able to shoulder the cost of the program, in many countries, disputes over USFs have caused disbursement delays. For example, GSMA notes that some 64 USFs have more than USD$11 billion still waiting to be disbursed.[1]

1 http://www.gsma.com/publicpolicy/wp-content/uploads/2013/04/GSMA-USF-Main-report-final1.pdf

Technology

School technology consists of several aspects including the connection quality (speed of the Internet connection), the extent of the school's LAN, the WAN connecting schools to other educational facilities in the district, supporting hardware and services, and plans for regular maintenance and upgrades. These five components can be mapped onto a national framework highlighting good practices and the complete possibility frontier (Figure 9).

Figure 10: Good Practice Technology Components

Source: Authors
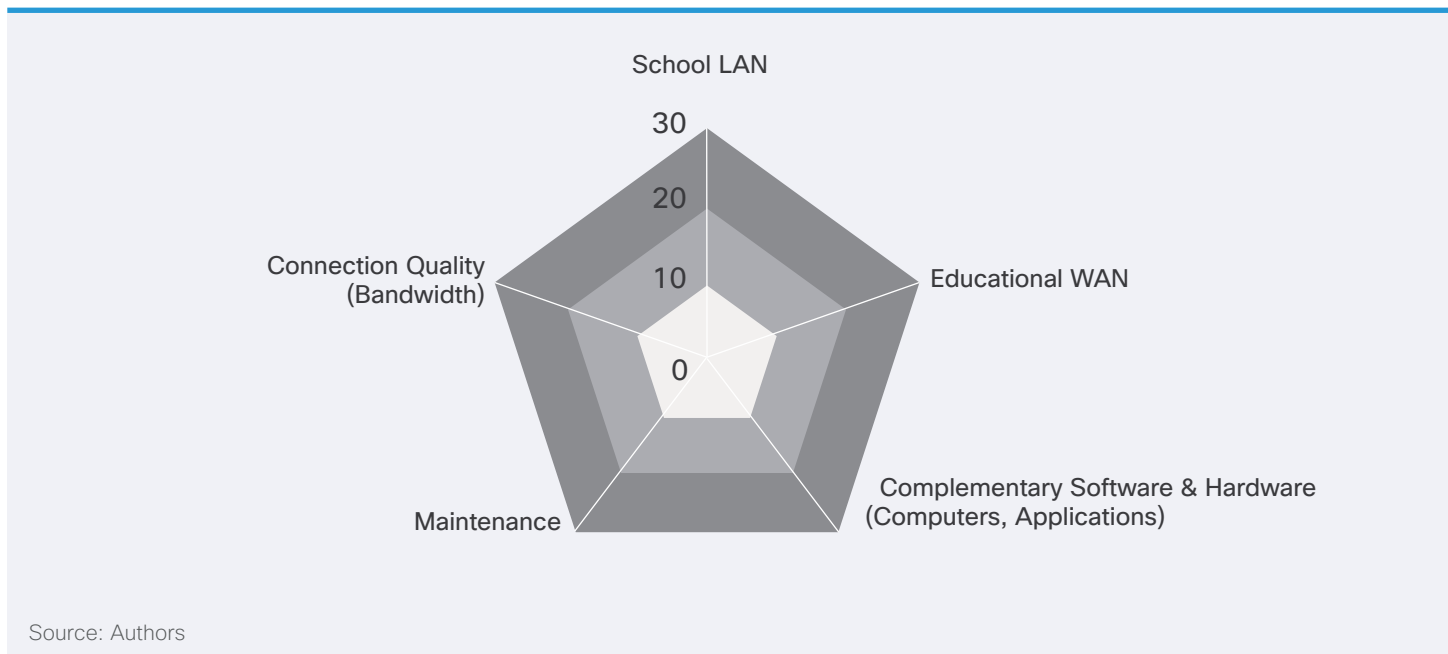
Connection Quality

All of the countries studied recognize the importance of providing faster bandwidth connectivity for their schools and are in the midst of a transformation to higher-level broadband (Table 11). This push is driven by the recognition that faster broadband is essential to support the proliferation of mobile devices in schools, the need to distribute Internet to all classrooms and to seamlessly access bandwidth-intensive e-learning applications. The countries have adopted different approaches to boosting broadband through either new initiatives or modification of existing programs. Ireland has established a uniform speed and has introduced 100 Mbps to all of its post-primary schools. New Zealand is deploying fiber optic cable that will cover 99.9% of all students with the size of the school dictating the actual bandwidth. Portugal has established a target speed of at least 48 Mbps for its schools. The United States has modified its E-rate program to support the longer-term target of 1 Gbps per 1,000 students. Uruguay has also modified its decade-old education connectivity plan to increase school connection speeds from 512 kbps to 10 Mbps.

Table 14: Broadband Speed Targets

Country	Target	Current status
Ireland	100 Mbps (post-primary schools)	Completed in 2014
New Zealand	98% of schools with fiber optic (minimum speed of 100 Mbps)	92% connected at December 2014 with all schools by 2015
Portugal	≥ 48 Mbps (by 2010)	In 2012, the number of students covered by broadband speeds greater than 30 Mbps was: Grade 4: 32%; Grade 8: 47%; Grade 11 (General): 58%; Grade 11 (Vocational): 44%
United States	100 Mbps per 1,000 users in the short run and 1 Gbps per 1,000 users in the longer term	34% with speeds over 100 Mbps (2013)
Uruguay	Increase average bandwidth from 512 kbps to 10 Mbps	Average speed of 512 kbps (2011)

Source: Adapted from HEAnet, New Zealand Ministry of Education, Presidência do Conselho de Ministros, European Schoolnet, FCC, U.S. Department of Commerce and ANTEL.

In support of higher connection quality, the countries have taken measures to upgrade other aspects of their schools' networks as well. New Zealand has partially subsidized local area networks in schools, Ireland has included local area networks as part of its broadband project, Portugal has funded upgrades to local area networks, and the United States has partly subsidized internal connections.

School Local Area Networks (LANs)

All of the countries recognize the importance of wired and wireless LANs for distributing bandwidth within schools. LANs, which incorporate Wi-Fi, are typically an integral part of their connectivity programs and are fully funded or subsidized. Most countries have guidelines on how LANs are to be installed in the schools.

Table 15: Local Area Networks

Country	Remark
Ireland	Includes LANs as part of the connectivity. Guidelines for installation of Wi-Fi[1] calls for scalable solution supporting a minimum of 3,000 simultaneous active devices.[2]
New Zealand	The School Network Upgrade Project (SNUP)[3] subsidizes school LANs. It is expected that LANs will be installed in all school buildings used for teaching, including libraries and computer suites. In 2011, 75% of all classrooms in primary and secondary schools were networked.
Portugal	More than 30,000 pieces of LAN equipment have been placed in schools financed through several programs.[4]
United States	USF program funds school local area networks.
Uruguay	As part of the CEIBAL program, all schools are provided with internal wireless networks with coverage in all classrooms.

Source: Adapted from HEAnet, New Zealand Ministry of Education, Presidência do Conselho de Ministros, European Schoolnet, FCC, U.S. Department of Commerce and ANTEL.

[1] http://www.pdsttechnologyineducation.ie/en/Technology/Computing-Devices-Tablets/Wireless-Guidelines-for-Schools-Feb-2015.pdf

[2] http://www.pdsttechnologyineducation.ie/en/Technology/Networking-Wireless-Networks/

[3] http://www.minedu.govt.nz/NZEducation/EducationPolicies/Schools/Initiatives/ICTInSchools/ICTInitiativesAndProgrammes/ICTInfrastructure/SNUP.aspx

[4] http://www.dgeec.mec.pt/np4/409.html

Wide Area Networks (WANs)

Some countries are leveraging wide area education networks (WANs) to provide wide area networking and Internet connectivity. Drawing on the expertise of such networks lowers costs, enhances maintenance and provides centralized services such as firewalls, data centers, email, remote access and education content, etc. In Ireland, the scope of the country's higher education network (traditionally connecting tertiary institutions) was expanded to include primary and secondary schools. The New Zealand government has established an educational network in parallel with the school fiber optic rollout. The Network 4 Learning network provides Internet access, monitors connectivity and hosts an educational content portal. In the United States, there is no national network for public primary and secondary schools; instead this is implemented at the state level. In Uruguay, the incumbent telecom operator provides Internet access to schools as a universal service obligation. Within that context, it has established a virtual private network for schools with security, network monitoring and hosting of educational content.

Table 16: Education Networks

Country	Education network	Comment
Ireland	HEAnet (www.heanet.ie). Backbone speed of 10 Gbps	Offers network management & monitoring including remote management of school networks as well as security & web hosting services.
New Zealand	Network for Learning (N4L) (www.n4l.co.nz)	Offers online content filtering, network monitoring, network security and remote access as well as the "Pond" portal featuring educational content (www.pond.co.nz).
Portugal	Education network exists but only for tertiary institutions. Instead, a contract was awarded for managing school connectivity.	Contractor links schools through a logical network and provides server hosting.
United States	Implemented at state level but school connection eligible for USF funding. Target of 10 Gbps per 1,000 students has been established.	In California, the K12HSN (www.k12hsn.org) network connects kindergarten through secondary schools and provides teaching content, videoconferencing and network monitoring.
Uruguay	Education network exists but only for tertiary institutions. However, as part of its connectivity obligation, ANTEL has created a virtual private network (VPN) for schools with backbone capacity of 100 Mbps.	The VPN offers technical support as well as a firewall, content filtering, and hosting the educational portal (uruguayeduca.edu.uy).

Source: Adapted from HEAnet, New Zealand Ministry of Education, Presidência do Conselho de Ministros, European Schoolnet, FCC, U.S. Department of Commerce and ANTEL.

The potential impact of cloud-based applications was discussed above, but WAN, often connected to both public and private clouds, can also be hugely beneficial to the management of a school's network infrastructure. Few schools have the resources to support a dedicated IT department, relying instead on an enterprising member of the faculty or staff who is willing to take on the added IT responsibility. A WAN connection can enable a school to buy IT maintenance as a service, with virtually all IT support being provided remotely through the WAN.

Complementary Hardware and Services

Aside from the education portals, server hosting and network monitoring typically provided by educational networks discussed in the previous section, hardware is also important for the success of school connectivity programs. Connectivity and computing devices are intertwined. On the one hand, a device is needed to make use of the connectivity and on the other hand, the more devices in use, the more bandwidth required. Programs in Portugal and Uruguay have been related to 1:1 computer initiatives leading to a rise in computer availability. In other countries, there are ongoing trends to increase the number of students per computer over time (Table 14).

Table 17: Students per Computer

Country	Year	Primary	Secondary
Ireland	2000	16.3	10.9
Ireland	2005	9.1	7.0
Ireland	2012	7 (grade 4)	5 (Grade 8)
New Zealand	2001	10	6
New Zealand	2005	5	4
New Zealand	2011	3	3
Portugal	2002	38.9	
Portugal	2005	18.2	
Portugal	2011	2.1	
United States	2000	7.8	5.2
	2005	4.1	3.2
	2008	3.2	2.9
Uruguay	2012	1	

Source: Adapted from national education agencies.

In countries such as Portugal or Uruguay, devices for students represented the largest component of the total program investment. Changes in both technology and in the adoption of devices offer intriguing opportunities to improve investment efficiency.

In addition to computers, devices such as printers, projectors, and interactive whiteboards benefit from and complement internal school connectivity. Simultaneously, smart phone penetration is growing very rapidly. Many students, even in developing countries, are coming to school with computers in their pockets that are more powerful than the laptops used in the early stages of our target country programs. Given that school LANs can easily be equipped to manage the access of personal devices to the school network, future school connectivity programs should build on the availability of personal devices to augment their student device strategies.

Content

The technology chosen by each school must be tailored per department and per classroom. In some cases, resources permitting, educational tools or systems may be personalized according to the needs of each individual student. A multitude of factors will determine whether a highly flexible 1:1 computer program is compatible with a school's environment. How teachers and students use technology will determine the type of equipment that will best assist the learning process.

Demographic differences should be considered as well. For example, primary schools are more likely than secondary schools to report time spent on small-group and individual instruction rather than lectures, as are schools with very high household incomes when compared

to their lower-socioeconomic counterparts.[1] Typically the range of electronic options available will also depend on the budget of the school, as will frequency of instructional material use.

Depending on the subject taught and grade level, technology needs might vary as well. While upper-level, research-intensive courses may require that every student have an Internet-connected device for in-class assignments, a primary school class may only require paper and pen with the occasional online materials provided via handout from the instructor. Smart boards provide educators with the option of presenting online materials to cohorts of students but may not be appropriate in some settings.

Furthermore, given the expansive variety of educational tools available to schools once they have access to broadband, the obtainable content for each classroom will be different. Language Arts classes may review a variety of tweets or blog posts one day to learn about professional writing; Moodle and Blackboard provide students and parents with platforms

1 The Technology Project RED 2010. The Greaves Group, The Hayes Connection, One-to-Once Institute

that allow them to access materials for class and teachers with a method of communicating information about grades, scheduling, school policies, and student progress; tablets are slowly replacing paper-based books in some schools; and video conferencing has enabled teachers and learners to collaborate regardless of time zone or geography.

All of these applications can be hosted locally in a school or remotely and accessed through a public or private cloud network, allowing schools or school systems the flexibility to design and deliver the content that meets their needs. Locating applications in the cloud makes it simple to scale up and down services to a school or a region as the demand changes. As long as the connectivity is sufficient, a cloud-based application allows a school to pay only for the services they really need, nothing more. The cloud also supports the delivery of individualized applications to any device a student or teacher may bring to school, without requiring each device to be customized.

Training

The positive impacts of broadband may only be maximized if access is integrated in a school environment that places significant import on high quality teaching. Teacher quality is one of – if not the – most impactful factors of student achievement in primary and secondary education. Expert teachers can identify essential representations of their subject, can guide learning through classroom interactions, can monitor learning and provide feedback, can attend to affective attributes, and can influence student outcomes, distinguishing them from their other experienced peers.[2] More than class size, peer group, school profile or any other equally valid variable, teachers account for the most variance in student success, second only to that provided by the effort of students themselves.

At the core of quality teaching is effective teacher training, which, in the era of nearly ubiquitous connectivity, must include the development of digital skills. Failure to train teachers has negative consequences – students whose teachers are ill-equipped to educate miss out on future learning opportunities, which compound in the long run to count against them academically and professionally. Conversely, for schools that measure the value-added impact of their educators, enhanced training may lower attrition rates as a positive unintended consequence of improved test scores.[3]

2 Hattie, J. (2003, October). "Teachers make a difference: What is the research evidence?" Paper presented at the Australian Council for Educational Research Annual Conference on Building Teacher Quality, Melbourne. http://www.decd.sa.gov.au/limestonecoast/files/pages/new%20page/PLC/teachers_make_a_difference.pdf

3 http://www.nber.org/papers/w12155.pdf

Technology training is especially important. Without understanding how to use an educational tool, teachers cannot provide their students with the type of learning experience that their more technologically savvy counterparts can. This is true for all learning instruments – digital or not. However, given broadband's function as a powerful catalyst for economic, social, and educational advancement, the potential missed opportunity associated with its absence in schools is even greater. Educators, then, must be trained carefully, on not only which technologies to use in the classroom, but how each one may be most useful. While some training may be universal and streamlined, it should be tailored at the department level (and possibly even more granularly) according to the context of the classroom. The digital tools that each school chooses to adopt, when integrated appropriately, could drastically impact the trajectory of that institution's success as well as that of its students as it actively prepares its faculty for the digitized classroom of the 21st century.

Monitoring and Evaluation (M&E)

Monitoring and evaluation of school connectivity are essential for tracking progress towards targets to make sure programs are on track. Evaluations assess results of initial pilots and overall school connectivity. It bears emphasis that connectivity requirements are not a static target, and monitoring and evaluation determine when programs are not keeping pace with requirements and need to be re-launched Ireland tracks ICT in schools through periodic schools censuses and the educational authority's inspectorate division carries out evaluations of school connectivity.[4] Ireland carried out a pilot of its program for rolling out 100 Mbps to post-primary schools in order to perform an evaluation

before extending the program to all schools.[5] This allowed it to learn from the initial experience in order to fine-tune the program for subsequent deployments. New Zealand produces regular monitoring reports on school connectivity progress.[6] Portugal publishes an annual survey on the status of school technological modernization.[7] In the United States, a broadband map displays school connectivity[8] and the USAC publishes annual report on E-rate activities.[9] Uruguay carries out regular monitoring on computer dissemination and availability as well as various evaluations of impacts.[10]

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4 https://www.education.ie/en/Publications/Inspection-Reports-Publications/Evaluation-Reports-Guidelines/ICT-in-Schools-Inspectorate-Evaluation-Studies.pdf

5 http://www.pdsttechnologyineducation.ie/en/Technology/Schools-Broadband/High-Speed-100Mbit-sec-Broadband-Schools-Programme/100Mbps%20Evaluation%20Report%20Sept%202012.pdf

6 http://www.med.govt.nz/sectors-industries/technology-communication/fast-broadband/deployment-progress

7 http://www.dgeec.mec.pt/np4/100/

8 http://www2.ed.gov/broadband/index.html

9 http://usac.org/about/tools/publications/annual-reports/default.aspx

10 http://www.ceibal.edu.uy/art%C3%ADculo/noticias/institucionales/Evaluacion-del-Plan

Conclusions

While achieving a basic Internet connection used to be seen as an achievement in and of itself, today's schools need fast broadband and wireless local area networks to accommodate cloud applications and the proliferation of Internet-enabled devices in schools. The following highlights emerge from the countries studied in pursuing high levels of Internet access in schools and upgrading connectivity to 21st century standards:

Feasibility. Once the commitment is taken to connect or upgrade school connectivity, deployment can progress relatively quickly. This is especially true when upgrading from narrowband to broadband. In Portugal, 7% of schools had broadband in 2005; it took just 18 months to connect the remaining 93% with high-speed Internet access. In New Zealand, all public schools were provided with fiber optic in four years and in Ireland, it took five years to provide all post-primary schools with a 100 Mbps connection. At the same time, rapidly falling costs and technological improvements provide an opportunity for developing country schools to leapfrog their schools into the 21st century. They can skip the narrowband connectivity phases that most developed nations went through.

Vision. Successful programs are driven by a high-level political understanding regarding the importance of school connectivity as the foundation for developing intelligent societies in order to leverage the economic potential of information and communication technologies. Examples of such high-level support include the education policy of the governing National Party in New Zealand: "We can improve the education of all young New Zealanders by ensuring they are learning in modern classrooms

with modern technology."[1] School connectivity programs also help reduce the digital divide between schools: Ireland and Uruguay deployed connectivity first to rural schools and the United States provides the largest subsidies to poor and rural schools. School connectivity is also critical for competitiveness. Portugal launched its school modernization program in part out of concern that it was falling behind other European countries. These top-level visions are typically backed up with appropriate funding and direction.

Targets. Concrete goals and targets are essential for a successful connectivity program in order to have a specific objective that can be monitored. All of the countries studied established explicit goals with clear deadlines. For example, New Zealand has a target of fiber optic connections of at least 100 Mbps by 2016 to the 97% of schools where this is economically feasible. Ireland set a target of 100 Mbps to all post-primary schools within five years. The United States has a medium term goal of 100 Mbps per 1,000 users and a longer-term goal of 1 Gbps per 1,000 students. Portugal

1 https://www.national.org.nz/docs/default-source/PDF/2014/policy/education---21st-century-schools.pdf

established a target of at least 48 Mbps by 2010 while Uruguay plans to boost average school bandwidth from 512 kbps to 10 Mbps.

Funding. A successful school connectivity program requires a sustainable mechanism to fund fixed and recurring costs over time. In several of the countries studied, the government has recognized the importance of ICT in education and committed budget for the capital costs of modernizing school technology. Another source of financing is a universal service fund (USF). In addition to the United States, Morocco and Turkey have also drawn on this resource to subsidize Internet access and enhance school connectivity.[2] Although a number of countries have USFs, many are not used effectively or have not begun to disburse money.[3] These funds can be significant for boosting school connectivity, particularly since they circumvent the at-times consuming task of designing an appropriate funding program. A related option that can reduce the administrative overhead of a universal service fund is to require operators to provide school connectivity as their universal service obligation. This approach is used in Uruguay where the incumbent telecommunication operator provides connectivity to schools. The case studies also demonstrate the benefits of a wide range of funding partners, particularly for capital costs. In Portugal, contributors besides the government include beneficiaries and telecom operators. New Zealand is leveraging the state-owned backbone provider. Ireland, Portugal and Uruguay have also collaborated with development agencies to support their school ICT programs.

Technology Requirements. Several technological aspects of school connectivity programs work in concert to ensure a robust system is available for students and educators. The experience of the programs reviewed here demonstrate that over time per-student bandwidth needs are regularly updated, and that within school networks (LANs) are essential to extend connectivity through out the campus and to every student and educator.

Educational Networks. Incorporating educational networks into school networks leverages the economies of scale and expertise, lowering the overall cost of connectivity. Educational networks also offer managed services such as firewalls, remote access, e-learning content, server hosting, etc. Several of the countries studied utilize such educational networks in their school connectivity plans:

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2 Intel. 2011. The Benefits of Applying Universal Service Funds to
   Support ICT/Broadband Programs.

3 http://www.gsma.com/publicpolicy/wp-content/uploads/2013/04/GSMA-USF-Main-report-
   final1.pdf

Ireland with HEAnet, New Zealand with N4L and in the United States, a number of states have their own school backbone networks. National Education and Research Network (NRENs) in a number of countries connect primary and secondary schools to their backbones.[4] This includes the Canadian Advanced Network and Research for Industry and Education (CANARIE), which connects over 2,000 primary and secondary schools.[5]

4 https://www.terena.org/activities/compendium/2014/pdf/TER-C14_WEB.pdf

5 http://www.canarie.ca/network/nren/institutions/

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Annex: Benchmarking School Connectedness

While access to the Internet is critical for schools, a wider definition of school connectivity encompasses broadband, Internet connected computers, websites, local area networks and virtual learning environments (European Commission 2013). This provides a holistic perspective on the use of Internet access and offers a more granular comparison for countries that want to monitor their school connectivity progress. Financial commitment is also important for achieving high levels of school connectivity. Benchmarks are provided below for countries with the requisite data.

Table 18: Benchmarking Secondary Schools, 2012

Country	Schools connected to Internet (%)	Schools with broadband (%)	Internet-connected computers (per student)	Schools with Local Area Network (%)
Ireland	100			
New Zealand	100			
Portugal	100	100	2.8 (2012/13)	
United States	100	98 (37% fiber, 2008)	3.1 (2008)	78 (Wi-Fi, 2008)
Uruguay	100	100 (35% fiber, 2014)		100

Note: * Server space for teachers to post their own web pages or class materials.

Source: Adapted from national education agencies.