Perspectives on ICT hot topics 2008

A brief analysis on the most debated issues of 2008 on ICTs in Education

Version 1.32– June 2009

Authors: Alex Twinomugisha (alex.twinomugisha@gesci.org) – 2008 version updated by Roxana Bassi (roxana.bassi@gesci.org)

Update and comments:

The latest version of this document can be found at http://www.gesci.org

Please send any comments and suggestions to the authors or GeSCI (info@gesci.org)

PERSPECTIVES ON HOT TOPICS

There are several issues considered crucial in the deployment of technology for education upon which no definite consensus exits or on which debates are inconclusive. These issues are referred here as "hot topics".

This paper brings these hot issues into perspective outlining what the issues are, the main arguments used (as pros and cons), best practices, and recommendations on what to do in a school environment and explores the effect on total cost of ownership (TCO).

The paper deliberately does not draw conclusions on any of the issues or take sides- this is simply an unbiased look at the hot topics presenting both sides of the argument.

We hope you find this report interesting. Your comments and suggestions are most welcome.

REFURBISHED PCS

Definitions:

Refurbished: used computers and peripherals that are donated or bought for use in educational institutions. The acquisition follows a process of testing the device, repairing and changing some parts, cleaning up the machine and reinstallation of new operating systems and software.

What is the issue?

Are refurbished PCs useful for schools given that they usually have reached their "end of life" in some former capacity?

The debate

Refurbished PCs are not so useful as they have reached their "end of life", can not run newer software and are more expensive than new PCs in the long run due to frequent breakdown and hence need for support and maintenance[1]. Developing regions also claim that Refurbished PCs are an environmental risk (transferred by the richer countries) and stifle growth of local computer manufacturing or assembly industries.

However, studies show that refurbished PCs are important and sometimes the only way to introduce ICT in schools and are also a relevant source of computers even in developing countries. Canada's Schoolnet used computer program provides about 25% of all school computers[2].

Are refurbished computers useful?

- The debate rages on and seems particular piqued in developing regions
- As Becta[3] states, it is only human to "*seek the newest, fastest and best equipment*" but we should give appropriate attention to alternatives to new equipment.

[1] See BBC article on software compatibility issues of using refurbs http://news.bbc.co.uk/1/hi/world/africa/2989567.stm (2003)

2 Islands in the Wastestream: Baseline Study of Noncommercial Computer Reuse in the United States http://www.compumentor.org/recycle/baseline-report/ (2004)

[3] British Educational Communications and Technology Agency (BECTA)- information sheet on recycled/ refurbished computers- http://www.becta.org.uk

- However, we live with and indeed thrive on many used goods such as cars and clothes- what's special about computers?
- The bottom line is a working PC in a school is important for teaching ICT skills, connecting to the Internet, etc all important for today's world. Debate would be more useful on usage in school and not equipment.

Who is involved in the debate?

The debate pitches donor types (pro refurbished PCs) against Non governmental / civil society types (anti refurbs). Interestingly, the schools seem to be silent in this debate.

Pros

- Cheaper than new PCs and can extend budgets to purchase more PCs for schools
- Can be effectively used for the most usual tasks of word processing and connecting to the Internet
- Are very cost effective to teach computer maintenance and repair courses
- Can run newer software and applications when used in a thin-client configuration with a server
- Reduce electronic garbage by using equipment for a longer period.
- Donating companies can usually deduct from taxes

Cons

- High failure rate of parts because most of the refurbished PCs are near "end of life" – leads to downtime and high cost of support and replacement
- Lack of spares for older model computers
- Can not run the latest software (mitigated by thin-client deployment)
- For developing countries can stifle the local PC assembly or manufacturing sector
- Environment concerns when it comes to disposal

Best practices / How to make a decision / criteria to consider in make a choice

The issues facing refurbished computers are more or less the same as those facing deployment of new computers

- As for new computers, schools must be committed to integrating ICT with careful planning, community buy in and training programs in place
- As with any project, realistic timelines for implementation and adequate skilled human resources required
- Need to plan for post supply and installation in terms of maintenance, support and parts replacement
- Proper packaging of refurbished PCs during transportation necessary to avoid high damage and failure rate on arrival at school
- Do a thorough hardware check. Wise to replace peripheral devices such as keyboards and mice with new devices
- Ensure that keyboard language is correct; for instance provide French key boards for computers destined to French speaking countries.
- Refurbished brand name PCs better able to withstand school use than new clones
- Consider legal issues of software licenses and privacy of data on the refurbished computer. For software licenses, can use open source software like Linux distributions. A program by Microsoft [4] also avails software licenses for refurbished computers.

The key to success lies with appropriate selection and refurbishment processes. The key is getting the right refurbished computer instead of just about any used computer as recommended by Tech Soup[5] and as argued by Schoolnet Africa[6] "*not every second hand computer is suitable for reuse*".

Total Cost of ownership

[4] Fresh start program https://www.techsoup.org/mar/Default.asp

[5] http://www.techsoup.org/learningcenter/hardware/archives/page9660.cfm

[6] Framework On Refurbished Computers For African Schools http://www.schoolnetafrica.net/fileadmin/resources/USED_IT_Meeting_(FINAL_REPO.pdf / http://www.schoolnetafrica.net/fileadmin/resources/Refurbished_computers_ResearchReport.pdf (currently offline) / http://www.schoolnetafrica.net/fileadmin/resources/TCO_Report_Open_Research_FOR_PUBLICATION_01.doc (2003) (links outdated)

There is very little data available on total cost of ownership. It is clear that refurbished computers are cheaper to acquire (or free) upfront than newer computers. Detractors claim high costs of maintenance and parts replacement due to high failure of refurbished computers as they are near their end of life.

According to research carried out by CompuMentor[7], "*In sum, the cost of ownership for refurbished computers was identical to that of new equipment*."

Cost Drivers

Cost of computers = purchase price + software + delivery + installation + maintenance + training

The variables in the equation when considering refurbished vs. new PCs are:

- Purchase price- lower for refurbished PCs (even for free)
- Maintenance- higher for refurbished PCs driven by more frequent breakdown and limited or no warranty
- Software- certain new software can not run on older PCs but can be solved through use of thin clients or by using older versions of the software

Questions to include in the questionnaire

- How many hours of maintenance for refurbished PCs vs. New PCs
- What is the warranty period on refurbs vs. new PCs?
- Are there any special tax cuts or additional fees on refurbs?
- What are the technical specs for the most common refurbs?
- Which refurbs are acceptable and which ones are not?
- What applications can not run on the most common refurbs?
- What is the source of most refurbs- direct donations, commercial refurb center, not for profit refurb center, other
- Does a commercial or not for profit refurb center exist locally? Should this cost be included in TCO maybe at national level?

[7] Islands in the Wastestream: Baseline Study of Noncommercial Computer Reuse in the United States http://www.compumentor.org/recycle/baseline-report/

What is the consensus?

According to Schoolnet Africa, no conclusive data exists and opines that "*Until it can be proven beyond doubt that the total cost of ownership of a new PC is less than that of a refurb, most schoolnets are committed to continuing to use refurbs in schools*" [8]

If you are interested in operating a refurbishment center check out this guide by Bridges "How to set up and operate a successful computer refurbishment centre in Africa: A planning and management guide"[9].

[8] Framework On Refurbished Computers For African Schools
[9] Bridges, http://www.bridges.org/publications/61

FREE AND OPEN SOURCE (FOSS) VS PROPRIETARY SOFTWARE

Definitions:

FOSS: Free and open source software, also F/OSS, FOSS, or FLOSS (for *Free/Libre/Open Source Software*) is software which is liberally licensed to grant the right of users to study, change, and improve its design through the availability of its source code. (Wikipedia)

Proprietary: Software where the publisher grants a license to use one or more copies of software, but ownership of those copies remains with the software publisher, making it impossible to modify the code.

License: legal instrument governing the usage or redistribution of copyright protected software. (Wikipedia)

What is the issue?

The issue is whether Free and Open Source Software or FOSS is cheaper than proprietary software and comes with more or unique benefits for education and social development.

The debate so far

- The pro FOSS camp claims that FOSS is much cheaper than proprietary software, does not lock schools into vendors and schools can customize the software for their own individual needs. Other debates revolve around the fact that somehow open source is good for general development (in this knowledge age, freedom and sharing of knowledge are key to development), hinders monopolistic tendencies and increases competition.
- However, all the claims above have counter arguments and in some cases are unproved. The debate seems to be more philosophical[10] and lacking in tangible substance. The Northwestern Educational Technology Consortium [11] has put together and analyzed all the popular arguments for and against Open Source and Proprietary software for school.
- The face of proprietary software seems to be Microsoft.

Who is involved in the debate?

[10] i4d "Free / Libre and Open Source Software (floss)" (2004) http://www.i4donline.net/oct04/global.asp

[11] Northwestern Educational Technology Consortium (2005) http://www.netc.org/openoptions/pros_cons/comparing.html

The debate pitches civil society and non governmental organizations against private companies that make proprietary software. There does not seem to be any unbiased independent research. Schools seem generally silent on this issue

Proponents of open source/ opponents of proprietary software

- Initial investment on licenses lower and hence entry barriers for ICT in schools lowered
- Can be more customized
- Is more secure, reliable and scalable because the source code is freely available for alteration
- Teachers and students can take and use the software at home without additional costs
- Schools are not locked into vendors which means greater independence from vendors and freedom to choose
- Is empowering allow communities to alter the software for their own needs
- Encourages innovation because of open and available source code

Opponents of open source software/ proponents of proprietary software

- Less compatibility with other software
- Less user friendly
- Total cost of ownership is lower with proprietary software
- Threatens intellectual property rights and creativity
- There are few open source applications for education
- There are few training materials for open source and few and expensive support personnel
- Software is not secure as it is easy to break in knowing the source code

Total cost of ownership

Few studies exist and are almost all inconclusive. The studies are usually commissioned by biased organization or bodies making them unreliable. Few true independent studies exist. Further, most TCO studies are at the enterprise level.

- According to a study for the State Capital of Munich [12] which considered migration to Windows XP/office XP, Windows XP/Open office and Linux/Open office, the most cost effective alternative in monetary terms is Windows XP/Office XP. However, the same study found the Linux/Open Office migration to have a higher "qualitative strategic" advantage. Technically and economically, the XP/XP migration was the least costly but can be attributed mainly to the existing predominant Microsoft products and lower costs of training as a result.
- At the center of the debate on TCO is the issue of "*losing past investments in training and software*" as Microsoft is usually predominant in existing situations as articulated by Rusten and Moses [13]. They argue that if one starts out with completely new educational systems, it may become cheaper both initially and long term to run OSS.
- No doubt that FOSS cheaper initially but mixed results on long term TCO being lower than proprietary software because of perceived higher running costs due to support and maintenance.

Cost Drivers

Cost of software = purchase cost + installation + customization + training + upgrade + Support + ongoing licensing

The variables likely to change for proprietary vs. FOSS are:

[12] A very good analysis of the issues and the final decision of the State Capital of Munich can be found at http://waste.informatik.hu-berlin.de/Grassmuck/Texts/Limux.html.

[13] "Open source- no free lunch" TechKnowLogia, January - March 2002 http://www.techknowlogia.org/TKL_active_pages2/CurrentArticles/main.asp?IssueNumber=15&FileType=PDF&ArticleID=373

- Purchase price- almost nil for FOSS. But MS licenses for schools have dropped to levels for about $2- $5 per PC per year for operating system and productivity tools (Office)
- Training- since proprietary has much bigger installed base, cost of training for upgrade much lower than for introduction of FOSS
- Upgrade license cost / license renewal - almost nil for FOSS but may be significant for MS
- Support- higher for FOSS because fewer skilled people but can change depending on country

Also other cost variables according to this interesting report[14] are:

- Linux server is cheaper than MS server because MS server requires purchase
- of different licenses for email (exchange), Database (MS SQL), Proxy/Firewall (ISA Server) whereas these are free/ at no additional cost for Linux
- MS charges for client licenses (called CALs) for access to server, email and database where as Linux doesn't
- When using Linux as terminal server (thin client), there is no client license costs where there is a client license cost if using MS Terminal server
- Other server applications e.g. LMS, CMS may be free or low cost compared to MS versions

Questions to include in Questionnaire

- What is the cost of an introductory training course to windows vs. to Linux?
- What is the cost of support per hour FOSS vs. Microsoft?
- Which applications are available for FOSS only, Windows only? What is the comparative availability?
- Is there a trend favoring either FOSS or Proprietary software?

Best practices/ Criteria to consider in making choices

[14] http://www.2x.com/calculator/win2linuxsavings.htm

- FOSS can be used with older refurbished computers making them more productive
- Several FOSS alternative software exists for education. A UNDP report[15] captures the issues as well as educational FOSS alternative.
- When migrating from proprietary to FOSS, consider starting with well established platforms such as the server platforms
- To reduce retraining and migration costs, consider a phased approach where operating system is retained and productivity (office) software transitioned to FOSS.
- Plan carefully and make the decision based on achieving the educational objectives rather than focus on the technology. Consider the pros and con of each type of software and your own local considerations for example availability of skilled support personnel.
- TCO components- Initial cost + installation + customization (including cost of macros and forms) + support and maintenance + upgrades

What is the consensus?

The debate is still raging. Unbiased research into the TCO of FOSS vs. Proprietary software is required. The conclusion nowadays seems to be that it is not about FOSS or Proprietary, but both, according to the educational needs. A few countries have decided through a law that open source software has to be used in educational institutions and in government offices in general.

Interesting resources

"Comparison study of free/open source and proprietary software in an African context" (2005) http://www.bridges.org/publications/21

[15] http://www.iosn.net/education/foss-education-primer (2007)

THIN CLIENTS VS. FAT CLIENTS

Definitions:

Thin client: a network computer without a storage device, which, in client/server applications, is designed to be especially small so that the bulk of the data processing occurs on the server.

Fat client: does as much processing as possible and passes only data for communications and storage to the server. A normal PC is a fat client.

The issue

Thin clients are more cost-effective for schools.

Pros

- Centralized management, support and control lowers support costs
- Higher security at the desk as desktop can be "locked down" – data can not be deleted, stolen or lost when the terminal is damaged or stolen or unwanted programs downloaded to desktop
- Easier and cheaper software upgrades, as this happens only on the server
- Better and easier software license management as this is centralized on server only
- Easy and after installation of clients requiring simple plug into network and switch on
- According to Wyse (which has a whole lot of whitepapers[16] in support of thin clients), teachers adapt better to thin clients because of their simple "plug –in and switch on" operation
- Eliminates multiple software versions, compatibility issues hence reducing costs
- No software and hardware debugging for new software deployments
- Consistent look and feel of desktop makes it easier for students and teachers to use from one terminal to another

[16] Wyse http://www.wyse.com/resources/whitepapers/

- According to Becta[17], energy saving because of lower energy requirements of terminals
- Teachers can better control student access to information
- Old computers can be salvaged and put to use with newer applications

Cons

- Single point of failure- if the server fails, all terminals fail. Can be mitigated by having redundant server
- Requires high bandwidth and redundant local area network (LAN) which is costly
- Does not handle multimedia applications well
- Can not run stand alone educational applications which don't run off a server
- Provide limited use of peripheral devices e.g. CD-ROMs, sound cards, ports to connect additional equipment such as digital cameras
- user acceptance ("I want big a BIG PC just like everyone else has!")

Vendors

The most common vendors for thin client solutions are: Sun Micro Systems, NCD, Wyse, Neoware (HP), Compaq, Dell, Linware

Types of thin clients

There are two main types of thin clients:

- Network Computers or dumb terminals- these are considered the true thin clients. A small piece of software is downloaded from the server for control purposes only and all the other software and applications are run on the server
- Windows based terminals- software is downloaded from the server and then run off the clients as it were a fat client. The client runs only the very processor and memory intensive applications from the server.

TCO Issues

[17] BECTA- http://partners.becta.org.uk/index.php?section=rh&rid=13802

- Most studies claim thin clients have lower TCO because of lower terminal price and lower support and management costs, as support and management is centralized
- However, opponents like Intel claim cost advantage has been eclipsed by recent lower standard PC costs and better PC central management and control systems such as those that come with windows server products and Linux operating systems making the TCO for thin clients and "managed or smart PC" about the same.
- Becta argues that thin clients are not cost effective for small deployments because of high cost of server when also considering the added benefits of fat clients (stand alone operation, multimedia capabilities).
- Intel[18] argues that thin clients scalability is expensive citing an example of 400 thin clients requiring 14 servers (30 clients per server) while 400 managed PCs would require 2 servers. The 14 servers (excluding redundant servers) would require more technical staff while a very robust, high bandwidth and redundant network would be required for the thin client solution making it very expensive.

Cost drivers

Direct cost of access device = purchase price + software + delivery + installation + maintenance / support + training

Variables likely to change for thin clients vs. fat clients

- Purchase price- may be lower for thin clients although some documentation[19] suggests that costs may be higher due to expensive server
- Installation costs- higher for thin clients because requires high speed, robust and redundant network BUT also considered lower for thin-clients because there is no need to install software on clients hence reducing setup time and hence costs

[18] Intel- http://www.intel.com/modelschool/whitepapers/Smart_VS_Thin_Client.pdf (currently offline)
[19] Intel- http://www.intel.com/modelschool/whitepapers/Smart_VS_Thin_Client.pdf (currently offline)
, UNESCO Technologies for Education, pg 85 (2002)
http://unesdoc.unesco.org/images/0011/001191/119129e.pdf

- Maintenance and Support- supposedly the biggest variable and much lower for thin clients. One TCO report[20] quoting other industry sources suggests savings of $800 - $1700 per PC. Savings supposedly driven by:
    - Easier day-to-day maintenance of installation of patches, software upgrades since all done on server once
    - Less labor required when migrating to new replacement system because no software installed on client
    - Less IT staff needed hence less salaries and training for administration since it is centralized at the server. The report quotes an industry report that says that help desk staff can be reduced by anywhere between 50% - 75%
    - Mean time between failures for thin clients is longer, thereby saving on maintenance and repair costs
    - Intel though argues [21] all most of the benefits around support and maintenance are neutralized by modern fat client centralized management systems
- Thin clients use up less power, generate les heat and therefore are cheaper to run in the longer term. Wyse[22] claims consumptions reductions of up to 85% in some models
- Thin clients don't need to be replaced as often as fat clients since they can survive software advancements. Server probably needs to be replaced sooner to cater for software upgrades but this would be same case with server in fat client networks.
- Software- few applications designed for client-server type applications[23]
- Incredulous[24] (?)- Fat clients lead to employee productivity drop as they can play around with settings etc (doodling)!

[20] "Calculating the savings of thin client computing" http://www.2x.com/calculator/fat2thinsavings.htm

[21] Intel- http://www.intel.com/modelschool/whitepapers/Smart_VS_Thin_Client.pdf (currently offline)

[22] Wyse (2001) http://www.wyse.com/resources/whitepapers/energy.asp

[23] UNESCO- Technologies for Education, pg 85 http://unesdoc.unesco.org/images/0011/001191/119129e.pdf

Questions to ask

- How many clients per server?- Estimates[25] so far come in at about 15 clients for 1 processor, 1-2 GB RAM or 30 clients for 2 processor, 4 GB RAM.
- Separate cost of thin client server from regular server- Assumption: same spec server will cater for twice as many fat clients as thin clients
- How many hours of support for thin clients vs. managed fat clients vs. fat clients simply networked?
- How much electricity consumed per thin client vs. fat client?
- Which applications can/ can not run on thin clients?
- What is the optimum number of clients which makes it economical to run a thin client solution?

Adoption Strategy/ Criteria to consider when making choices

- Becta[26] argues that thin clients should be deployed after careful analysis of the required needs and uses of the technology, TCO and particular circumstances of the school. In some cases, a mix of thin client and fat clients may be required.
- Intel[27] quoting a study by Gartner rules out the use of thin computers for content creation and situations which require high use of multimedia and effectively rules out their use in schools.
- Intel instead advocates for a "smart client" approach. Smart clients are defined as "*standard desktops or laptops remotely managed through a network*". This means that applications can be run "on and off the network" while at the same time having the advantage of a centrally managed and controlled client. Intel touts these smart clients as "*the right choice for education*".

[24] "Calculating the savings of thin client computing" http://www.2x.com/calculator/fat2thinsavings.htm quoting http://www.desktoplinux.com/files/article004/

[25] India TCO data quoting thin-client manufacturer, http://www.2x.com/calculator/fat2thinsavings.htm

[26] BECTA- http://partners.becta.org.uk/index.php?section=rh&rid=13802

[27] Intel- http://www.intel.com/modelschool/whitepapers/Smart_VS_Thin_Client.pdf (currently offline)

Application Service Providers- the future?

Application service providers or ASPs take charge of your applications hosting them for you. Access to the applications is through a standard web browser only making ASPs claim to be the ultimate thin client. Of particular interest to schools is the ability to share a hosted application among various schools thereby sharing costs while benefiting from some of the other thin client advantages like low maintenance and support. The Consortium for School Networking[28] however cautions that schools should be careful when contracting ASPs to ensure that they consider future protection in case of problems such as an ASP going out of business or data security and privacy issues.

What is the consensus?

These last years PC prices have lowered even more, and the launch of personal portable devices (1:1) for good prices has made the offer of available choices even more complex. There are more and more devices available for all price ranges, and a variety of new software, both proprietary and FOSS.

Schools have to be very careful and analyze the full TCO of each option before deciding.

[28] Consortium for School Networking http://www.cosn.org/

CONNECTIVITY

Definitions:

Wireless: local area network connectivity and Internet connectivity using radio signals, instead of cables, to connect computers.

Broadband: not really a connectivity technology but rather a groups of technologies (ADSL, cable) that can transfer information faster than previous ones (telephone modem)

The issues

What is the most cost effective and efficient connectivity option for educative institutions? Which is better- wired or wireless connectivity, narrow or broadband connections?

Networks to consider

There are three types of networks for schools to consider when thinking about connectivity options as the different networks require vastly different technologies and approaches. Please note here that we are concerned with "online" connectivity options. "Offline" connectivity solutions such as removable disks, CD-ROMs, USB disks also exist. Online solutions here can be defined as those solutions that allow real time or instant interaction, feedback and access to dynamic content.

Computer labs- usually a single room housing a number of computers connected to each other. Connection achieved by:

- Wired connection (typically Ethernet Cat 5 cable)
- Wireless connection (typically Wireless Fidelity or WIFI)

School wide- networks connecting computer labs, computers in classrooms and offices. The options here are:

- Wired Ethernet and Fiber optic cable
- WIFI
- Mix of wired and wireless

To School connectivity- basically connecting the school lab or school wide network to the Internet. Here, the options abound:

- Wired solutions
  - dial up modem over telephone,
  - Digital Subscriber Line (DSL),
  - Integrated Services Digital Network (ISDN),
  - Cable Modem
- Terrestrial wireless solutions-
  - Worldwide Interoperability of Microwave Access or WIMAX,
  - Cellular or mobile solutions
- Satellite solutions-
  - Interactive VSAT
  - One –way VSAT with terrestrial return
  - Mobile satellite systems such as Immarsat/ BGAN
  - Satellite radio multimedia data broadcast system e.g. World Space

Wireless vs. Wired solutions for Computer Laboratory and In school networks

Pros

- Flexible access allow anywhere, both in and out of class access
- Space- when used with laptops or PDAs with mobile carts
  - Can be carried to classrooms and used as and when required and stored away when not in use thereby relieving space requirements.
  - Eliminates "empty" classrooms as students use dedicated labs
- Faster to roll out than wired solutions
- Can be used to set up temporary networks, for example on special occasions such as parent days
- Wireless networks can extend beyond the school serving the community and encouraging life long learning as well as student access from home

Cons

- Low bandwidth (wireless typically up to 54 Mbps shared while wired solutions up to 100 Mbps dedicated) making them less ideal for bandwidth intensive applications such as multimedia or video streaming applications
- Insecurity problems if not properly configured

Note: cost of deploying wired infrastructure is now more or less the same than wireless connectivity.

Choice of connectivity option

- The choice of connectivity option is dedicated by these main factors:
    - Availability of technology- for example, ADSL, ISDN and Cable Modem not widely available outside major cities
    - Cost- generally satellite costs much more than other technologies
    - Bandwidth required- high bandwidth on the local area network may dedicate use of wired solutions
    - Coverage- if a wide area of coverage is required, then wireless solutions may be more feasible and cost effective than wired solutions
    - Reliability- where more than one solution exists, it may be prudent to choose the more reliable solution provided that the costs difference is not astronomical or depending on the applications required

Questions to ask

- What solutions are available in my area?
- What solutions are reliable enough?
- How much will it cost per month? And setup costs?
- What is the available bandwidth?

Connection method	Capacity (maximum)	Feasibility	Requirements	Range	Reliability	Capacity Scalability
Infrared	115.2Kbps to 16Mbps		Comes inbuilt in access devices	30 cm		none
Bluetooth	asymmetric mode: 721/57.6 Kbit/s symmetric mode: 432.6 Kbit/s both ways		Comes inbuilt in access devices	10 to 100 mts		none
Dial up connection	56 kbps	Medium- anywhere with landline coverage	Modem	Anywhere (cost of phone call)	Low to medium	Very low < 64 kbps
Leased wire line	ISDN – 128 kbps DSL- 1.5 Mbps	Low- depends on country's telecom	Modem	Mostly urban	Medium	Medium < 4 Mbps

Connection method	Capacity (maximum)	Feasibility	Requirements	Range	Reliability	Capacity Scalability
		infrastructure				
Terrestrial Wireless	WIFI 802.11 a and g- 54 Mbps WIFI 802.11 b- 11 Mbps	Low to medium- depends on country's telecom infrastructure although can be set up relatively cheaply	Access point and wireless network cards per equipment	10 to 50 mts	Medium to High	High < 100 Mbps
	WIMAX- 75 Mbps	Medium Cost of antennas can be very high	Antennas	35 to 50 km	Medium	
Mobile/ Cellular	Basic GSM- 9.6 kbps GSM- HSCSD- 38.4 kbps GPRS- 171 kbps EDGE- 384 kbps UMTS- 2 Mbps	Medium	Cell phone Modem	anywhere within cellular coverage	Low	Low < 2 Mbps
Fiber	In theory unlimited	Low - depends on country's telecom infrastructure	Modem		High to Very High	Very High > 1 Gbps
Satellite	• 100-155 Mbps (fully loaded transponder downlink) • VSAT- 100-155 Mbps (when loaded transponder downlink) •Mobile satellite-64 kbps (e.g. Immarsat, Worldspace)	Very High -	• Antenna • LNB + BUC • Modem • Receiver • Cabling	any where on earth	High to Very High	High < 155 Mbps

For more information on connectivity options please refer to GeSCIs "School Connectivity options matrix".[29]

[29] Connectivity options matrix available at http://www.gesci.org/ict-infrastructure-connectivity-and-accessibility.html

What is the consensus?

There is no definite answer. It all depends on your educational objectives, the technologies that are available in your area and the required bandwidth, which is related to the number of simultaneous users and the type of applications that are executed.

COMPUTERS IN CLASS ROOM VS COMPUTERS IN LABS

What is the issue?

What is the most effective way to deploy computers in order to ensure proper and maximum usage in an educational setting?

The Debate so far

The debate seems to favor[30] computers in classrooms as the best deployment strategy but however considers computers in labs as a necessary and sometimes only choice forced by few financial and logistical resources. Rule et al[31] argues for computers in labs as the best way to introduce and improve computer skills.

Related to this debate is the issue of "computer classes". As Culbertson[32] argues, "*computer schools should not be taught in isolation and that computer classes do not really help students learn to apply computer skills in meaningful ways*".

Pros and Cons

	Pros	Cons
Computers in Classrooms	• Spontaneous use of technology during lessons • Computer more likely to be integrated in curriculum and	• Higher support and maintenance costs: personnel need to go to each classroom • Less computer time per individual

[30] Troy University "Computer Lab vs. Classroom Computers" http://spectrum.troy.edu/~techtip/readings/labvsclassroom.htm / "Computer Labs versus Classroom Integration of Computers" http://instruction.nsd.org/instructional_tech/resource_library/help_documents/labvsclass.pdf

[31] Rule, Barrera, Dockstader & Derr, Comparing Technology skill development in computer lab vs classroom settings of two sixth form grade classes (2002)- http://www.ncolr.org/jiol/issues/viewarticle.cfm?volID=1&IssueID=2&ArticleID=66

[32] Culbertson, D Computer Labs versus Classroom Integration of Computers, http://instruction.nsd.org/instructional_tech/resource_library/help_documents/labvsclass.pdf

	Pros	Cons
	teaching • Promotes group work as students can cluster around PC during lesson • No time lost shuttling to and from computer lab • Teachers more likely to become comfortable with and use computers	• Computer use skills not easily taught • Inexperienced teachers may face class management difficulties • Expensive as all classes must have equal access to computers and software, all classes must be wired, all classes must have good electricity and security • Can make it more difficult for community to use computers in school
Computers in Labs	• Provides more computer time per individual • Easier to teach new skills to whole class • Better security as is centralized • Cheaper networking because centralized in one room • Peripheral devices such as printers can be easily shared • Lower support costs as support is centralized • Makes it easier to provide community access to computers	• Computer not properly integrated into curriculum • Limited time for students due to scheduling • Difficult to use for student long term projects due to time limits • Teachers may be frustrated due to scheduling conflicts or poor lab management

Cost drivers

Cost of computer deployment= purchase costs + delivery and setup + maintenance and support + facility preparation + training

Cost variables for computers in class vs. in lab are:

- Maintenance and support costs- higher for in class deployment
- Facility preparation- higher for in-class deployment as good electrical, security, cooling, lighting and network systems required
- Training costs- higher for in class deployment as every teacher has to be adequately trained to handle technical and pedagogical issues

MOBILE LABS

Mobile labs have become a much recommended deployment approach. They typically consist of a mobile cart with laptops with WIFI cards, charging system, WIFI access point and printer.

Pros

- Space savers- laptops and cart can be used on ordinary desks and carried away and stored after the lesson eliminating the need for special furniture
- Flexible- laptops with wireless can be used in many configurations in a classroom and in any classroom
- Eliminate the need for permanent and expensive wired networks
- Can be easily secured as cart is locked away when not in use

Cons

- Transportation limitations- not easily movable where stairs exist
- Laptops cost more than equivalent capacity desktops
- Laptops are more fragile than desktops
- Low battery life of laptops creates issues with charging between lessons.

ACCESS DEVICES

Device	Pros	Cons
PDA	• Flexible and mobile can be used in and out of class • Long battery life- 5 hrs • Light and easy to carry (portable) • Requires very little space to use • More applications available if used as thin client	• Less functionality than laptops or PCs • Non standard operating systems e.g. Palm, Windows CE, Linux
Laptop	• Flexible and mobile can be used in and out of class • Requires less space than desktops	• Heavy and can cause strain if carried around a lot • Low battery life average

Device	Pros	Cons
		1.5 hrs • Higher cost than desktops of equivalent capacity
Tablet PC	• Can be used for taking notes easily	

LIFE CYCLE OF HARDWARE

The Issue

What is the useful life of electronic hardware equipment? Specifically, what is the useful life of computing equipment? This issue is important in determining the frequency of replacement and hence TCO.

The Debate so far

Personal computers have a useful life time of 3-5 years for private companies. Generally the life time for schools is usually at least 5 years. If one considers the use of refurbished PCs in schools, then the life cycle of say a PC for a school would be well over 5 years.

Who is involved in the debate?

No concrete data seems to exist on the life cycle of electronic devices in schools.

Common causes of upgrades or replacement

Replacement is driven by a few major factors:

- Software upgrades requiring more computing power
- Parts and spares no longer available- typically[28] 5 years
- New technological break through

Life cycles of common devices:

• *Personal computers*

- According to DIT[33] PCs useful life is 5 years
- According to CNET Reviews[34], PCs useful life is 3-5 years
- But components like monitor, mouse, hard disk might have different life-spans

• *Laptop*

[33] Department of Information Technology (DIT), Information Technology Equipment Life Cycle (2005) http://www.michigan.gov/documents/Life_Cycle_Boilerplate_Report_86875_7.pdf
[34] CNET "A computer's life expectancy" http://reviews.cnet.com/4520-10166_7-5543710-1.html

- According to Gartner[35] laptop's useful life is 2-3 years

• *Server*

- DIT recommends 5 years

Cost Drivers

Cost of devices= purchase price + software + delivery + installation + maintenance + training

The life cycle of the device is impacted by:

- The type of usage it is subject to everyday (and specially improper usage)
- The quality of the electrical supply
- The environmental conditions (heat, dust)
- The quality of the original components
- If it was subject to preventive maintenance

The life cycle of the device would impact:

- Software costs (need to upgrade software)
- Maintenance costs. The impact on maintenance is related to more frequent breakdown as equipment grows old necessitating regular repair and replacement and expiry of warranty in the later years.

[35] Margevicius, Mark, "Desktop PC Life: Four Years for the Mainstream," Research Note T-13-8045, Gartner Group, August 21, 2001.

STUDENT TO COMPUTER RATIOS

The Issue
What is the optimum student to computer ratio for schools?

The debate so far
Student to computer ratio is driven by financial resource availability and secondly by educational objectives.

- According to Russell et al[36], the optimum ratio that schools should aim for is 1:1. (for more information on 1:1 models see the corresponding section)
- According to the US National Center for Educational Statistics[37], quoting from President's Committee of Advisors on Science and Technology 1997, p. 14, a reasonable ratio according to most experts is at least 1:5.

What is the consensus?

Ultimately, the ratio has to do with how much effective time each students gets to work on the equipment. If there are 40 students per machine, and they work in groups of 2, each group gets about 1 hour a week to work with the machine. If you have 70 students per machine, they each get 2 hours a month, which is not sufficient to learn much and even less to integrate ICTs into the different subjects. A ratio of 1/5 seems o ensure at least one hour per student per day with a computer, or more if they work in groups.

[36] Russell, M., Bebell, D., Cowan, J., & Corbelli, M. *"An AlphaSmart for each student: Does teaching and learning change with full access to word processors?"* (2002) http://www.bc.edu/research/intasc/PDF/AlphaSmartEachStudent.pdf

[37] "What is the ratio of students to instructional computers in public schools?" http://nces.ed.gov/pubs2001/InternetAccess/3.asp

1:1 EDUCATION / 1:1 COMPUTING

Definitions:

1:1 education: The definition of one-to-one technology is essentially providing every teacher and student with a portable laptop, notebook or tablet PC for continuous use both in the classroom and at home (Center for Digital Education, 2004). It must be noted that the concept implies that the device then becomes the private property and space of the student, as opposed to models where ICT devices are shared and not personalized[38]

The Issue

1:1 Education, where each student owns an access device and uses it in class and at home, is said to be the ideal ICTs in education integration scenario. Opponents suggest this might not be the case.

The debate so far

Since the launch of the first 1:1 project, called "One Laptop per child"[39] in 2005, the idea of having cheap access devices (laptops) for every student in a class has stirred a lot of debate as being the first opportunity to apply the constructivist learning theory. Since then many companies have developed different portable devices[40], mainly oriented towards the developing countries, searching for massive deployment of these tools.

Who is involved in the debate?

The debate opposes NGOs, Commercial companies, government officials and educational experts with other educational experts and NGOs. Most countries are still skeptical, s no conclusive data exist on the results of applying 1:1 education.

Proponents of 1:1 models say:

[38] "1:1 Technologies/Computing in the Developing World - Challenging the Digital Divide" by Mary Hooker, GeSCI

[39] OLPC organization http://laptop.org/

[40] For a list of available devices check "Quick guide: Low-cost computing devices and initiatives for the developing world" maintained by Infodev located at: http://infodev.org/en/Publication.107.html

- 1:1 educational models can revolutionize education and bring developing countries' students to the level of the most advanced countries in a few years
- Low cost equipment makes it possible to equip all schools in a country
- Low power consumption is suitable for environments with electrical limitations
- Solutions offer good features and software for educational purposes

Opponents of 1:1 models say:

- ICTs are no magic solution for education and a technological project cannot be deployed without considering the educational objectives first. Opponents suggest that these solutions are too much technology-centered.
- Most solutions are deployed without really taking into consideration the educational objectives, teacher training or even educational software and content.
- The cost has been higher than expected, and with a TCO that can be 300% of the initial investment
- Countries should invest their money in more basic things like health, roads or simply in "education for all" initiatives.
- The technical complexity of having a large number of machines in classroom and the infrastructure to support this is just too much for most schools

TCO Issues

As with any other massive ICT deployment in schools project, TCO for 1:1 models is quite complex. You can find some cost components in an article by Jon Camfield on OLPC News.[41]

What is the consensus?

This is a new subject and the debate is just starting. One general conclusion is that 1:1 initiatives have helped in lowering the market price of portable low cost educational access devices.

[41] http://www.olpcnews.com/implementation/plan/cost_of_olpc_in_haiti.html

As of now, no conclusive results of the various pilots around the world exist. You can access "OLPC News"[42] for new up-to-date debate information.

For more information of the educational side of 1:1 please read our report "1:1 Technologies/Computing in the Developing World - Challenging the Digital Divide"[43]

For technical recommendations regarding the selection of 1:1 devices please refer to our "Low cost devices toolkit"[44]

[42] http://www.olpcnews.com/

[43]http://www.gesci.org/integration-of-icts-into-teaching-and-learning.html

[44] Low cost computing devices toolkit available at http://www.gesci.org/ict-infrastructure-connectivity-and-accessibility.html

DISPOSING OF COMPUTER EQUIPMENT AND ENVIRONMENTAL CONSIDERATIONS

The Issue

Computers and other IT equipment have to be disposed of properly in order to minimize their impact on the environment.

The debate so far

There is no debate anymore as all sources agree that IT equipment poses an ecological threat as it is discarded into landfills with normal garbage while containing several poisonous components (lead, cadmium, barium, mercury, arsenic, etc) that can seriously damage the environment.[45]. Discarded equipment is called e-waste. In 2004, quoting OECD figures, Solving the E-waste Problem (StEP)[46] noted that the global ICT trade represented 7.7 percent of gross world product[47] . As a by-product of this trade, e-waste, is the fastest growing source of municipal waste on earth (50 million tons of electronic waste each year). If not disposed of properly, e-waste can result in toxic substances seeping into soil and groundwater, harming the local environment and people's health. In the developing world, e-waste levels are expected to triple in the next five years as electronic goods become more affordable and desirable[48]. There are a number of

[45] Toxic Time-bomb Waits to Explode In Your PC! (2008) http://www.boloji.com/environment/117.htm

[46] Solving the E-waste Problem (StEP) is an initiative of various UN organisations with the overall aim to solve the e-waste problem. Together with prominent members from industry, governments, international organizations, NGOs and the science sector actively participating in StEP, we initiate and facilitate approaches towards the sustainable handling of e-waste.

[47] All: About Electronics (CNN). December 2007. http://edition.cnn.com/2007/BUSINESS/12/03/eco.ewaste/

[48] All: About Electronics (CNN). December 2007. http://edition.cnn.com/2007/BUSINESS/12/03/eco.ewaste/

guidelines[49] available concerning the conscientious purchase, use and disposal of ICTs, which draw on current good and emerging practices in government agencies and businesses.

What to do

There are several things you can do to reduce this contaminant process to the minimum:

1) Try to buy "greener" equipment, check for specific regulations for each region. For example, EPEAT (http://www.epeat.net/) is a system to help purchasers in the public and private sectors evaluate, compare and select desktop computers, notebooks and monitors based on their environmental attributes.
2) If possible try to maximize the life of computers as much as possible, by refurbishing them, donating them or breaking them apart in order to reuse components and parts[50].
3) When getting rid of equipment, search if some company or NGO in your area accepts machines to break them apart and re-use basic material, like gold and other metals[51.] A computer recycler is a business or organization that salvages useful computer parts before breaking down what's left, safely removing hazardous materials in the process. Note that some recyclers will charge a fee to accept old computer equipment, especially monitors.

[49] Greenpeace's Guide to Greener Electronics. Available at: http://www.greenpeace.org/international/campaigns/toxics/electronics/how-the-companies-line-up / Environmental Protection Agency (EPA) Regulatory Programmes for "E-Waste Waste".Robert Tonetti, EPA Office of Solid Waste. October 2007. Available at: http://www.epa.gov/epaoswer/hazwaste/recycle/ecycling/docs/e-wasteregs.pdf

[50] "Ten tips for donating a computer" (2008), http://www.techsoup.org/learningcenter/hardware/archives/page9675.cfm

[51] Bridges "How to set up and operate a successful computer refurbishment centre in Africa: A planning and management guide" http://www.bridges.org/publications/61

4) Check if there are regulations in your country regarding the disposal of electronic equipment. Some countries are starting to charge an extra amount to new equipment in order to subsidize the disposal of older equipment[52].
5) If no law exists in your country, work with government agencies and NGOs in promoting one and protecting your country's resources from e-waste.

As an example, the "Electronics Environmental Benefits Calculator"[53] by the US Center for Clean Products and Clean Technologies can be used in quantifying the benefits of environmentally sound management of electronic equipment.

[52] RL31505 - Recycling Computers and Electronic Equipment: Legislative and Regulatory Approaches for "E-Waste" 18-Oct-2002; James E. McCarthy; 23 p. http://www.ncseonline.org/NLE/CRS/abstract.cfm?NLEid=36470

[53] http://eerc.ra.utk.edu/ccpct/eebc/eebc.html