COMPUTER SYSTEM SUSTAINABILITY TOOLKIT

UNIT 3:

Establishing Your School's First Computer System: Planning for Success

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This unit will help the leadership and staff at schools that do not yet have a computer system or lab make decisions about establishing a new computer system at their school. This unit may also be useful for SPTs at schools that already have computers and are thinking about buying more computer equipment or establishing additional computer labs. If your school already has a computer system and you are not considering expanding it at this time, you may wish to skip Unit 3 and jump to Unit 4.

Why do we want to establish a computer system or lab at our school?

This is an important question for the SPT to discuss and answer. At first, the answer to this question may appear to be simple. Members of the SPT may answer, "Yes, we should establish a computer system at our school." However, before you jump to this conclusion, it is important for you and the SPT to consider, discuss, and answer a few other related questions. Going through the following questions will help you and your SPT carefully consider the consequences of deciding to establish a computer system or lab at your school. Because of the importance of these discussions, you should plan for two to four hours for the first meeting on this unit.

To facilitate the discussion of these questions, you may want to divide the SPT into two or three smaller groups, and then ask each group to discuss and answer the questions below. To make the process efficient, you should tell each group to spend a specific amount of time discussing and answering each question. Each group should have one person record the most important points of the discussion and the final answer. Periodically, to make the meeting progress effectively, you may want to stop the small group discussions and have each group briefly present the main points and answers to the questions its members have discussed.

The questions that follow should help you determine if your school should establish a computer system or lab. Before starting the discussion, it would be helpful to present this list of questions to the SPT and ask if the members would like to add any other critical questions for discussion. Once you have a final list, you can start the discussion process.

Proposed discussion questions:

1. What are the most important reasons for establishing a computer a system or lab at our school? What specific benefits, educational and other, do we expect to gain by establishing a computer system or lab at our school?
2. How much money will we need to establish a quality computer system or lab (buy, install, and secure the equipment) and operate it for the next five years? Do we have the staff with the skills needed to establish the computer system or lab and operate it? If not,

where will we get help, and what will it cost to select and buy the equipment we will need, prepare the school and classroom for the lab, install all the hardware and software for the new system, and operate the new computer system?

3. Do our teachers and other staff have the skills needed to use the computers and other equipment, integrate the use of these computers to enhance the teaching of subjects that make up our curriculum, and manage and maintain the computer system? If not, what will we need to do, and how will we do it, to build and strengthen the skills of our teachers to use and manage this new computer system?
4. Where in the school will we establish our computer system or lab? What classroom or other school building will we use for our new computer lab? Will the room with the computer system or lab be used for teaching other subjects, or will it be used exclusively for using computers? If we don't have an existing classroom for the lab, where can we build one?
5. Will the computer system or lab be made available to members of the community to use during non-school hours? If yes, what will need to be done to make it possible for community members to use the new computer system or lab during these hours?

This initial discussion will help you and the other members of the SPT decide whether or not to establish a computer system or lab. The following sections of this unit will help you and the other SPT members to continue these discussions and refine your initial answerers to these questions.

How much money will we need to establish and operate a new computer system?

At first this question may seem relatively easy to answer. All you need to do is determine the cost of one computer, and then multiply it by the number of computers you think you will need for your new system or lab. For example, you may determine that a suitable new desktop computer from a local store costs the equivalent of US$835, and you think you will need 10 or 20 computers for your computer lab. Therefore, it would cost US$8,350 - $16,700 to establish your school's new computer lab. Unfortunately, buying the computers is only one of several expenses you will need to consider when determining how much money you will need to establish a computer system or lab at your school. The following table, and the accompanying spreadsheet on the Toolkit's CD, includes other types of expenses you will need to consider when determining the total cost of establishing and operating a new computer system or lab at your school. This is often called the Total Cost of Ownership (TCO), which is discussed in greater detail below. While some of the costs may be zero (for example, the government or a donor organization may donate the computers) or very low, it is important for planning purposes to consider and include each of the cost categories presented below. Because each school's situation is unique, you and other members of the SPT may need to add other cost elements to this table and the accompanying **Cost Estimate Template** on the CD.

As shown in this table, the total cost to establish and operate a computer system at your school may be significant. Because of this, it may be necessary for you and the SPT to consider ways you can use your computer system to generate revenue to cover management and maintenance costs

COST ESTIMATE

NO.	DESCRIPTION OF COST ELEMENTS	UNIT COST (US$)	UNITS	TOTAL COST (US$)
1	Computers (desktops, laptops or other types) for students and teachers to use.			
2	One or more computer servers to provide file sharing and networking services.			
3	One or more printers for the computer lab.			
4	Other computer hardware such as a scanner, uninterruptable power supplies, surge protectors, digital cameras, web cams, etc.			
5	One or more data (LCD/DLP) projectors for the computer lab.			
6	Networking hardware to connect the computers together to form a network to share files, printers and access the Internet.			
7	Shipping the equipment to the school.			
8	Installing and configuring the equipment and software so the system is working properly.			
9	Software for the computers including: a basic office suite, antivirus/antimalware, utilities, education management software, and other special educational software.			
10	Furniture for the new computer lab to make it possible to use the computers effectively.			
11	A room for the computer system or lab, either an existing classroom or new room built for the lab.			
12	Refurbishing an existing room that will be used for the new computer system to prepare it to house and operate the computer(s) and to keep them safe and secure. This may include increasing the number of electrical outlets in the room, improving the room's lighting, providing an air conditioner, leveling the floor, repairing windows, adding metal security grills to the windows and the door, etc.			
13	The estimated cost for electricity to operate the computers and other equipment in the lab. This may be the actual cost of the electricity, of diesel to run a generator, or to buy and install a solar-powered system to generate the electricity needed to operate the new lab (to calculate a cost estimate for the electricity the new computer system will use, follow the instructions in the text box below).			
14	The estimated cost of consumables, including ink/toner and paper for the printer, blank CDs, upgraded software, antivirus updates, etc.			
15	The cost to establish a connection to the Internet. This may be as simple as buying a modem and the cables needed to get connected. It can also require buying and installing a satellite dish. You will need to contact the local or national Internet service provider to learn about the different options and their costs for obtaining Internet access. Unit 4 will guide the SPT through the process of determining the cost of Internet access.			
16	The monthly fee for Internet access. Some service providers charge by the amount of data that is downloaded and uploaded each month; others charge a flat fee regardless of use.			
17	Hiring new staff to manage and maintain the computer system or lab and teach students and teachers to use it.			
18	The cost to provide staff with initial training to use the computers and other equipment and integrate use of the computer system into routine teaching and learning activities.			

and recover the system's recurring costs. Unit 7 will help you and the SPT identify ways to use your computer system to generate income to meet ongoing operational costs.

What should we do to prepare our school for a computer system?

There are three basic physical arrangements often used to establish a computer system in schools to improve education: 1) distribute the computers across multiple classrooms in the school; 2) install the computers in one room to create a computer lab; or 3) use a mobile computer cart with laptops that can be moved from room to room or have students bring the laptops from the cart into their classroom. Some schools use two or three of these approaches.

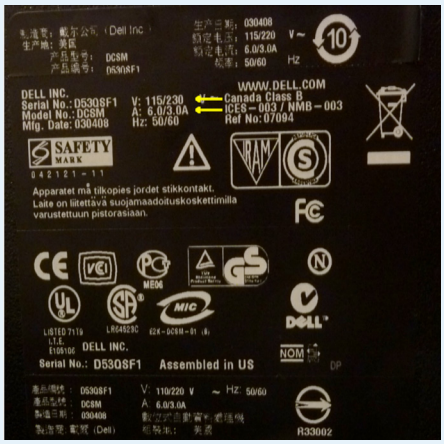
Regardless of which strategy you and your team selects, the SPT will have to prepare your school for the new computers. As you plan for your new computer system, you will need to consider the following main preparation efforts:

Girls in a school in Amman, Jordan collecting laptops from a computer cart for use in their classroom.

- Improving the physical infrastructure of the school in one or more rooms. This may include increasing the number of electrical outlets in rooms, upgrading the electrical supply, installing network cables, improving security in rooms where the computers will be placed, taking steps to reduce the level of dust in rooms with computers, buying new furniture to provide suitable work surfaces for students to use the computers, improving classroom lighting so computers can be used during the day and at night, etc.
- Building and strengthening the capacity of all teachers to use the computers to help manage classrooms, prepare lessons, and integrate the use of the computer system into their classroom teaching.
- Establishing a schedule for using the computer system that will provide equitable access by all students and teachers.
- Informing the students at the school about the new computer system and how it will be used to improve teaching and learning and about their responsibilities to help maintain and sustain this valuable asset.
- Informing the parents and members of the community about the new computer system and how they may have access to this important community asset.
- Reorganizing the school's budget to include additional line items to cover ongoing expenses related to maintaining and sustaining the computer system.
- Carrying out additional activities described in other units of the Toolkit to enable your school to sustain and grow this important educational resource.

Estimating the Cost of Electricity

1. The first step to calculate the total amount of electricity that your computer equipment will use is to look at the small sticker on the back or bottom of each piece of equipment (see diagram below) and record the voltage (volts) and amperes (amps) that each device uses. Multiply these two numbers together to calculate the amount of watts of power each device consumes. For example, a typical laptop power supply uses 20 volts and 4.55 amps of electricity to operate and therefore it takes 91 watts of power (20 volts x 4.55 amps = 91 watts) to operate the laptop. Add up the number of watts consumed by each piece of equipment to determine the total watts for all the equipment that will be part of your system.
2. Calculate the number of watts that all of the equipment will consume in a typical day. To do this, first multiply the total number of watts used to operate all of the equipment in the lab by the average number of hours you expect that the equipment will be used in a typical day. Remember, some equipment may remain on the entire school day and other equipment may remain on for 24 hours a day. Since this probably will be a very large number, you can convert the number of "watt hours" to "kilowatt hours" by dividing this by 1,000 (1,000 watts in a kilowatt). For example, if I use my laptop for 13 hours on a typical day, it will consume 1,183 watt hours of electricity each day (91 watts x 13 hrs = 1,183/1000) or 1.83 kilowatt hours each day.
3. Calculate the number of kilowatt hours of electricity used in a typical year by multiplying the above number by the total number of school days you expect the equipment to be used. Remember, if you expect members of your community to use your new computer system in the evenings and on weekends, you will need to include these times in your calculation. For example, I estimate that I use my laptop six days each week or 312 days in a year, so I will consume 570.96 kilowatt hours of electricity to use my computer for a year.
4. Finally, determine the cost per kilowatt hour your school pays for electricity. This should be included on the school's electric bill. If a central authority pays for the school's electricity, you can substitute the cost you pay for a kilowatt hour of electricity at your home. For example, in Rockville, Maryland, in the U.S., I pay US$0.16 per kilowatt hour of electricity (total charge for electricity on a monthly bill divided by the number of kilowatt hours consumed that month). If you generate electricity at your school with a diesel or gas generator, multiply the cost of fuel to run the generator each hour by the number of hours a year the generator will be needed just to operate the computers.
5. Finally, calculate the estimated total cost of operating your computer system each year by multiplying the cost per kilowatt hour by the total number of kilowatt hours of power consumed each year. For example, it costs me about US$91.35 per year ($0.16/KwH x 570.96 kilowatt hours per year = US$91.35/year) to operate my laptop computer. Select the voltage rate that is appropriate for your country (most countries use 230V for their standard voltage). Then multiply that number by the appropriate amperes (found to the right of "A" and highlighted by the second yellow arrow). If your country uses 230V, you would select the second of the two amp rates. Therefore, multiplying 230V times 3.0A would tell us that it takes 690 watts of power to operate this computer.



The example above was found on the bottom of a desktop computer. The voltage is found to the right of the "V" highlighted by the first yellow arrow.

What computer equipment should we consider buying for our computer system?

Even though computers and related equipment have come down in price over the last few years, buying a large number of computers to enable your students and teachers to have effective access will be a major expense. Establishing your computer system may even be the single largest capital investment your school will make. While the initial cost to buy equipment, purchase software, prepare your school for the computer system, and train your staff to use these new tools will be high, this initial cost probably will be less than the ongoing costs over three to five years to maintain and sustain the computer system, pay for the electricity to power these new tools, buy consumables to support the use of the computer system, and secure the system against theft and damage. When you combine the cost to purchase the equipment and establish the computer system at your school with the cost for operating, maintaining, and sustaining the computer system, you will determine your computer system's **Total Cost of Ownership (TCO)**. It is critically important to estimate the TCO when you are evaluating and comparing different equipment options. The computer with the lowest price in the store may end up being much more costly to operate, maintain, and sustain over time than more expensive alternatives, so when you ask different equipment vendors for price quotes, you also need to have them estimate the TCO for the equipment they are recommending. In your request for quote, you should also emphasize that your purchase decisions will be based on the TCO, not just on the initial purchase price.

Experience shows that many equipment vendors and computer shops will not be very concerned about your school's TCO for the equipment they recommend. They will be more concerned about selling you equipment they have in stock. Also, many of their customers are only concerned with paying the lowest prices for the equipment, so vendors may be unprepared to answer your questions about TCO. However, since this is your school's precious money, you will want to base your purchase decisions on the TCO, not just on the lowest initial purchase price. The following parts of Unit 3 will help you and your SPT evaluate the TCO for different computer equipment options.

In addition to considering the TCO in making your decision about which equipment to purchase for your computer system, it is equally, if not more, important to keep focused on the educational and classroom management objectives you expect to achieve by establishing a computer system. These educational objectives should drive your computer purchase decisions, not technical specifications. The technical aspects of the equipment, the type of computer chips that are used, the processing speed, the gigabytes of memory and storage, and the number of "bells and whistles" that are part of each piece of equipment should not be the primary focus for your purchase decisions. Computers and other equipment are just tools; it is more important to know what you will be able to achieve by using these tools rather than what these tools are.

Another way to think about this is to imagine going to a restaurant for a special occasion: the chef will be much more concerned with the quality of the meal he or she is preparing than with how special his or her pans and stoves are. For the school, it is much more important to focus on the educational and classroom management results you want to achieve with your computer system than to focus on the specifications of the equipment.

At the start of Unit 3, you and your team discussed why you want to establish a computer system at your school. This assessment should enable you to define the educational and management objectives you want to achieve by establishing a computer system at your school. At this point in the Toolkit, you may want to revisit these initial questions with your SPT and refine your school's objectives. The clearer everyone is about what your educational objectives are, the better choices you will make about which equipment to buy. You should use your objectives, along with the TCO, to decide which equipment options will enable you to achieve your educational objectives and provide the lowest TCO.

Which types of equipment should we buy?

The following section of Unit 3 will assist you and your SPT to identify and evaluate different equipment options for your school's computer system. The Toolkit will not tell you what equipment you should buy. One reason for doing this is that the types, brands, and options available in the technology marketplace change rapidly. Any recommendation for a specific brand or a set of specifications would be out of date in a few months. Also, not all types and brands of equipment are available in all locations and countries. Furthermore, each school's educational and school management objectives, along with its specific context, create a unique situation for which there is no single recommended equipment.

However, the Toolkit will provide you and your SPT with some general information about different types of equipment options to consider when making decisions about the characteristics of the computer system you will establish at your school. This overview is organized in three sections: 1) computer choices; 2) networking choices, and 3) peripheral choices (software choices will be discussed in the next section of Unit 3).

Total Cost of Ownership

Some key elements to determining the total cost of ownership and use:

- Buying the right equipment—initial costs;
- Beyond opening the box—cost to transport and install the equipment;
- Paying for new or used donated equipment—the cost of getting the donation, refurbishing and upgrading used equipment for use in your school and the cost to maintain the donated equipment;
- Preparing school infrastructure—the costs to build or refurbish a room and school building to use and keep the equipment secure;
- Operating the equipment—energy costs;
- Software and software upgrades—initial purchase/upgrade costs;
- Getting everyone ready—training costs;
- Managing the system—cost of support staff;
- Keeping the system operating—technical support and maintenance costs;
- Getting and staying connected—Internet connectivity costs;
- Sustaining and expanding your system—investing in sustaining and growing your system; and
- Computers don't last forever—planning for replacement costs.

Computer Choices: When you walk into almost any computer store or visit a computer vendor's website, you will encounter multiple choices of brands, models, specifications, features, and "special deals." It can be very confusing and, if you have not determined your objectives for the computer equipment you want to buy, you will be even more confused. To a great extent, the many variables in the computer marketplace are designed to confuse you. If you are confused, then it is easier for a salesperson to convince you that a specific model is best. Fortunately, the Toolkit will

help you cut through the clutter and be prepared to deal with your local computer store or equipment vendor. When this version of the Toolkit was written, there were four broad categories of computer systems commonly used in schools: a) desktops; b) full-featured laptops; c) netbooks; and d) thin client systems.[4]

Full featured desktops include two general types of systems. In one, the computer "box" or CPU (central processing unit) is separate from the computer screen. Another type combines the CPU and the screen into a single unit, or an all-in-one desktop solution. In both of these types, the keyboard and mouse are also usually separate units. Desktops that are based on computer chips from Intel Corporation or AMD (the two major manufacturers of computer chips for personal computers) and Microsoft or Linux operating systems (OS)[5] are the most common types of computer systems in the world. Computers based on Intel/AMD chips and Windows OS are often referred to as WinTel systems. Another company, Apple, also makes computer systems based on Intel chips and the Apple operating system. Unlike WinTel systems, which are manufactured by many different companies, Apple is the only company that is allowed to make Apple computers. As a result, Apple only has about a 7 percent share of the global computer market and is not common in many countries. For these reasons, the Toolkit focuses on non-Apple systems.

The following is a list of advantages and disadvantages of desktop computers for schools.

- Desktop computers are the most common, and many named brands and clone systems are available in most major cities in the world. As a result, the parts that make up desktop computers, especially those where the monitor is separate from the CPU, are relatively inexpensive and easily available in most major cities.
- Because desktops are very common and based on a common set of easily available parts, they are usually less expensive than full-featured laptop computers.
- Some desktop models allow users to add new features by installing special cards or to upgrade components or to increase capacity. For example it is relatively easy to add a new hard drive to a desktop computer, but it is very dificult to do so in laptops or netbooks.
- Desktop systems are generally easier for users to maintain and repair since the CPU is relatively easy to open and many of the different components, such as power supplies, hard disk drives, and memory chips, can be replaced with easily available substitutes.
- When the screen is separate from the CPU, it can be less expensive to repair systems by replacing one defective part rather than having to replace the entire unit, as with a laptop, if repair is not an option.
- Because of their size and component structure, desktop systems take up more

[4] There are a number of other variations, but these four types are most commonly available.

[5] A computer's operating system (OS) is the basic software that provides the computer with the instructions for all basic operations. Without operating system software, a computer cannot function. Microsoft's OS is the most common in the world and comes in many varieties, including Windows 98, Windows XP, Windows Vista, and Windows 7. Microsoft is a private company that sells its OS to computer manufacturers and consumers. Linux is an open-source OS that is available in different versions. Most Linux OS software can be downloaded for free from websites on the Internet.

space than do the three other types of systems. Once a desktop computer is set up on a desk, it dominates the desk and makes it difficult to use it for other purposes. One consequence of this is that a room with desktop computers is not convenient for non-computer uses. This is one reason why schools establish special computer labs. For example, in one high school in Macedonia, desktop computers were installed in the science room. After this was done, the teachers and school leadership realized that the students could no longer carry out science experiments on the desks because there was not enough space and liquids could easily be spilled on the computers. In the end, the school had to establish a computer lab in a new room.

- Desktop computers must be plugged into the school's electrical circuit to operate. Most desktop computers do not contain a battery, as laptops and netbooks do. As a result, the room where desktops are installed must have enough electrical receptacles and sufficient electrical capacity to support all computers operating at the same time.
- If there will be more than 10, 20 or more desktop computers in a single room, or in several rooms, on the same electric circuit, it probably will be necessary to upgrade the school's electrical system to handle the heavy load.
- Many desktop computers, especially the lowest-priced models, consume much more electricity than do comparable laptops, netbooks, or thin client systems. In Brazil, for example, each low-priced desktop and one with monitor consumed 850 watts. Therefore, 20 of these computers would consume about 17,000 kilowatts of electricity a year.

At a rate of US$0.25 per kilowatt hour, it would cost about US$4,250 a year just to use these computers during the school day. In contrast, 20 full-featured laptops would cost about US$390 per year to operate in this school, a savings of $3,860. After five years of use, the savings would be US$19,300, enough to buy 20 or more new computers.

- Desktop computers tend to generate much more heat than do the other three systems. The more electricity a computer consumes, the more heat it produces. One consequence of this is that a room with 20 or more computers can become very hot and uncomfortable, especially in countries with hot, humid climates. This extra heat can make it very uncomfortable for users or increase the cost to operate an air conditioner to cool the room.

  Also, if a computer cannot efficiently dissipate the heat it produces, the main computer chip can overheat and stop operating. Furthermore, as desktop computers become dusty inside, they will overheat more rapidly, start to function erratically, and their components will fail more often. In one school in Indonesia, for example, the rate of computer failure due to overheating caused by dust was so extreme that it was too costly to keep the computer lab operating.

To prevent computer failure and make the computer lab more comfortable for students and teachers, some schools have had to install costly air conditioning systems. While this will keep the room more comfortable, the annual cost for electricity will increase significantly, sometimes approximating the initial purchase price of the computers. This very high TCO could make low-cost desktop computers the wrong choice.

- Since desktops will remain on the desks in the computer room, it is often necessary for the school to install iron grilles over windows and doors to protect them from theft. However, this may not be sufficient; in one school in Brazil, thieves broke into the computer room through the ceiling and stole all of the computers. The annual cost of protecting the computers from theft by installing protective infrastructure and hiring night watchmen can exceed the initial purchase price. Again, the TCO for low-cost desktop computers that demand extra security features can make them very expensive.
- The all-in-one desktop computer requires less space than conventional desktop computers, making it easier to use the computer lab for other purposes. Also, all-in-one systems often consume less electricity and generate less heat than conventional desktops. In contrast, these all-in-one systems are often initially more expensive than conventional desktops to purchase and maintain.

Full-featured laptop computers are available in many different sizes and configurations, based primarily on the size of the screen and keyboard, the storage capacity of the hard disk drive, and the presence of a CD/DVD drive. Usually, as the weight of the laptop decreases, the price increases and the durability diminishes. The following is a general list of advantages and disadvantages of using laptop computers to create a school's computer system.

- The initial purchase price of laptop computers is generally higher than that of conventional desktop computers with similar features. However, the TCO for laptop computers may be much less.
- Laptop computers are mobile; they can be stored in a cabinet or cupboard when not in use, so the room where they are kept can be used for other purposes. The mobility of laptops also makes it possible to take them from the room where they are stored to somewhere else in the school. Some schools have optimized mobility by buying special carts with wheels—which can be moved easily between rooms—to store the laptops. This makes it easier for teachers to integrate use of computers into their curriculum because students do not have to move to the "special" computer lab to use the computers to study history. With laptops, the computers can come to the history classroom.
- Generally, as mentioned earlier, laptop computers consume much less electricity than do desktop systems, which can lower their TCO.
- Laptops take up less space on student desks than do conventional desktops. This makes it much easier to create lessons where the benefits of using the computer are blended with conventional learning activities. The combination of taking up less space and having greater mobility also makes it much easier to organize learning and the use of computers into teams. Research shows that forming teams can accelerate

and improve the quality of learning. Additionally, employers emphasize that good teamwork skills are very important to success.

- One advantage of a laptop's mobility is that schools can allow teachers to borrow the laptops in the evening to enable them to prepare lessons, strengthen their skills by using the laptop, prepare lesson plans, and update student records. Experience shows that, as teachers grow used to using laptops routinely, they eventually buy personal laptops. In Indonesia, for example, none of the teachers in a rural school owned personal laptop when the first computer lab was established. Three years later, however, more than 80 percent of the teachers owned them.
- Since laptops can be stored in a steel cupboard or on a cart, it can be much less costly to add infrastructure to protect them from theft. In Puerto Rico, for example, the computer carts with the laptops are kept in a small windowless room constructed of concrete with a single steel door. It was less expensive to build these small secure rooms than to protect the entire school or individual classrooms and hire watchmen. As a result, the TCO for this school's laptop computer system is less than that it would have been for a system using conventional desktops.
- While it can be less costly to secure a cabinet where the laptops are stored when not in use, the small size and mobility of laptop computers makes them very easy to steal if they are not managed carefully. For example, in one school, several laptops were stolen during a coffee break from the room where they were being used for a teacher professional development workshop. There are also numerous cases of laptops disappearing from schools during the school day when they are left on desks in rooms after students and teachers have left. This problem is not the fault of the laptop; it is caused by users' poor habits and ineffective school policies and procedures. This problem can be managed inexpensively by creating a culture of care and attention to the security of the computers that is everyone's responsibility.
- While the laptop's battery allows it to be used without being plugged into an electrical outlet, most laptops can operate on battery power for only two to four hours. Also, as a laptop ages, the amount of battery power diminishes. Eventually, within two or three years (about 300 to 500 full recharges), the battery will need to be replaced so full mobility can be restored. Replacing a laptop's battery can cost from US$100 to more than US$200.
- One serious problem with replacing a laptop's battery is disposing of the old battery properly. Most batteries used in laptops today use lithium-ion technology. While not as toxic as lithium metal, lithium-ion batteries do contain metals that can contaminate water supplies. Also, if lithium-ion batteries crack open to expose the chemical material to moisture, they care burst

into flames. Responsible schools that decide to use laptop computers will need to spend extra money to properly dispose of old computer batteries, thus increasing their TCO. Many countries do not have the capability to recycle or dispose of lithium-ion computer batteries properly, and throwing out an old laptop battery can damage the environment and be risky for children who might find old batteries and turn them into toys.

- Another problem that arises due to the laptop's limited battery life is that laptops cannot be used for an entire school day without being recharged or replacing the battery. One approach to handling this problem is to have a spare set of batteries kept in a special recharging device (as shown above) so they are kept fully charged. When needed, these spare batteries can replace batteries that need to be recharged in the recharging bay for later use. This solution increases the initial cost of the computer solution by up to US$5,000 or more for 20 laptops. In addition to costs, there are few recharging devices as compared to the many types of batteries that are manufactured.

  It is also possible to use laptops while they are connected to the school's electrical supply via the laptops' power supplies. This requires sufficient outlets in each room where laptops will be used to accommodate 10 to 20 or more computers. This probably will require the electrical supply in these rooms to be upgraded and additional outlets added, thus increasing the TCO for a laptop solution. Also, keeping laptops tethered to their external power supply and cords reduces their mobility and makes it increasingly difficult to use them in any room in the school and the many power cords on the floor can be a safety hazard.

An example of a recharging station for laptop batteries.

- Most laptop computers on the market are designed for use in an office environment by a single user who does not open and close it many times during the day. In schools, many different people use laptops and will routinely open and close them many times a day. Most office laptop computers are simply not designed to survive the level of use that happens in most schools. One common consequence is that the hinges, especially on low-priced computers, wear out quickly and stop holding the screen open. As a result, the screens either fall shut on the users' hands or fall back against the desk possibly damaging the screen. Additionally, because of their size, the electronics for the laptop are placed just beneath the keyboard, and if a user accidently spills a drink on the keyboard, he or she may destroy main computer board.
- Another common problem with laptops is that their screens and hard drives can be damaged easily when the laptop is dropped or bumped during use. The screens and hard disk drives in most office laptops, especially low-cost units, are not protected against sudden

movements or being dropped. In busy classrooms, the risk of this happening is high. Since laptops are more specially designed than are desktop computers, it is more expensive and difficult to find replacement parts and repair them. In many countries, parts for many laptop computers are only available in the capital city or outside the country. To address these problems, some manufactures have created semi-rugged laptop computers that include reinforced hinges, shock-mounted screens and hard drives, and a liquid proof membrane under the keyboard to protect the system from accidental spills. Because of these additional features, these semi-rugged laptops are more costly than conventional laptops, but their TCO can be much less, especially when the laptop will be used between three and five years. Unfortunately, semi-rugged laptops are not very common in many countries, and some manufacturers advertise their systems as "semi-rugged" when they are not. If you decided to buy semi-rugged laptops for your school, you should ask that the vendor demonstrate the semi-rugged features by dropping the computer and pouring some liquid on the keyboard when the computer is turned on. If the vendor refuses to do this, the laptop probably is not truly semi-rugged.[6]

Netbook computers, which were introduced in 2007, are much smaller (see diagram on following page), lighter, and less costly than full-featured laptops. To make them smaller, lighter, and less costly, manufacturers had to cut corners and eliminate many features common to conventional laptops. Below is a list of advantages and disadvantages of using netbook computers to create a school's computer system.

- The most common reasons people buy netbooks is their relatively low cost (US$200 – US$400 in late 2010) and their small size. Many schools, especially primary schools, have chosen to buy netbooks for their computer system because their initial purchase cost is less than most alternatives, and their lower capacity was not considered to be a problem for primary classrooms. The limited capacity of netbooks may, however, be a problem for use in secondary schools.
- An advantage of their small size is that they can be stored easily in a small cabinet or cupboard that can be built in one secure room in the school, thus lowering the TCO. Also, if one or two of them are stolen, the cost to replace them is much less than with other computer options.
- Due to the nature of the Intel computer chip used in netbooks, the screen cannot be larger than 25 cm (diagonal measurement). Also, the netbook's keyboard is around 20 percent smaller than a conventional laptop's keyboard. The smaller screens and keyboards can make it more difficult for older students to share them. However, the relatively low initial purchase price can enable schools to buy more of these computers so sharing among groups of students is easier.
- The netbook's small size and low-powered computer chip means that they consume less electricity, so batteries last longer than they do in conventional

[6] Some companies also build fully rugged computers that are fully water- and dustproof and can withstand very harsh physical treatment, including being run over by a car. These fully rugged systems are much too expensive for schools, which do not need this level of protection.

This picture showing the difference in size between a full-featured laptop and a netbook computer.

laptops. However, once the battery dies, the netbook must be plugged into its external power supply to recharge and be used.

- The small size of the netbook means that it does not include a CD/DVD drive; therefore, to install and use some software, you must buy external CD/DVD drives that are plugged into one of the netbook's USB ports. This adds another cost to the system and increases the number of parts that must be managed or that can be lost, stolen, or broken. Also, using an external CD/DVD drive will reduce the time the netbook can be used before having to plug it in.
- The lowest-cost netbooks come with low-capacity hard disk drives, which can limit the ability to install educational software and makes it impossible for students to store their work on the netbook.
- Netbooks' small size makes them more fragile and less durable. They are broken much more easily, and their key components may not stand up to the intense, multi-person use that will take place in schools. Therefore netbooks may need to be replaced after two or three years rather than the four to five years for other options. However, the low initial purchase prices of netbooks may make the TCO less than that of longer-life conventional laptops. Some companies, such as Intel and the OLPC Foundation, have designed more durable netbooks specifically for use in schools (especially primary schools). These more durable netbooks, which are more expensive than those designed for individual use, also include software (usually only available in English or other global languages) to make these computers especially useful in classrooms.[7]
- The small size of netbooks may make them less suitable for use in secondary schools, which will demand fuller-featured computers and ones that are more durable and able to withstand intense use by teenagers.

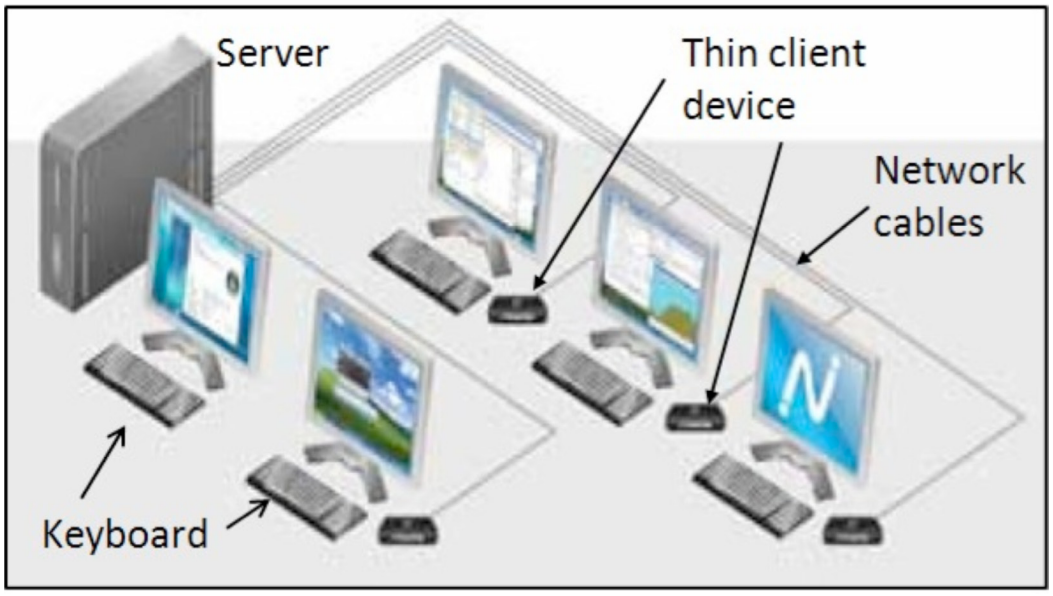
Thin client computers, which do not consist of stand-alone computers, have to be connected via network cables to a special desktop-like computer, known as a server, that provides all computing functions and stores all content and software that the "clients" need to function. A thin client system consists of a cluster of small devices, about the size of paperback books, that are connected together by cables to a server to create a network. Each device is also connected to its own keyboard, mouse, and screen."

NComputing, a company in the United States, has developed a thin client system specifically for schools. The diagram below, from an NComputing publication, illustrates what such a system looks like.

[7] The OLPC (one laptop per child) computer (www.olpc.org) was designed for use in primary classrooms in developing countries. Since these computers can only be purchased in very large quantities by central governments, they are not discussed in the Toolkit.

Below is a list of advantages and disadvantages of using thin clients to create a school's computer system.

- The only parts of most thin client computer systems that need to be connected to an electrical outlet are the screens and the server. Power for the thin client device is provided through the network connection to the server. As a result, the cost of electricity for a thin client system is up to 80 percent less than for a desktop system and only slightly less than laptop or netbook systems.
- Thin client systems are much less costly than conventional desktop computer systems. The cost of each thin client station (including the cost of the server) can be about the same as that of a robust netbook computer.
- Because a thin client computer system requires that each of the computer stations be connected to a server (up to 10-12 clients per server), a thin client system requires that a cabled network be installed in the room where the system is used. This often means that schools have to have a dedicated computer lab.
- A thin client system is based on having all clients connected to one or more servers. A 20-station thin client system would require two servers. To be efficient, each server must have a fast computer chip, one or more larger capacity hard drives, and more computer memory than a conventional desktop. This translates into a computer that will cost two to three times more than a conventional desktop computer. In addition, more skill is needed to set up and maintain the thin client servers than is needed to manage a cluster of conventional desktops and laptops.
- Even though the thin client device is small, the screen, keyboard, and mouse take up as much space as a conventional desktop system (especially when the CPU is stored on the floor or on a shelf below the desk), so it is just as difficult to use the desks where a thin client system is installed for other subjects as with conventional desktops.
- The companies that sell thin client system promote their systems based on studies that show that the TCO for thin client systems is up to 86% less



than conventional desktop networked systems. Even if the TCO is not 86% less, it is clear that it is much less than conventional desktop systems.

- Most schools will likely not be able to repair thin client devices. However, since there are no moving parts in these devices, they do not generate any heat, and they are not connected to the school's electrical supply, they will be less likely to need repair. As with desktop computers, servers can be serviced and repaired at schools if they have the staff with the needed skills.
- Since thin client systems targeted toward schools are relatively new, they may not be easily available in all countries and vendors may not provide support to schools outside major cities.

Networking Choices: There are many benefits to connecting the computers in your system together to form a network. The following are some of the most important benefits:

- A network makes it easier to share files and for students to access common files, documents, and educational resources that teachers have prepared for their lessons. If the school's computers are networked, teachers do not have to copy documents or exercises to each of the student's computers. They only have to copy them to the classroom folder on the central computer's hard disk. Then each student can access these common files for the lesson when needed. Similarly, each student can be assigned a specific folder on the central computer where they keep their work at the end of a session. Then teachers can easily access students' work for review, feedback, and grading.
- A network enables the system's computers to access the printer and other peripherals such as shared, networked hard disk drives.
- A network makes it possible for all computers on the network to gain access to the Internet if the school has established an Internet connection.
- A network makes it possible for teachers to manage and monitor what students are doing during a lesson. Classroom management software enables a teacher to display an image on his or her screen on each student's computer. This eliminates the need for an expensive data projector in the classroom. Similarly, the teacher can display the screen of a student's computer on everyone's system to show how different students have completed tasks. This type of software can also be used to keep students on task, since they are not able to wander around the Internet, play a game, or work on other tasks.

Three basic types of computer networks are commonly used in schools:

1. A cabled network, often called an Ethernet network, involves connecting each computer to a central computer or network device via a special dedicated network cable installed in or on the wall, or in or along the floor of the room. Each computer plugs into the network using a short cable. To be connected to the network, each computer must be equipped with an Ethernet adapter. Fortunately, most computers sold today include a network adapter. A cabled network provides faster network communication than do the other two types of networks.
2. A wireless or WiFi network involves the use of a wireless or WiFi "radio" that sends and receives signals to

computers that are equipped with a wireless or WiFi adapter. Most laptop computers manufactured today include wireless adapters, and small adapters can be purchased and installed easily on desktops to enable them to be connected to a wireless network. The WiFi radio is then connected to a network device that links it to different devices such as a central computer or sever, a printer, a shared network hard drive, and the Internet. A WiFi network does not need to have any cables installed in the walls or floor other than the one that connects to the Internet. The speed of WiFi network communication depends on the type of WiFi system built into the computers on the network. In addition, each computer shares a fraction of the capacity of the WiFi radio, and as more computers are added to the WiFi network, the total capacity available to each computer decreases. It is similar to sharing a cake: as the number of people sharing the cake increases, the size of each person's slice gets smaller.

3. A powerline Ethernet network uses a building's system of electrical wires to connect computers together and access shared services and resources without having to install special network cables in all of the rooms in the school. The computers are connected to the building's electrical system through a powerline Ethernet adapter. This is a small device, about the size of two packs of cards (as shown above), that plugs into an electrical outlet. A network cable is plugged into the adapter, which may also have an electric outlet into which other electric devices can be plugged.

An example of a powerline Ethernet adapter

One common approach to using a powerline Ethernet network is to use it to connect a WiFi radio to the powerline Ethernet adapter so all computers in the room are connected to a wireless network, and through the powerline Ethernet adapter, they can also be connected to computers in other classrooms, the school's server, or the school's Internet access point. Since the small powerline Ethernet adapters can be moved to rooms where they are needed, it is inexpensive to create a fully networked school. This is much less costly and easier than building a cabled network that connects all of the rooms in the school or building in a school-wide wireless network.

In addition to the hardware and infrastructure needed to establish the network, software to manage access to and use the network is also needed. The simplest networks do not need any additional software; in most cases, the computer's operating system software (Microsoft XP, Windows Vista, or Windows 7) can be configured to connect each computer to basic shared devices. More advanced network functions will require that special network operating systems software be installed on the central computer or server and configured to allow each registered user to access and use network services.

Commercial network software, such as Microsoft's Small-Business Server software, can be purchased, and open-source Linux OS software can be installed for free. Setting up and managing a small school network requires some skill and knowledge however, and experience around the world shows that students can learn how to do this. In Macedonia, Brazil, Senegal, and Indonesia, for example, students who are part of schools' Student Support Technician Clubs (SSTCs) (see Unit 6 for more information on SSTCs) are responsible for maintaining their school's network

Peripheral Choices: In addition to computers, it is often necessary to include other hardware to complete your computer system. A brief discussion of some of the more common peripherals for school computer systems follows.

Printers are one of the most common computer peripherals found in school computer systems. While many printers are relatively inexpensive to purchase, the cost of ink or toner and paper can add up quickly. As with computers, it is important to evaluate printers from a TCO perspective. The many types of computer printers can be organized into three broad categories based on the needs and budgets of most schools: 1) color inkjet printers; 2) black & white LaserJet printers; and 3) multifunction inkjet and LaserJet printers.

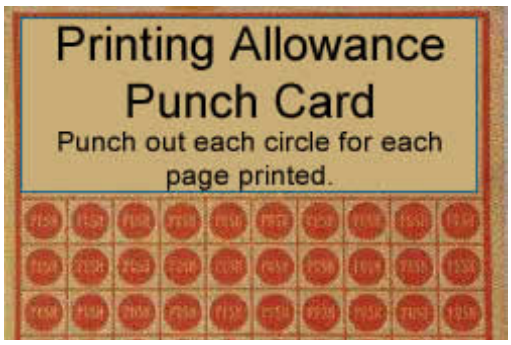
- Color inkjet printers are usually the least expensive to buy but often have the highest per page printing costs. If you decide to purchase an inkjet printer, we recommend that you do not buy ones with vertical paper feeds. Experience shows that in schools, dust, insects, and other items can easily fall into the paper bin, which can damage the printer. We recommend that the paper bin be horizontal (as shown in the picture above).

An inkjet printer with a horizontal paper feed.

- Black & white LaserJet printers are faster and can have a lower per page printing cost than color inkjet printers. However, they use more electricity and can be damaged more easily by power surges and low levels of electricity. They are also more expensive to buy initially and, therefore, more expensive to replace. They are also more complex and more difficult to maintain and service, and spare parts may be difficult to find in some locations.
- Multifunction inkjet and LaserJet printers combing printing, scanning, and copying functions in a single device. This simplifies the computer system and can be less expensive than buying two or three separate devices. Some multifunction printers also include fax capabilities. One of the challenges of multifunction printers is that the copying function is simply a process of scanning and printing a document. Copying on these devices is much more costly than it is using conventional photocopiers. Also, the copying function is much slower with these devices than it is with conventional photocopiers.

You should keep the following considerations in mind when evaluating different printing options:

- Make sure ink or toner cartridges are locally available for the printers you are considering.
- Calculate the TCO for the printer by estimating the number of ink or toner cartridges and the amount of paper you will need to buy each year, and then add this to the purchase price of the printers you are considering.
- Inkjet printers that offer different cartridges for each color can be less costly to use over time, since you only have to replace the cartridge that is empty. The cartridges that include all colors in a single cartridge will need to be replaced once one of the colors is used up, even if you have barely used the other colors.
- Some more expensive printers automatically print both sides of a sheet of paper, which helps to reduce the amount of paper used. All printers can print on both sides of a sheet if the user manually flips over each sheet of paper.
- Printing material from a computer is easy; users just click a button on the screen. This can make printing addictive and lead to increased expenses for printing and maintenance. Some schools address this problem by giving each student and teacher a punch card (as shown above) or coupon book specifying the number pages that can be printed for "free" during a specific period such as monthly or over a semester. Once a user has printed all of his or her free pages, the user must pay for any more he or she wants to print. The cost for additional printing is calculated on a cost recovery basis, which is the actual cost of printing one page (ink plus paper) with a 10 to 20 percent additional charge for maintaining the printer. This kind of system



A sample punch card to control printing costs.

makes people consider carefully whether they really need to print a document or not.

Uninterruptable power supplies (UPSs) (as shown in picture below) are often purchased for each desktop computer so if the power goes off, the computer will stay on for a few moments to allow the user to turn it off properly without losing any work. Unfortunately, the batteries in these devices, especially low-priced UPSs, tend to lose their capacity to hold a charge in a year or so. Also, not all UPSs have the capacity to prevent power surges from damaging computers. The cost of these devices will increase the cost of a computer lab using desktop computers since each computer needs one device. An alternative is to purchase a good-quality **surge protector** (as shown above) that can be used with two to four computers. It is more important to

An example of a UPS.

An example of a surge protector.

protect computer equipment from power surges than to protect them only from power loss. Also, surge protectors can be used with all computer equipment. They are less costly than UPSs, so if they are damaged by a power surge they are less costly to replace than a computer or UPS. When buying a surge protector be sure that you are not just buying a simple power strip.

If electrical power at the school is unreliable, it is advisable that the power to the computer room is turned off by a main switch when the power goes off. Then each computer and all other computer equipment can be turned off. A few moments after the power returns to the school, the main switch can be turned on followed by turning on each computer and other equipment. The reason for doing this is that the greatest amount of damage due to power surges occurs when power is restored at a school. If the main switch is turned off, then the surge will not reach the computers. Another good policy is to always turn off the power at the main switch to the computer lab at the end of the day. Then, if there is a power surge during the night, no equipment will be damaged. Doing this will also ensure that the lab is not consuming power at night when no one is around. This could conserve electrical power and therefore money.

Powerline Conditioners/Stabilizers are used to keep the level of electricity (voltage) constant. This is especially important for computer networks, which can be disrupted when the voltage fluctuates. If a technician is not able to be in the computer lab to restart the network if the electricity fluctuates, then buying a good-quality Powerline Conditioner/Stabilizer might be the best solution. To protect this device from major power surges, use a surge protector between the conditioner and the wall outlet.

Data Projectors (as shown below) are used with computers to display the contents of the computer screen on the wall so everyone in the room can easily see and read the information. Projectors are often used in classrooms to allow teachers to present information to students. Projectors can be especially useful when there are not enough computers for everyone to use. A teacher with a laptop and a projector can create participatory lessons with digital content. Students can also operate the computer and share what they have created. There are two basic types of projectors, LCD (Liquid Cristal Display) and DLP (Digital Light Processing) projectors. Until recently there were few differences in terms of advantages and disadvantages between these two types of projectors. There is some evidence that the TCO for DLP projectors is less than with LCD projectors. The initial purchase price for the two types is also quite similar.

A typical LCD/DLP project.

Recently, a few companies have produced DLP projectors with LED (light emitting diode) lights that have the same level of brightness as conventional projectors. The big difference between these "bulb-less" projectors (those with LED lights) is that there is no bulb to damage or burn out. Conventional projector bulbs have a lifetime rating of 1,000–2,000 hours (more expensive projectors may have a life time rating of 4,000 hours), while LED projectors are rated at 20,000 hours or more. For this reasons, we recommend buying DLP projectors with LED light technology. It is important to look for projectors that are rated at around 2,000 lumens (the intensity of the light produced by the projector), which is the level required to project images during the day in bright classroom, especially on walls that may not be clean or white. There are several portable LED projectors rated at 100–200 lumens (as below) and cost between US$300 and US$500. While they may be attractive because they are portable (some even run on batteries) and relatively inexpensive, they will only work well for small groups and in a dark room. At the time this Toolkit was written, Casio Corporation was manufacturing a line of "green" LED projectors rated at 2,000 – 3,000 lumens and that generate much less heat than conventional projectors. (see below) As a result, these projectors consume much less electricity than other varieties. The TCO of the LED projectors should be much less than that of conventional systems, and they should be less prone to failure.

An LED "bulb-less" projector from Casio.

What software should we obtain for our computers, and where can we get it?

Software, which enables computers and their peripherals to function, comes with all of the instructions needed to operate, computers, communicate, and take instructions from users to accomplish specific tasks. For schools, the many different types of software can be organized into the following four categories: 1) operating system (OS) software; 2) basic productivity applications; 3) educational software; and 4) utilities to carry out specific utility functions to manage and maintain the computer, and other applications to perform other work. Within each of these categories of software there are three general types or varieties: a) commercial or fee-based software; b) open-source software that is free to use and allows users to modify and customize the underlying code; and c) freeware that is free to use (often only for educational users) but users are not allowed to modify the underlying software code.
The Toolkit will discuss each of these categories below to help you determine which of the software types is best for your school's situation and needs.

Operating System (OS) Software: As mentioned earlier, two major types of OS software are available, Microsoft Windows® and Linux.[8] Windows® is a commercial product that users must purchase. Most computers sold around the world (other than Apple computers) come with some version of Microsoft Windows® installed, and its price is included in the cost of the computer.

[8]At the time this Toolkit was written, Google Corporation had recently released the initial version of its Chrome OS. This OS is being designed to operate a computer that is universally connected to the Internet. For many schools in the world that have no or only limited access to the Internet, the Chrome OS many not be useful for some time to come.

A few manufacturers also sell computers with a version of Linux installed, and these systems are less costly than those with Windows® installed since the company didn't have to pay for the OS. It is also possible to buy computers without an OS installed so that users can install the OS that they want.

Microsoft Windows® is currently the dominant OS for personal computers. As a result, many more people know how to use, manage, and maintain Windows® than know how to use the different varieties of Linux. Also, since Windows® is more common in offices and companies around the world, it is important that students learn to use it so they have the basic set of computer skills employers demand. Unfortunately, using Windows®, especially for schools or ministries of education that are buying many computers, can make the TCO much higher than it would be if Linux were used. For example, the Ministry of Education in Macedonia decided to install Linux on the servers used with the thin client systems the government installed at all primary schools across the country. With hundreds of severs being purchased, the savings from using Linux rather than Windows® were substantial, which enabled the Ministry to buy more computers for its schools. The savings realized from using the Linux OS did not stop with just the OS. All of the other software the government wanted to install on these servers was also open source and, therefore, free from any license fees. In the end, the Government of Macedonia didn't pay any money for any of the software on these computers. It also will not have to pay for updates and future versions.

There are, however, other costs involved in using Linux. Since the teachers and computer technicians at the schools were not familiar with Linux and the other open-source software on these new computers, the government and donor organizations that were helping to improve education in the country had to spend money to train teachers and technicians to use this open-source software. Additionally, money had to be spent to translate the OS and open-source applications to Macedonian and Albanian (the two languages spoken in Macedonia). This was both a cost and a benefit. Since Macedonian is only spoken in Macedonia (a small country with a little more than two million people), nearly all commercial software is not available in this language, and it is not possible for the country to create a local language version on its own. Since users can customize open-source software, it was possible for the government to create local language versions of its software for use in schools and households across the country.

One of the most important questions to ask when deciding which OS to use is whether people with the skills and experience with Linux and related software are available to help the school use these open-source options. For example, in South Africa and Brazil, Linux has become very popular, and a number of people are skilled in using it and a variety of other open-source applications. Because of this, schools find it much easier to choose Linux rather than Windows®. At the same time, students who learn to use Linux are not necessarily disadvantaged in the job market if they are more familiar with Linux than Windows®. Usually, students become skilled in both since the computers they have at home are usually Windows® -based systems. In other countries, this situation will be the reverse, so choosing Linux over Windows® could end up being more expensive.

It is possible, however, to configure a computer to use both OS. The user would choose which OS to use when he or she starts the computer. This "dual-boot" configuration, as it is called, allows users to learn to use both types of OS software.

Basic Productivity Applications: The three basic types of productivity applications most commonly found installed on school computers are word processing, spreadsheet, and presentation software. Again, Microsoft is the dominant producer of productivity applications and sells them as different versions of its Office Suite, which includes Microsoft Word (word processing application), Microsoft Excel (spreadsheet application), and Microsoft PowerPoint (presentation application).

The main alternative to Microsoft's commercial application suite is a suite of open-source applications called Open Office (http://www.openoffice.org), which includes Writer (word processing application), Calc (spreadsheet application), Impress (presentation software), Draw (application for creating diagrams and sketches), and Base (database application). The Open Office suite is freely available to download and can be used and distributed free of charge. It is available in many different languages, and there are versions of Open Office for use on computers running Windows® and Linux. The latest version of Open Office can open and use files created with different versions of Microsoft Office applications. Also, files created with Open Office applications can be saved so they can be used by people who are using Microsoft Office.

To compete with Open Office, and to make it possible for schools to buy the Microsoft Office suite rather than "pirate" it, Microsoft has established partnerships with many ministries of education around the world through its Partners in Learning (PIL) program, which enables public schools to receive legitimate copies of Microsoft Office at very low costs. If you are interested in using Microsoft applications, you should contact the local or regional Microsoft representative and ask whether Microsoft's PIL program is active in your country.

Google Corporation has also developed a suite of online office applications, called Google Docs, which includes word processing, spreadsheet, presentation, and drawing applications. Google Docs are designed to be used on the Internet, not on stand-alone computers.

Educational Software: Software that people use to learn something can be classified as educational software. Because this definition could include all types of software, even entertainment software and games, it is important to refine how we classify software as educational. Broadly speaking, educational software is any software that is created with the explicit objective of enabling people to learn new skills, improve existing skills, or gain and enhance critical cognitive capabilities (logical thinking, making predictions, solving problems, thinking critically, etc.). For example, there is software students can use to practice different types of mathematical tasks, improve spelling, and increase their vocabulary. There is also software to help someone learn to do a specific task such as using Windows® or other complex computer applications. Training software can also teach someone to dissect a frog, build a simple electric motor, diagnose and repair a computer, or learn a foreign language. Other software, such as strategy games and simulations, can enable students to strengthen their strategic thinking skills,

logical thinking, and problem-solving and prediction skills while also having fun.

Educational software can also help a teacher create resources and learning aids to enhance student learning. For example, there is software that makes it easy for teachers to create crossword puzzles to help their students learn basic vocabulary and concepts. Finally, a class of educational software organizes and presents information, often reference information, to learners in interesting ways using multiple media. Examples of these types of educational software include a digital encyclopedia, dictionary, and thesaurus.

As with the software, categories mentioned earlier, some educational software is commercial, others are open source, and still others are free for non-commercial use. A connection to the Internet is needed for schools to find and download open-source and free educational applications. Schools with computers using Linux can download a comprehensive set of educational software from Edubuntu (http://edubuntu.org/). One part of the Edubuntu community, the KDE Education Project (http://edu.kde.org/) focuses on developing high-quality educational software that is available free of charge. When this Toolkit was written, KDE educational software was being repurposed to run on computers using Windows® as well (http://techbase.kde.org/Projects/KDE_on_Windows).

Before your SPT decides to buy commercial educational software, you should search the Internet carefully to see whether a similar free or open-source application is available. Then you can test this with your students before spending the money to buy software that may not be useful.

Finally, some of the best educational software is included in the suite of office applications discussed above. You and the SPT should encourage the teachers and students at your school to use these applications to create tools and resources to make learning exciting and enable students to build and practice many critical skills and abilities.

Software Utilities and Other Applications: This is a catch-all group that includes software to help manage and maintain your computers; to protect your computer system from computer viruses, spyware, and other malicious software; to help you communicate with others around the world; to explore and use the Internet; and to enable teachers and students to do specific tasks. As with the other three categories of software discussed above, some of the software in this group is commercial, some is available for free, and some is open source. The list below briefly outlines the different types of software included in this category.

- Utilities to help you **manage and maintain your computers:** One of the most important utilities for every computer with Microsoft Windows® is some form of antivirus software. Several types of antivirus software are available free of charge on the Internet.

  Even if your school's computers are not connected to the Internet, they can become infected with viruses by people who use files they created at home or at a cyber café on the school's computers or use USB flash drives/memory sticks with school computers. Many computer viruses are not destructive, but all of them can disrupt the operation of your computers and make them work more slowly. Some viruses can be very destructive by deleting files and even

disabling the computer's OS. When computers are connected to the Internet, some viruses can take control and distribute malicious software or engage in illegal activity. Other viruses can steal information stored on a computer via the Internet. It is critical, therefore, that your school installs a good antivirus application and keep it up to date by installing new antivirus definition files regularly. Doing this will require some type of access to the Internet, either by having one or more of your school's computers connected directly to the Internet, or by downloading files at a cyber café or from another computer outside the school that has Internet access, and then installing these files on the school's computers.

- Another group of useful utilities are those used to **compress (zip) and un-compress files.** One of the best free utilities for this is Zip Genius, which is available for free on the Internet in different languages. Adobe Acrobat Reader, also available for free from the Adobe website, enables users to view files that are PDFs (portable document format). Other free and commercial utilities enable you to create PDFs. One popular PDF creator is PDF995, which can be purchased for US$9.95 or can be downloaded for free (supported by advertisements). Another useful and free utility, CrapCleaner, will help clean clutter from your computers, thus making them run more smoothly.
- Another group of utilities **enables users to communicate** with people at a distance if your computers are connected to the Internet. The most common tools for doing this are free web-based email services such as Yahoo Mail (http://www.yahoo.com), Gmail (http://www.google.com), and MSN (http://www.msn.com). These services also offer free Instant Messaging (IM) services, which allow users to engage in text and voice chat with other members on the same IM network. One of the most popular tools to enable people to talk with others at a distance either via a computer-to-computer connection or a computer-to-phone connection is Skype (http://www.skype.com). This free tool enables users to talk for free with one or many people at the same time via the Internet when all users are connected via computers. Skype also allows people using a computer to call someone on their phone and send text messages to cell phones. These computer-to-phone services, while inexpensive, are not free.

How should the computer lab be configured for quality teaching and learning?

It is common to arrange desks in the computer rooms in a series of rows facing the front. Unfortunately, for many reasons, this is the worst possible way to arrange a computer lab. First, teachers standing in front of the room cannot see what the students are doing on their computers during the lesson. For example, it is not possible for the teacher to see whether any students are falling behind or making mistakes. Also, teachers are not able to tell whether all of the students have completed a step and are ready to move on. Also, since students are curious, it is common for them to explore the computer they are using during a lesson rather than staying on task, and the conventional arrangement in rows prevents the teacher from knowing which students are not focusing on the lesson. It is can also be very difficult for teachers to move among the desks, to provide personal attention, especially in a crowded lab

where two or more students are sharing a computer.

There are also practical reasons why arranging the lab in a series of rows is bad. For example, in the case of desktop or thin client systems, this arrangement makes it difficult to connect the computers to electricity and network cables. To address this issue, channels are dug into the floor for electricity and network cables and then covered with wooden, metal, or cement planks. Building these channels into the floor can add significant expense to the school's computer system and lab. Also, once the channels are in place, it is difficult or impossible to change the arrangement of the desks and computers.

For these educational and structural reasons, it is much better to arrange the desks with desktops computers or thin clients along the walls. All of the cables can then be fixed in conduits along the base of the wall without costly changes to the room's structure. More important, teachers can see what all of the students are doing on their computers and can easily move among them to provide personal attention. It is also easier for students to watch and learn from their peers and to form dynamic learning teams.
If your school chooses to buy laptop or netbook computers, you will have much greater flexibility in arranging the furniture in the room to meet active and team-based learning objectives. For example, desks can be clustered together to create learning pods or arranged along the wall. These changes in the way a classroom is organized can be made to suit a specific learning objective or lesson—the arrangement does not have to be permanent. This feature of using laptops and/or netbooks can enable your school to avoid having to create a dedicated computer lab.

Concluding Thoughts for Unit 3: After reading this unit, we hope you and your SPT are still considering establishing your computer system or lab. Evidence from around the world shows that introducing computers can have a positive effect on teaching and learning and on the relationship between schools and their communities. While it can be challenging to establish a high-quality computer system or lab, and there are many things to learn and decisions to be made along the way, the effort has its rewards—higher-quality education. The remaining units in the Toolkit will help you and your team achieve success in establishing your computer system, maintaining it so that it continues to deliver benefits, and sustaining and growing this asset at your school.