Just In Time Publication

August 2008

USAID
FROM THE AMERICAN PEOPLE

EQUIP1
Educational Quality Improvement Program
Classrooms • Schools • Communities

Alternative Computer Labs: Thin Client Laboratories A Cambodia Pilot

In an effort to make access to information technology (IT) more cost-effective and sustainable, the USAID-supported EQUIP1 Educational Support to Children in Underserved Populations (ESCUP) project[1] in Cambodia is piloting a cutting-edge computer lab that uses "thin clients." Rather than stocking a computer lab with 10-15 individual computers, a thin client lab is a set of networked workstations that run off of one central computer, or central processing unit (CPU). Most of the cost-savings resulting from the operation of a thin client lab come from reduced equipment costs, low maintenance requirements, and reduced energy consumption. Other factors, such as environmental ruggedness, slim profile, centralized resourcing, and the decreased likelihood of viruses make thin client labs an attractive alternative to traditional computer labs in developing countries. In July 2008, the ESCUP Program put one prototype thin client lab in place in Kor Secondary School in eastern Cambodia.

In spite of the pessimism of many naysayers who believed that such technology could not work in Cambodia, lab set up has been completed and the lab is currently operating without any difficulties. To increase the likelihood of sustainability of the lab, the project also installed solar panels to power the facility. The use of solar panels for a lab of over 10 computers is made highly feasible with thin client technology because each workstation only consumes 35 watts of power compared to about 300 watts of power for a workstation in a traditional lab that consists of a CPU tower and a monitor.

ESCUP is using the thin client prototype lab described above to iron out all kinks in the set-up, operation, and maintenance of these types of labs and inform future installations; the prototype will then become a model for implementing future labs in Cambodia. With support from USAID, 12 more labs will be set up over the next year in Cambodian secondary schools. Early cost-savings are encouraging: the equipment for the lab is 44% cheaper than that in a traditional lab and there is an 88% reduction in energy use overall. ESCUP expects additional advantages as such labs will be operational for longer and upgrades will be greatly facilitated by the fact that only one computer in the lab, the mother station, needs to be modified with new software and RAM memory.

1 ESCUP is implemented by the American Institutes for Research (AIR), World Education, Kampuchean Action for Primary Education (KAPE) and CARE.

Context

Providing access to computer technology for Cambodian children is an expensive undertaking – not only in terms of monetary costs, but also opportunity costs. With competing needs for even more basic requirements such as textbooks, teachers, and basic teaching supplies, most projects have been hesitant to divert scarce resources from these needs into information technology. Projects such as the One Laptop Per Child Project (OLPC) have been surrounded by controversy in development circles for putting an emphasis on IT before other basic needs have been met. With this history as a backdrop, efforts in Cambodia to introduce youth in state schools to Information Technology (IT) have mainly utilized the development of traditional computer labs as a preferred strategy. Because labs are centralized in one room, maintenance and usage is more manageable.

Early attempts by many donors in Cambodia to develop computer labs often took the form of dumping used computers on secondary schools and leaving the schools to their own devices to identify appropriate IT curricula, provide for energy costs, set timetables, ration usage, and train instructors. Needless to say, these efforts usually did not amount to much. Eventually, NGOs began implementing activities in which schools applied, and were selected for, computer labs. The NGOs provided all of the hardware and trained instructors identified by the school while local partners assisted in the coordination and actual setup of the labs, room renovations (i.e., increased security with metal doors, dust proofing, and electrical wiring), identification of appropriate curricula, and subsequent monitoring. Government schools have been expected to provide a room to house the lab as well as student desks for furnishings. They are also expected to assign teachers to receive training and staff the labs as well as see to security when the lab becomes operational. In many cases, schools and communities have also provided cash matching funds to facilitate the renovation of a lab.

While traditional computer labs have provided access to and taught basic computer skills to thousands of students in Cambodia since they were first introduced at the beginning of the decade, the traditional computer lab model has raised a number of significant issues in implementation, including high costs (for equipment, set-up, and maintenance), high energy costs, theft, viruses, the need for highly qualified technical support staff to repair and maintain the labs, and the need for frequent upgrading. This backdrop provides the primary rationale for ESCUP's efforts to develop a new lab configuration using thin client technology.

The Thin Client Solution

Thin clients are self-contained devices that can take the place of a CPU. A thin client is networked to a central CPU and acts exactly like a CPU. There are no moving parts and it is essentially a large circuit encased in a dust-proof container. Each thin client workstation is connected to a monitor and keyboard just as a CPU would be.

ESCUP began the process of developing a prototype lab by identifying a school with strong management and a highly professional teaching force located in a rural area. Kor School met these selection criteria. The project then partnered with a local NGO called Kampuchean Action for Primary Education (or KAPE) who helped to renovate a classroom allocated by the school for the prototype. The community made a cost share contribution to the renovations, which cost over $1,000. Renovation included putting in tile flooring, fans, and adding ceiling tiles to ensure dust proofing. While the tile flooring is not a requirement, it helps in the maintenance and upkeep of the equipment in the room and the project staff and community felt it was a worthwhile investment. ESCUP purchased the technology with USAID funding and transported the equipment to the rural target school. Thin client technology is rare in Cambodia but staff were able to find a supplier with the needed technology. Microsoft Corporation, which recently opened an office in Cambodia, was also able to give considerable guidance about suppliers and needed software. The supplier then trained ESCUP staff on installation and maintenance and they have in turn transferred these skills to local teachers who will be responsible for the lab. The lab is configured with 11 student thin client workstations, which are all networked to a central CPU for the teacher (i.e., a total of 12 stations make up a solar powered thin client lab). More stations could be added in theory but this would require additional solar panels, which would add significantly to the cost, as each additional panel costs $2,500. Thus, a lab of 12 stations is optimum for a rural Cambodian school with no access to electricity, at least in terms of cost. All of the software in the lab is run from the central CPU, which allows different users to work on different programs at each work station at the same time.

Students at Kor Secondary school working in their new thin client computer lab

Traditional vs. Thin Client Computer Labs

A savings in equipment costs of 44% coupled with an energy saving of 88% makes the use of thin client labs a very attractive and exciting alternative. Below is a comparison between traditional computer labs and thin client labs in terms of various factors.

Equipment Costs

Assuming a set-up of 11 student workstations and one teacher workstation with a printer equipment costs for a traditional lab include one printer and 12 CPUs each with a CRT monitor, keyboard, and Uninterrupted Power Supply (UPS) battery.[2] In contrast, a thin client lab requires one mother station (a high-capacity server computer that functions as the teacher's computer) with a UPS battery, LCD monitor, keyboard, and printer, and eleven thin client units, each with an LCD monitor, keyboard, and power surge protector. Table 1 below breaks down the equipment costs by unit for a lab that would consist of 11 student workstations and one teacher workstation that includes a printer. It costs 56% less to buy the equipment for a thin client lab.

Table 1 – Unit cost for equipment in a thin client lab and a traditional lab

	Thin Client Lab	Traditional Lab
Student Workstation Equipment		
Thin Client unit or CPU	$145	$480
Monitor and Keyboard	$180	$120
Surge Protector/Battery	$5	$90
Student Workstation Total	**$330**	**$690**
Teacher Workstation Equipment		
Thin Client unit or CPU	$720	$480
Monitor and Keyboard	$180	$120
Surge Protector/Battery	$90	$90
Printer	$200	$200
Teacher Workstation Total	**$1,190**	**$970**
Lab set-up with 11 student workstations and one teacher workstation	**$4,820**	**$8560**

2 These devices typically serve as a buffer for small power outages in developing countries and provide a period of time to save documents for longer outages. Additionally, a UPS battery can prevent hard drive crashes, which might result from a sudden loss of power on a hard drive's internal spinning disks. Thin client workstations do not require a UPS because there is no hard drive that can crash, although the mother station does require a UPS battery. Installing power surge protectors, which only cost about $5, is still wise on thin client workstation, but these can be purchased and installed more cheaply than a UPS backup battery.

In the thin client lab prototype, ESCUP installed LCD screens rather than CRT screens. Although LCD screens are more expensive ($180 versus $120), the use of LCDs, which use 65% less energy, is the preferred alternative for solar powered labs. Additionally, a thin client setup eliminates the need for an Uninterrupted Power Supply (UPS) battery for each student workstation, generating additional savings. While each student thin client workstation does not require a UPS battery, it is still necessary to purchase one UPS battery for the server computer in a thin client lab. Nevertheless, this represents a cost savings as compared to a traditional lab in which a UPS battery is required for every CPU in the lab.

Energy costs

The costs for electricity to run a lab have been one of the most difficult issues confronting implementing agencies in Cambodia. Once an NGO no longer supports the energy maintenance and upkeep of a computer lab, paying for the energy becomes problematic. Because schools are not allowed by government to use their operating budgets for utilities, the primary funding source identified by schools to pay for electricity costs has been the resort to special student fees. This necessarily has the effect of limiting computer access to students who are already somewhat privileged.

While computers consume a lot of electricity, thin clients do not. The thin client unit itself only uses 5 watts and an LCD monitor uses about 30 watts of power, so the total for each workstation is 35 watts. In contrast, a CPU tower consumes over 150 watts and CRT monitors consume over 100 watts, for a total nearing 300 watts. With each solar panel producing only 300+ watts of electrical energy at a cost of $2,500 per panel, it is easy to see how thin client technologies align with alternative energy sources, which are cheaper in the long run but very expensive for initial capital investments. For a traditional computer lab using the set-up described earlier, the power requirements would be approximately 3,600 watts, requiring about $30,000 in solar technology. A thin client lab of 11 stations requires only 385 watts plus another 300 watts for the mother computer for total consumption of about 685 watts; two panels, an investment of $5,000, is required for a thin client lab.[3] Thus, there is a large difference between the investments in solar energy equipment required for a traditional lab versus that for a thin client lab. Because the manufacturer guarantees the solar panels for 20 years, there will be no maintenance costs associated with the panels until 2028, at which time it is very likely that solar energy technology will be much more prevalent and, quite possibly, cheaper. The only recurrent

3 Each solar panel generates 300+ watts. Output varies depending on weather conditions, but schools are closed during rainy season in Cambodia, so this reduces the amount of cloudy days during which the lab is operational. Even when it does rain, it does not seem to have affected energy output by an appreciable amount. Implementation has demonstrated that two panels produce enough output to support a lab of 11 thin clients and one main server, which requires 685 watts to operate.

cost for energy would be battery replacement, amounting to approximately $100 every three or four years. Since schools in Cambodia have their own operating budgets that can be used for repair of such things, schools will easily be able to plan for this expense.

The $30,000 investment required to put solar panels on a traditional lab is prohibitive; therefore, traditional labs in rural areas without electricity are forced to continue using diesel fuel as energy. Generator fuel costs at Cambodian schools runs about $100 per month, or $1,000 each year (for a school year of ten months). While it will take five years for a thin client lab to break even in terms of energy costs, if the savings due to equipment are also factored in, the break even point occurs approximately after one year of operation and becomes more cost-effective after two years. See Table 2 below.

Table 2 – Investment in equipment and energy for thin client lab versus traditional lab.

	Thin Client Lab	Traditional Lab
Year One		
Equipment*	$4,820	$8,560
Energy costs **	$5,000	$1,000
Subtotal for Year One	**$9,820**	**$9,560**
Year Two		
Energy costs **	$0	$1,000
Total for Years 1 & 2	**$9,820**	**$10,560**

* Assumes a one-time cost for each type of lab. Values were taken from Table 1
** Assumes the purchase of two solar panels for the thin client lab (a one-time cost) and $1000 for each year for a traditional lab.

Environmental Conditions and Maintenance

In addition to the cost of the computers and energy used to power those computers, maintenance and upkeep costs can also be high and prohibitive in traditional labs. Putting computers in a room that has dirt floors, an uncovered ceiling and no air conditioning or fans decreases the estimated lifespan of a computer substantially, rendering the investment virtually worthless. Computer labs in most rural schools exist in an environment that is characterized by dust, insects, small lizards, and rodents. These pests easily enter the open back ends of CPU containers (where fan vents are located) and proceed to wreak havoc with the internal parts. This leads to the need for frequent maintenance, even when schools clean computer rooms regularly. Thus, IT programs require local province-based teams that can make visits to labs at least once a month or more if machines break down. Monitoring agencies have generally reported that in any given month, an average of two computers are inoperative due to hardware or software problems or both. The hardware problems arise mainly due to the difficult operating environment and the failure of student operators to grasp the damage that simply switching a computer off does to moving parts that are spinning at several thousand

times per minute. Software problems generally arise from students self-installing incompatible software and games that often come with very damaging viruses.

The large amounts of dust that are sucked in by cooling fans cause electrical circuits to get coated and also impede the operation of the fans themselves. Both of these conditions cause the equipment to become hotter than usual, which eventually leads to mechanical failure. It should be noted, however, that thin clients do not have any moving parts and so do not have fans. That means no dust saturated air is sucked into its casing. Without moving parts, the potential for mechanical failure is greatly reduced. Thin clients are likely to reduce maintenance costs greatly and keep workstations in operation for longer periods of time. It is expected that such visits[4] will only require one hour of oversight per month, compared to over 4 or 5 hours per month for a traditional lab where each individual computer requires maintenance. General purpose PCs are large and thus difficult to rehabilitate. Based on past experience, repairs are often attempted within the lab during daytime hours, which means either closing the lab or adding a distraction to a class in session. There are times when a computer must be removed to headquarters for closer inspection, meaning that one workstation will be down for a week or more. Thin clients are small, cheap, and do not need complicated software installations. They are ultimately swappable if they break. And they are less likely to break because of their simplified construction and high-quality one-manufacturer build.

Space Savings

Without a large computer tower, CRT screen, and UPS battery, additional space becomes available within a computer lab with a thin client configuration. This offers several advantages: new computer labs can be smaller, or that new and existing computer labs can fit more workstations into the same amount of space. This could have important implications for capacity, since students are often doubled or tripled up at one workstation. That said, adding more student workstations to the thin client lab configuration will mean an investment in at least one more solar panel depending on how many workstations are added. As noted above, however, the initial investment is quickly recovered due to savings in equipment and reduced energy use.

Students at Kor Secondary School working at one of the thin client student workstations

4 These visits are conducted by a local partner in the target province.

Viruses

Monitoring teams assigned to traditional labs report that many computers were thoroughly infected with viruses. These viruses usually came from flash disks and CDs brought in by students. One virus laden flash disk or CD can infect an entire network, and suddenly $10,000 in computer equipment is rendered semi-functional. Of course, there are ways to prevent students from infecting lab computers. Technical support staff have in the past configured the workstations to prevent unauthorized software installations and required passwords for any system configuration changes. But these standards were difficult to enforce. Following the path of least resistance, workstations found themselves cluttered up with useless software (installed by students) and it was obvious that computers were being used for things outside of Microsoft Office and typing practice. Thin clients, on the other hand, close down the path for virus entry into the lab network because there is simply no means of inserting a flash drive or CD into the student workstation unit and all changes in configuration happens at the server level.

Centralized Resourcing

Part of the difficulty of running a computer lab for the purpose of computer education is getting every workstation to be identically configured. Each workstation requires the same software in the same state of configuration, and each is required to look the same, as far as windows and system menus are concerned. This did not often happen well, requiring considerable investments of time by technical support staff to constantly reconfigure the labs each month, due to tampering by students. By centralizing the software and configurations through the use of thin clients, only one computer needs to be maintained in this way (i.e., the central CPU unit, which is networked to the 11 thin clients). Changes made here immediately present themselves on all workstations accessing it. This also means that multimedia educational materials are also much easier to use, given the ease with which they can now be distributed in a thin client network. That is, all multi-media presentations can be orchestrated from one computer instead of 10 or 11.

It should also be remembered, however, that configuring all of the thin clients in a lab around a single server introduces a large point of vulnerability into the lab's operation. The obvious question is – if all of these thin clients depend on one server computer, what happens if the server breaks? The obvious answer is – the entire lab is out of service. The same would be true if the network router burnt out. That said, the benefits outweigh the risk of this happening. Repairing the server computer costs the same as fixing any computer in a traditional lab, so in terms of cost, there is no difference. In terms of functionality, on the other hand, thin client labs are at a severe disadvantage when the server computer in not functional. The risk can be minimized by taking the following steps:

- Connect the server computer to a UPS with a data cable will inform the server when there is a power outage so it can safely shutdown, minimizing the risk of a hard disk failure.[5]
- Configure the system to use two identical hard disks, mirrored in such a way that the failure of one allows the second functioning one to be used automatically.
- Careful use of dust covers and monthly cleaning of dust from fans.
- Use diagnostic software, which scans for problems before they cause complete failure.
- Purchasing high-quality memory chips and hard drives (the two most likely components to fail).
- Having on-hand backup systems, fully configured, which can be dropped in to keep labs functional while their original equipment is being repaired. This could be structured into the agreement between schools and the technical support organization, ensuring that there are one or two such systems available at any given time in case a server goes down.

Advances in Technology

Because all of the actual computation in a computer lab under a thin client regime would be done on the server, advances in technology could be realized simply by upgrading the server. This saves enormous amounts of time for technical support staff to upgrade software in a lab. Additionally, there are cost-savings as well due to the fact that only the server computer must have the upgraded technology installed. For example, if upgraded RAM was necessary, only the mother station would be upgraded in a thin client lab, while in a traditional lab the RAM in every single computer would require upgrading; the cost to upgrade the thin client lab would be 1/12 of that for a traditional lab. Once the mother station is upgraded, the entire pool of clients in a lab are immediately affected. So, in a traditional lab, all computers need to change as the software and hardware become outdated, but in a thin client lab, only one of the 11 or 12 pieces of equipment need to be upgraded.

Theft

A motorbike is an attractive target for theft because it is an item that is fairly generic and can easily be converted into cash. The same is true of mobile phones. And to the same extent, PC workstations and monitors are also very attractive and locally re-salable. Thin clients are useless without a server, and given that they are such an unknown technology in Cambodia, it is unlikely that if stolen they will end up in the hands of people that actually want them. Taking additional steps to secure them makes it even more unlikely they will get stolen.

5 The server computer in a thin client lab requires a UPS, but in a thin client lab it is only necessary to purchase one UPS for the teacher's server computer and not for each student workstation.

Nevertheless, theft by thieves who are tantalized by anything with an LED and an electrical cord is still a real possibility. Because of a thin client's small size and light weight, a lab could easily be emptied in short fashion, whereas a traditional lab equipped with desktops would take much more work and time. The One Laptop Per Child program struck upon an interesting idea to lessen the likelihood of stolen OLPC laptops by painting them green.

Modes of Procurement

Although there was concern that thin client technology might not be available in Cambodia, this problem turned out not to be the obstacle that it could have been. Nevertheless, there are only two suppliers in the entire country that appear to know what thin clients are and have access to them. This might prove to be more of a difficult problem in other developing countries that are far from technology hubs that are ubiquitous in East Asia.

Training Requirements & Capacity Building

Thin clients are not general purpose computers and do not operate as a standard computer does. The software that powers a thin client is developed by Microsoft and it is very well documented, but it is not part of the general computer curriculum at most technical schools or universities in Cambodia. Additional training for the assigned staff is required to operate and maintain thin client computer labs. Capacity building has not been difficult, however, given that the configuration of thin clients and the server are very well documented, so it has been possible to put together specialized procedures and guidelines.[6] In order to reduce training requirements, a "master" copy of a working server installation could be cloned from a hard drive kept for that purpose. In addition, the supplier has been able to provide direct training to staff and counterparts and are available as a resource should major issues arise.

Software Requirements

The software requirements to run a computer lab configured with thin clients were also thought to be a potentially big problem in setting up the prototype lab. Once again, this proved not to be the case. The software is readily available through the supplier. The main server runs on Windows XP Professional Service Pak 2, which is available through Microsoft while the thin client software to operate the network is free and comes with the brand of thin client purchased for use in Cambodia. The name of this software is NC2000xp, which is manufactured by a Chinese company called Net Computer. Thus, software requirements turned out not to be a major problem in the set up of thin client labs either.

Conclusion and Forward Directions

The introduction of thin client labs under ESCUP has addressed major technical issues in

6 Currently these procedures and guidelines are only available in Khmer.

promoting ICT access in Cambodia. However, their introduction needs to go beyond issues of technology but should also impact teaching and learning in target schools. As a first step in this direction, the program has installed *Encarta* and other educational research programs on the server in the lab so that students can easily access a wealth of information on animals, history, maps, and other topics. ESCUP will next move to build a bridge between these interactive media resources in the computer lab and the way that teachers teach. Thus, several teacher training modules on using interactive media for classroom instruction are currently in development to help build this bridge. When these are available, they will be posted on the ESCUP website, which is provided below. The same is true of monitoring tools that need to focus both on technical maintenance as well as integration of thin client lab capabilities into the teaching-learning environment of the school. It is likely, however, that it will be a long process before teachers change their traditional behaviors and actively incorporate interactive media into their teaching.

In conclusion, the investment in a thin client prototype lab in Cambodia is an exciting undertaking with potentially valuable and advantageous impacts. It is extremely likely that this type of lab will make the investment in Information Technology much more worthwhile for governments and projects in developing countries – bringing IT to the disadvantaged at lower costs, particularly in this age of high energy costs. Of course, caution is paramount and it is important to ensure that one is not sacrificing educational quality for the lower investment price. Initial indications from the ESCUP experience, however, are that this technology is available, cheap, reliable, energy efficient, and highly conducive to schools in rural environments in Cambodia.

For more information about ESCUP's thin client prototype lab, please contact Chief of Party, Mr. Kurt Bredenberg at kurtb.worlded@online.com.kh or Mr. Sok Channa, IT Team Leader at sokchanna@kapekh.org or Mr. Sieng Heng, CTO for the ESCUP project, at sheng@usaid.gov. ESCUP's website address is: http://www.equip123.net/equip1/escup and most documentation will be made available through the Activity Menu Toolkit, found here: http://www.equip123.net/equip1/escup/activitymenu.

Thin client computer lab at Kor Secondary School