AC 2010-2073: EXPERIENCE WITH USING THE XO-1 (OLPC-ONE LAP TOP PER CHILD) TO JUMP START PRE-ENGINEERING AND SCIENCE EDUCATION IN RURAL UGANDA

Frank Duda, Grove City College

Frank T. Duda, Jr. obtained his Ph.D. degree from the University of Pittsburgh in 1975. He is a registered professional engineer in the state of Pennsylvania and is currently a professor of electrical engineering at Grove City College, Grove City, Pennsylvania

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Abstract

Since 2000, faculty and students from Grove City College's Engineering Program have been assisting secondary schools in rural northwestern Uganda develop applied science education. In 2004, in cooperation with donors from the US and UK, a new secondary (high school) girls' boarding school was started with an initial class of 25 girls. At the same time, the Ugandan Government Ministry of Education made biology, chemistry and physics compulsory for secondary students. The Ugandans partnered with the Japanese Government to embark on a new applied science education approach through the Secondary Science and Mathematics Teachers' Program (SESEMAT).

Three science teacher's seminars were organized and offered to approximately 30 Ugandan secondary science teachers. The teacher's were shown an initial version of the XO-1 Laptop and the OLPC educational approach was explained. The teachers agreed unanimously to investigate if the XO-1 could be a viable teaching aid of applied science in rural Uganda.

This paper describes our experiences in evaluating the viability of the XO-1. Some issues considered are the mechanics of connecting the XO-1 to the internet in rural Uganda, sustainability of the XO-1 in the harsh environments, comparison of the XO-1 to other computer hardware delivery systems such as a net-book, and the advantages and disadvantages of delivering applied science education considering the constraints that the Ugandan teachers must teach from a prescribed syllabus and Ugandan students must pass the Uganda National Education Board (UNEB) exams to continue their education. The XO-1 was evaluated at the new girls' secondary boarding school which now has a population of 125 students and the S4 students recently completed their UNEB exams.

Background

Ten years ago an aggressive development program was started in Pittsburgh to partner with the Church of Uganda to further the economic, social and humanitarian development in the Bunyoro Kitara Kingdom[1] (BKK) in northwest Uganda. This Kingdom is the oldest Kingdom in Africa and by most accounts the poorest region in Africa, if not the world. To date, Pittsburghers have invested approximately 5 million dollars USD in the region. Well over 500 individuals from Pittsburgh and other locations in the US as well as from other countries have been involved in the work, most having travelled to Uganda to be involved first hand.

Some of the results of this program include: 1) A health clinic has been recovered, refurbished and upgraded to a level 1 health facility with a newly opened maternity ward and operating theater. 2) A 20 acre coffee farm was developed and is being operated by a team of Ugandans. The harvested coffee is processed and sold out of Pittsburgh and the generated profits sent back to the Kingdom. 3) Approximately 30 new water bore holes have been drilled and an equal number of non functioning bore holes have been refurbished and put back into operation. 4) An orphanage with a capacity of 100 children has been built and is currently operating at maximum capacity. 5) Several hundred solar photovoltaic lighting systems have been procured and installed in medical facilities, school facilities, and private homes and community facilities.

Very early in the program it became clear that it would be beneficial to invest resources and manpower to partner with the education community in Uganda to develop pre-engineering and secondary science education in the BKK. The previously discussed aggressive development program became the catalyst for the effort discussed in this paper: the effort to use the XO-1[2] (OLPC-One Lap Top Per Child) to jump start pre-engineering and science education in rural Uganda.

Findings of survey trip to BKK in 2004

The author organized an initial survey trip to BKK. The trip was made up of a team of engineering educators and coordinated with education leaders in BKK. A summary of the trip and findings of the team were reported in a previous ASEE paper[3] and the authors were awarded the ASEE International Division Global Engineering & Engineering Technology Educator Award for 2005.

Three significant findings of the team relating to the XO1 project were the following: First, the team found one progressive innovative secondary school (Bulindi Secondary School in extremely rural BKK) which had a well equipped multiple IBM type computer lab consisting of laptops connected to the internet through a satellite system. This system was donated by a group of educators from Canada and was operated by two computer knowledgeable individuals who had set up the facility and were staying on for an additional year to make sure that it was kept in operating condition. The infrastructure needs of the system (electrical power needs, secure facilities, etc.) were provided by the local BKK community (primarily the parent-teacher's organization of the school).

Second, the team found that there was a significant need to change the way of educating the Ugandan children. The system[4] was "pass the exam" outcome oriented instead of "application" oriented. The education system is modeled after the Ordinary/ Advanced (O/A) level approach taken in the UK. Although there are slight differences between the UK system and the Ugandan system to account for the Ugandan culture, the Ugandan students must pass periodic Uganda National Education Board (UNEB) exams to continue their education and the teachers must show that their students are successful in passing the exams. In general, the team found that Ugandan teachers must teach from a prescribed syllabus and Ugandan students must pass the UNED exams to continue their education. The team had the opportunity to visit with officials in the Ugandan Government Ministry of Education and Sport. They found that the government of Uganda had recently partnered with the Japanese Government to address the needs of adding an applied science component to the educational process. The program is called the Secondary Science and Mathematics Teachers' Program[5] (SESEMAT). The subsequent adoption of the program made biology, chemistry and physics compulsory for secondary students. The SESEMAT program also recognized the limitations that the Ugandan educational system has in trying to meet the need to add the applied science component to the educational process; namely, the lack of resources (lab infrastructure, lab equipment and supplies, etc.). One component of the SESEMAT program is the development of applied laboratories using readily available supplies and to teach the teachers how to use the laboratories.

A third finding of the survey trip was that for the most part the teachers in BKK were adequately prepared to teach applied science to their students. They recognized the limitations of their current educational system and were supportive of the SESEMAT approach. Although their formal education was limited by the O/A requirements, the teachers recognized the importance of applying their formal education to nurture development. They were in fact practicing applied science and engineering in their daily lives. However, because they were located in BKK, far (200 km) from the center of power in the capital of Kampala, they were not adequately informed of the new program. They wanted to meet with other teachers in their region to learn from one another. To meet this need, the team developed a series of teacher's seminars.

Teacher's seminars

Three teacher's seminars have been conducted since 2004. The general format is to gather secondary science teachers together at one of the schools and offer them a program to meet their desires to learn more as to how to incorporate applied science into their teaching and still meet their requirements as specified by the Ugandan Government. The seminar program has grown progressively with 15 attending the first seminar in 2006 and 30 attending the most recent seminar in August, 2009. Fourteen teachers from the first seminar attended the other two also. The Government of Uganda was also informed of the fact that the teachers from BKK were not given adequate attention and they have also started a program to train teachers from BKK to train other teachers in the SESEMAT program. Five of the 14 teachers who attended our seminar in August 2009 also had the opportunity to attend one of the government programs.

At the first seminar, the teachers were shown the XO-1 laptop and the One Lap Top Per Child (OLPC) educational program was explained to them. The OLPC educational program consists of a near indestructible, child friendly laptop preloaded with educational programs and also internet and local area network connectivity. The teachers enthusiastically opened the laptop and started to perform some of the inherent programs. They found that to them the use of the computer was intuitively obvious and they could see the advantages of incorporating the computer into their teaching. They wanted to see what the computer would do when connected to the internet.

Implementation of the OLPC program in BKK

A program is being developed to first procure an appropriate number of XO computers and to also incorporate them into the teaching of pre-engineering and applied science education in BKK. A final phase of the program is to evaluate the effectiveness of delivering educational material using the XO compared to other methods.

The OLPC program was developed with the expectation that countries would purchase one for each of their young people. Although the program is extremely aggressive, several countries have committed to purchasing the laptops. Uganda has not been convinced to participate. The

OLPC program developed another method to obtain the XO. The program entails private individuals buying one for themselves and buying another that would be donated on their behalf to a developing country. The total effective cost to each purchaser would be $400. We have participated in this program to procure the XO for the BKK project. It has not been difficult to locate funders from the original group from the original development program partnering individuals from Pittsburgh with people in BKK.

After the XO's were procured, a decision had to be made where to locate the computers. The first priority was the importance of maintainability of the computers. Although the computers are very rugged and are advertised as being mechanically indestructible, we wanted to put them to the test.

The second priority was the availability of electric power. The computer has a long lasting lithium battery that still has to be powered from some electrical source. A school with either access to the national power grid or its own generator would be ideal. Although alternative electric charging systems such as photovoltaic solar or mechanical operated human, wind or water power were considered, the extra cost involved to obtain these systems would make the project too expensive. However, electrical and mechanical engineering students at Grove City College (GCC) have conceived of senior engineering design projects to meet the XO project's needs of producing a design to reduce the cost of these alternative charging systems.

A third requirement (although not critical) was the availability of internet connectivity. Although the XO could be used as a stand-alone computer, we wanted to evaluate the usefulness and effectiveness of it as an internet computer.

The Bulindi Secondary School previously visited on our first survey trip seemed like the ideal location. In addition, the Head Teacher had attended all three of our teacher's seminars. When we visited Bulindi in August 2007, we saw a far different computer lab from when we had visited in 2004. The Canadian computer people had returned home leaving the computer lab in the hands of the school administration. The original laptops had been replaced with desktops because of sustainability issues with the laptops. Finally, even though the internet connectivity was still available, none of the computers were actually connected due to technical issues.

In short, the well equipped, well functioning computer lab which we saw first- hand in 2004 was in 2007 only a collection of computer hardware not being used and aging quickly. From this experience, we learned that even though the community is supportive – remember the parent teacher's organization provided the infrastructure - it takes a more comprehensive support system to maintain the complex systems that are required to support the XO educational system.

Choice of test site

In late 2004, in cooperation with donors from the US and UK, a new secondary (high school) girls' boarding school, Canon Njangali Girls' Secondary High School, (CN) was started by the Church of Uganda in the town of Hoima in the BKK. One of the school's missions was to provide applied science education to secondary girl students. The school opened with 25 students in 2004 and has grown to a faculty of 15 teachers and 125 students in September 2009.

The school is located on the national power grid and also has its own generator. They have "wireless" internet connectivity for the administration and teachers. The school has an active parent-teacher organization who are constantly providing extra resources to improve education. The Head-Teacher of the school, Esau Muhumuza, was one of the original organizers of the previously mentioned teacher's seminars and has been trained by the Ugandan Government in the implementation of the SESEMAT program. The US Aid (USAID) funded the building of a provisional laboratory building in 2007. In addition the Pittsburgh group has made significant contributions to the science lab infrastructure as well as the purchase of science lab equipment. The most recent addition (August 2009) was a research quality inverted objective 1000X microscope and digital camera system. CN was chosen as the test site.

Experiences with using the XO at Canon Njangali

- The teachers were able to effectively destroy the operating system. The operating system of the XO is a version of LINUX which typically is robust. But during our attempts to connect the computer to the internet, we found that the operating system was compromised. We brought the computer back to the US and reloaded the operating system following the easy to follow instructions on the OLPC support site[6]. The work could have been done at CN but would have been very cumbersome. The process involved downloading the new operating system to a flash drive connected to a Windows based computer connected to the internet. Once the operating system was loaded onto the flash drive, the flash drive was installed in the XO by connecting the flash drive through the XO USB port. There is software permanently installed in the hardware of the XO that permits the XO to read from the flash drive. In general, we found the computer to be well designed for sustainability, very flexible and easy to be modified[7] if so desired.
- The hardware of the XO could not be compromised. The keyboard and display are appropriate for children's use. If an older individual wants to use the XO as a word processor, etc., he or she can easily connect a full size keyboard to the USB port on the XO. A printer can be attached but we have not done that. Unfortunately there is only one USB port on the XO so it is necessary to share that port with the appropriate hardware. The printer must have a USB connection.
- The XO was attached to the internet successfully. However, it could not be attached at CN on their "wireless" system. The "wireless" system in their terminology is actually a wireless telephone modem combination. The XO comes with a WiFi antenna/receiver system and supporting software. We only have to add a wireless WiFi transmitter to a satellite internet connection that was available at another school in the vicinity. We used a readily available D-Link WiFi router which we purchased in the US and took to Uganda. We saw similar devices sold in Kampala that should work as well for about the same price as the one we bought in the US. We also found several teachers and computer support people in BKK with the ability to connect and maintain the computer/internet system. The installation and monthly maintenance of the satellite internet connection would add significantly to the cost of the system.
- Although the use of the XO computer is fundamentally designed to be intuitively obvious, whether it is to the individual user is a function of many interconnected background experiences. For example, when the XO was given to a senior practicing mechanical engineer in Pittsburgh, his evaluation was "I am surprised at how it is not as

intuitively obvious as I expected it to be". There are a complete set of operating instructions on the OLPC web site but we found that it was helpful to provide our own operating manual. A student electrical engineer at Grove City College, familiar with desired applications of the XO, developed a document that provided a brief overview of its functions, how to turn it on and off, and how to use the pre-stored programs appropriate for pre-engineering and science education.

- The pre-stored programs that we tested and found most appropriate and effective are: MEASURE, CALCULATE, PIPPY, and TURTEART. MEASURE can be used to calculate frequency, rms value, etc. of audio signals that can be entered through the microphone or software. CALCULATE is a scientific calculator with trig , Boolean, and logarithmic capabilities. PIPPY and TURTEART are programs that help teach computer programming.
- There are several other programs that can be used to excite the child's interest in not only science education but education in general. WRITE is a simple word processor. RECORD is a digital camera, video camera and microphone that can be used to take pictures and make videos and sound recordings. TAMTAMMINI is a song creation program similar to GarageBand on the MAC. We found it useful to help with cultural education.
- Although we have not fully explored the potential use of the internet connectivity, we have observed that the XO, when used on the internet, functions as an easy to use Browser and can get access to most internet information available to anyone with a Windows or MAC machine. The OLPC educational project has a "private" server accessible through the XO. The student can find specifically developed programs for the user of the XO. The ones we reviewed were very well done and certainly would enhance science education.
- Because the operating system is LINUX based we did not have any issues with viruses, malware, etc. when connected to the internet. This was a great relief to the Ugandan teachers since they spend much time and money keeping their Windows machines virus protected.
- We still had to have Windows based computers at CN to effectively run the educational program. We needed a Windows based laptop to control the digital camera for the above mentioned microscope project. The manufacturer of the microscope/camera system did not provide operating software for the LINUX system so we were forced to purchase an XP based computer.

Conclusions and future work plans

We found that for our XO computer project to be successful, it was necessary to have the support of those who have to implement the project, and also those responsible for immediate and long term sustainability. We were fortunate to have capable, highly trained, practical oriented local individuals to help with the original installation and also the long term maintenance of the computer systems. The good training these individuals received in Uganda says much for the computer education program in Uganda. As with any project, the sustainability issues must be considered and addressed. Again, we were fortunate to have the complete support of the Head Teacher as well as the individuals responsible for prioritizing the spending of the limited funds at their disposal. The Head Teacher effectively obtained the necessary funds to maintain the system and insured that the computers would be taken care of on a day to day basis. The individuals who managed the financial resources put the sustainability of the computers very high up on their list of ways to spend their resources.

A project such as ours, using the XO laptop to jump start pre-engineering and science education, requires the integration of many sub parts. Often the success or failure depends on the correct implementation of all the subparts. The infrastructure must be in place and able to be maintained. The people directly involved must be first convinced of its worth. Then they must be given the training, tools, and appropriate relief time and recognition in order to experiment with alternatives to the "normal" way of doing things. Finally, even though a computer system may have many different applications, care must be taken to prioritize each application and integrate it into the project as time permits.

Bibliography

1. AllRefer Reference. Uganda: Country Study and Country Guide (2010) [Online]. Available: http://reference.allrefer.com/country-guide-study/uganda/uganda38.html
2. Surowiecki, James, Philanthropy's New Prototype, *Technology Review*, November/December 2006, Pgs, 48-56.
3. Idowu, Peter, Duda, Frank, Lauffer, Douglas, A Proposal for Partnership with Makerere University Towards Addressing Fading Interest in Science Education in Rural Western Uganda, *2005 ASEE Annual Conference Proceedings.*
4. Black, T., et. al (1998) Science Education in Uganda: Progress and Possibilities, *International Journal of Science Education,* 20, 239-252.
5. Gunteese, Mary Ntete K., Innovations in the Teaching of Science SESEMAT Project in Uganda*, Report of the 5th Conference of the African Convention of Principals - Kampala, Uganda - 24-29 August 2008.* Available: http://www.icponline.org/images/stories/confs/acp2008/acp200811.pdf
6. Upgrading Your XO to the Latest Stable Release, Available: http://wiki.laptop.org/go/Support
7. Turner, James, Hacking the OLPC, *IEEE Spectrum*, August 2008.