AC 2009-2181: UTILIZING THE XO COMPUTER FOR UNDERGRADUATE RESEARCH AND LEARNING OPPORTUNITIES

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Utilizing the XO Computer for Service Learning Opportunities:  
Collaborating with US Institutions and Paraguay Educa to Support  
XO Implementation in Wisconsin and Paraguay

Abstract

The One Laptop Per Child Project, created by the One Laptop Per Child (OLPC) Foundation, the program’s mission is to serve the world’s children by providing educational opportunities through the creation of low-cost, durable “XO” computers with programming specifically designed for collaborative learning. The development and support of the XO computer involve many professional skills and fields; including engineering and education. Currently 1.2 million XOs have been deployed globally, including approximately 15,000 in US schools.

The completion of this mission is often difficult both in securing funding and attaining access to skilled professionals, because the vast majority of the XO deployments are located in developing countries with few resources. Another aspect of technology deployments in developing countries rarely discussed is that many of the financial donors, both government and foreign, are more willing to contribute money to purchase computers, while very few contribute funding to develop the infrastructure and skilled professionals that are essential to the success of any technology deployment, regardless of location. This is a substantial problem when considering that research shows the initial costs of computer deployments in developing countries consists of only 25-33% of the Total Cost of Ownership over the course of a five year period.[1]

To address this problem, student organizations at the University of Wisconsin-Madison and Skidmore College in New York have formed a collaborative relationship that also includes Paraguay Educa, an NGO coordinating the country-wide XO deployment in Paraguay. This collaboration was formed to help provide the country-wide XO deployment in Paraguay and the small, experimental deployment in Wisconsin with the required technical support. The joint project strives to utilize the skills and resources found on university campuses in the US to benefit disadvantaged students both within the US and abroad, while providing quality educational opportunities for undergraduate and graduate learning and research. The research conducted to-date that seeks to estimate the Total Cost of Ownership in computer deployments considers but does not include the voluntary contributions made by students. This paper strives to exhibit and examine the value of student contributions from the academic perspective. Further research is planned to formally evaluate the value of the student contributions and their effects on reducing the TCO for XO deployments in developing countries.

The first section of this paper will explore the evolution of the Wisconsin OLPC project and its repercussions in the foundation of the UW OLPC and OLPC Skidmore organizations. The second section consists of a literature review of the cost of implementing computers in the US and developing countries, focusing on the Total Cost of Ownership model. Finally, the third section will discuss the service learning projects and evaluate the student learning and the benefits of forming collaborative relationships both within the United States and internationally.

OLPC Introduction/Background
One Laptop Per Child is a non-profit organization based in Cambridge, MA, that designed and manufactures the XO computer, a durable, low-cost computer for use in elementary school education in developing countries. OLPC’s mission is to provide a means for learning, self-expression, and exploration for the nearly two billion children in the developing world that have little or no access to education. While by nature children are eager for knowledge, many countries have insufficient resources to devote to education—sometimes less than $20 per year per child (compared to an average of $7,500 in the United States). By giving children ownership of an XO laptop, OLPC provides children with a digital platform to the outside world, access to vast amounts of information, a way to connect with each other, and a springboard into their future. Moreover, countries involved in the project develop an essential resource—educated, empowered children. [2]

One Laptop Per Child, UW- Madison

The Wisconsin OLPC Project was initiated by the former Chancellor of the University of Wisconsin- Madison, John Wiley, to investigate the viability of the XO computer as an educational tool for use within the state's economically disadvantaged areas. The project is currently being coordinated out of the Engineering Learning Center at the University of Wisconsin- Madison, College of Engineering and involves faculty and students from across the campus, most notably the School of Education, Computer Science, and the College of Engineering.

The project was officially launched in June of 2008 with a six week pilot that was conducted as an undergraduate research project by a student and faculty members from the University of Wisconsin-Madison, College of Engineering. The student population that participated in the pilot consisted of nine minority children enrolled in a summer enrichment program. The pilot's main objective was to gain a general insight of the XO as a learning tool and to identify some of the possible obstacles that a teacher might experience when teaching with the XO. The research also looked at changes in the students' self esteem and strove to identify the learning outcomes experienced by the students as the project progressed. The pilot was run as an undergraduate engineering research project and involved nine disadvantaged minority students. The summer pilot highlighted not only the learning opportunities provided by the XO to the elementary students, but also the learning experienced by the undergraduate researcher.

The Wisconsin OLPC project was expanded during the fall 2008 semester to include 75 XOs, deployed in seven independent sub-deployments that each consist of different student populations, learning environments, and educational content. Research on each individual project is being conducted as well as an "umbrella study" that will study and compare the various aspects of the individual projects to form a more broad understanding of the XO within various school environments.

Parallel to these efforts, a group of students at the University of Wisconsin- Madison created the One Laptop Per Child, UW- Madison (UW OLPC) organization to support the needs of the seven sub-deployments that are currently underway within the city of Madison. A central aspect of the everyday work being done by UW OLPC students is to further evaluate the collegiate learning that is occurring as undergraduate and graduate students volunteer to work on the project. Accordingly, the UW OLPC's mission statement is as follows:
"We are an organization established to promote interest in, provide support for, and develop a local community around the One Laptop Per Child vision. We view OLPC as a valuable educational platform rooted in innovative technology. Our goals include community outreach, student development, and educational research. To this end, UW OLPC has established and is expanding local, national, and international relationships. Opportunities are also available to tailor projects to member initiatives and address specific needs of existing OLPC deployments worldwide. UW's OLPC student organization exists as a dynamic epicenter for communication and coordination among the OLPC community at large."

The increasing amount of support for the Wisconsin OLPC project has resulted in a wonderful resource for the educators working in the various deployments in Wisconsin. Moreover, the creation of this support network based at the UW-Madison campus has proven to be large enough that its core members have started providing assistance to the XO deployment in Paraguay in collaboration with OLPC Skidmore.

**OLPC at Skidmore**

The One Laptop Per Child organization at Skidmore (OLPC Skidmore) was created with the specific goal of supporting the XO deployment occurring in the country of Paraguay. The organization was founded when Skidmore College students with personal ties to the OLPC deployment team in Paraguay sought to utilize the college's active citizenship program in an effort to aid with software development. The OLPC Skidmore organization has established a formal collaboration agreement with the University of Wisconsin and Paraguay Educa, a local NGO created to coordinate the OLPC implementation in Paraguay.

UW OLPC in turn has provided the OLPC Skidmore organization with guidance and test machines during the initial phase of its foundation. OLPC Skidmore now serves as a liaison between the University of Wisconsin and the team in Paraguay, working to communicate the needs and problems of the local deployment team to UW-Madison and give practical solutions to Paraguay Educa both from Skidmore and from the research division at the University of Wisconsin. The international collaboration with OLPC Skidmore and Paraguay Educa has enabled the UW OLPC group to work locally on the Wisconsin OLPC Project while still participating in the global OLPC movement.

In contrast to the UW OLPC organization, OLPC Skidmore does not carry out a local deployment and focuses exclusively on Paraguay’s first big scale implementation of 4,000 XOs. Therefore, OLPC Skidmore is tailoring its efforts in the creation of educational activities utilizing the Sugar environment by altering and improving existing activities to improve their use by Paraguayan educators. Through constant interaction with Paraguay Educa, OLPC Skidmore provides both UW OLPC and OLPC Skidmore feedback of the day to day problems encountered by deployment teams in developing countries.

**Total Cost of Ownership/Implementation**

When considering the cost of deploying computers in developing countries, the World Bank notes that very little relevant data and research exists. One tool used when considering the cost of such technology deployments is the Total Cost of Ownership (TCO) model. Much focus has been placed on the race to create a $100 laptop and other ultra-low cost computers for
developing countries but the costs of supporting these projects past the initial hardware investment has been largely ignored. The TCO model divides costs into three separate categories; a) initial costs, b) recurrent costs, and c) hidden costs. The initial costs of a technology deployment are often the most highly visible and can include hardware and software purchases, retrofitting buildings with cabling and wiring, and distribution. Recurrent costs represent the on-going costs required to support the deployment such as technical support, training, electricity, and other consumables. Hidden costs can come from replacement hardware, damage or theft, planning costs, and end-of-life costs.

Research has shown that the TCO for 1:1 computer deployments in schools in the US are over $1000 annually and more than $400 in developing countries.\[1] Of these costs it has been found that the initial hardware costs account for only 25 to 30% of the TCO. The initial cost of hardware purchases is surprisingly low when compared to the cost of training the educational and support staff. It has been shown that the labor-costs required for the technology deployments far out paces the costs associated with the initial purchase of hardware. A study done by Vital Wave Consulting in 2008 found that of the investment required to support a computer deployment over a 5-year period in a developing country the initial costs accounted for 26% of the total investment, the recurrent costs accounted for 61% and hidden costs accounted for 13%.\[5] These findings are surprising when considering the amount of attention focused on initial costs.

**Critical Success Factors**

Research has also shown that one of the main factors for success in computer deployments in any environment is access to a pool of skilled professionals and training.\[5] By definition developing countries are usually lacking in skilled IT professionals and this creates a problem with technology deployments in these countries. The use of open source software is another factor that must be taken into consideration when discussing the availability of skilled professionals. Trained Linux professionals are rare in developing countries. This coupled with the fact that Linux trained professionals command higher salaries than comparable Microsoft trained professionals often creates problems when funding the recurring costs of a computer deployment. In order to help offset this cost, the students of UW OLPC and OLPC Skidmore have teamed up to provide Paraguay Educa with as much support as possible from their respective campuses. These service learning projects provide the XO deployments in both Wisconsin and Paraguay with some of the essential support and development they require while providing the students with opportunities to use their skills and gain valuable experiences.

**Undergraduate Learning Opportunities**

The Wisconsin OLPC Project is a unique deployment in comparison to other XO deployments because it is the only OLPC undertaking based out of a large research institution, the University of Wisconsin- Madison. The research-focused environment, characteristic of UW- Madison, provides the Wisconsin OLPC Project with access to a large population of skilled professionals in technical fields and education. Hence, the Wisconsin OLPC Project has access to a critical mass of human capital: skilled instructors and 43,000 college students that have historically proven to exhibit their active citizenship. The university’s human and financial
resources have resulted in an enormous amount of both technical and educational support for the Wisconsin OLPC project.

The Wisconsin OLPC Project pilot conducted during the summer of June 2008, resulted in numerous positive learning experiences and provided concrete evidence about the overall effectiveness and viability of the XO computer on the elementary school level. The pilot highlighted the wide variety of professionals required to moderate the study and the potential for organized learning on the collegiate level through service learning projects. As the study was expanded and more students volunteered, the skills employed created a multiplying effect evidenced in the students involved; each with a different majors and focuses. Every student was asked to contribute in any way they found personally rewarding and beneficial to the deployment needs. This approach allowed the facilitators to break down the barriers between students from different departments and created a more effective group dynamic where all students were encourage to learn from each other.

The skills required to support the project can be broken down into four categories, a) hardware/software b) education, c) research methods, and d) language and translation. This general division of capabilities highlighted the need for an interdisciplinary approach to the project with students from various fields including sciences and engineering, education, humanities, and linguistics. This eclectic group of volunteers had to be proficient, but not necessarily experts, in each area. Training sessions for volunteers were provided by educators from the sub-deployments along with student leaders from UW OLPC. This initial training program was designed to build learning communities and peer-to-peer learning within the students volunteering on the Wisconsin OLPC project while preparing them to contribute to off campus initiatives.

### Student Projects

The students at both UW-Madison and OLPC Skidmore have started a wide variety of service learning projects that benefit the XO deployments in both the US and Paraguay. Service learning is made up of three core elements: a) clearly defined learning objectives, b) student involvement in selecting or designing the service activity, and c) a theoretical base. Together, these elements aim to satisfy society's needs while fostering relationships between the students and the community. The service learning projects chosen by the students were inspired by the each student's professional skills and interests in the XO deployment, whether in Wisconsin or Paraguay.

#### Paraguay Educa Server Cage

During the fall 2008 semester, students in UW OLPC were given the task of designing a theft and weather resistant cage that would allow Paraguay Educa to securely store their school servers when setting up the computer infrastructure in schools. The students were given a number of parameters including that the cage had to protect the server from moisture dripping from the roof as well as dust floating in the air. Another key design criterion was that it had to have a simple strategy that would allow for easy installation while effectively deterring any would-be thieves.

The UW students successfully completed the design project and provided Paraguay Educa with detailed computer models along with written instructions on how to fabricate the
cage. The server cages were fabricated in Paraguay by an outside contractor and installed in the schools. A graphic of the server cage is shown in Figure 1.

This student project is a wonderful example of how college students can successfully apply their professional skills while supporting non-profit efforts around the world. The students worked with a diverse team comprised of people from numerous countries and cultures which required them to alter their normal practices in engineering design courses to accommodate the needs of the group. In the long term, the UW College of Engineering curriculum has decided to incorporate these design projects as student projects for the freshmen Introduction to Engineering Design course.

Read Application Improvements

Students at OLPC Skidmore are programming improvements to the Read application for the XO. Read is the e-book reader application on the XO and an important component of the Sugar graphical user interface. The improvements being implemented are focused on improving Read for classroom use by teachers. Currently, the addition of a timer is being programmed to Read in order to track the amount of actual reading that students are doing. The idea is to register the time spent actively on the application and the readings assigned in a meaningful manner to the school server so that the instructors get a good idea of how much time students dedicate to studying and reading for pleasure.

In the future, the OLPC Skidmore plans to incorporate into the Read application a feature that would allow teachers to add annotation and/or questions to a reading, as well as having the answers input by students be sent back to the school server for grading. This application would measure reading comprehension and problem solving skills with the primary objective of developing active readers through interactive, fun activities.

Barcode or RFID Tracking System

One of the major problems identified in many XO deployments around the world is the lack of a structured plan on how the coordinating organization should track the computers during
deployment and maintenance. Students at both UW-Madison and Skidmore have started collaborating on designing a tracking system that will solve this problem for Paraguay and can eventually be replicated in other deployments around the world. The project will result in an open source software system that will be paired with either bar codes or RFID scanning hardware to track the computers as they move about the system.

The joint-nature of the project required that it first be divided into two distinct parts so that the students of UW OLPC could tackle one part while the students at OLPC Skidmore could work on the other. The UW OLPC portion of the project was to design and analyze possible tracking systems that will be both cost effective as well as feasible considering the resources and staff using the system. This portion of the project includes many elements from Systems Engineering, which includes creating system models to simulate how the units will flow through the system and identifying the points at which the computers need to be scanned. Finally, the students will do a cost-benefit analysis to determine which technology, barcodes or RFID, is the best choice for the project. The second part of the tracking system, which students from OLPC Skidmore are working on, is the design of the software, data base, and reader interfaces. The final plan for the project is to implement the resulting tracking system and test it in Paraguay over the summer of 2009 and make any revisions deemed necessary.

Umbrella Study

The Umbrella Study is being conducted by students from UW OLPC and is designed to generate broad, general conclusions about the viability and usability of XO as both a learning and teaching tool. The diverse yet diminutive nature of the Wisconsin OLPC Project provides a unique opportunity for this comprehensive research. The diversity the student populations, environments, and content exhibited in the seven sub-deployments of the Wisconsin OLPC Project enables the Umbrella Study to look at seven individual case studies simultaneously and draw broad conclusions from the aggregated observations and data.

The level of comprehensiveness with which the Umbrella Study will research the XO has been unattainable in previous research conducted in various developing countries. This uniformity in the deployments in developing countries is due to the central organization and coordination provided by either the government or an NGO created for this purpose. The loose organizational structure of the Wisconsin XO Project gives each of its educators the freedom to implement the XO in any way they feel will best satisfy their students’ needs. This freedom has resulted in the large variety found in the populations, environments and content of the sub-deployments. The final conclusions and insights from the Umbrella Study will be used by UW students traveling to Paraguay during the summer of 2009 to help improve and expand the teacher training program in preparation for the accelerated growth that is scheduled for the project.

Evaluating Student Learning

University students have played an integral part in the Wisconsin OLPC project and a lesser but notable presence in the Paraguay deployment. The university students involved in the project covers a range of majors, focusing mostly on engineering and computer science. This trend is seen as a reflection of the project’s nature as well as the choice of academic departments that were chosen to house the XO projects in their respective universities. The Wisconsin OLPC
The Wisconsin OLPC project is based out of the UW-Madison Engineering Learning Center, which has resulted in a tendency toward recruiting engineering students. However, students actively involved in the Wisconsin OLPC project come from many departments at both the undergraduate and graduate levels. The departments that the students come from include Biomedical Engineering, Electrical and Computer Engineering, Industrial and Systems Engineering, Chemical Engineering, Computer Science, Psychology, and the School of Education. Students from OLPC Skidmore largely consist of undergraduates from the Computer Science and Government departments.

The diverse nature of the students participating in the projects has brought challenges along with the benefits. Formal assessment of the undergraduate and graduate student learning is currently being undertaken but has not been completed as of the publication date of this paper. While the formal evaluation is lacking because of the early nature of the projects, there is substantial self-reported evidence that the project has improved the learning experiences of the university students involved and provided them with opportunities to utilize the skills they are learning in their classes. The following are examples of the testimonials students have given about their involvement with the project.

*I am a graduate student in engineering at UW-Madison and I feel that I have been able to grow as a student and professional engineer as a result of being involved with the Wisconsin OLPC project, OLPC Skidmore and Paraguay Educa. My involvement in the project has given me the opportunity to apply my skills as an engineer, develop sound research methods, and work with professionals in many fields. I find my work with the OLPC project beneficial to me not only as a student but also as a citizen of the world. It has given me the opportunity to apply my skills in a way that benefit the local community as well as the developing world.*

*I am always looking for a way to give back to the local and global community and thought UW OLPC was a good way to do so; however, I never imagined I would learn as much as I did. I found myself asking professors questions after hours and staying up late reading about the latest XO developments. My involvement in the project has given me more confidence to lead future projects, and has ultimately changed my course of study at the university.*

*I am a freshman undergraduate student studying computer science at Skidmore College. While working with OLPC Skidmore I have been able to apply my programming knowledge learned in computing classes to real world problems. I have also acquired valuable experience and communication skills working as a team with my fellow students at both Skidmore College and UW-Madison. But most of all, with my contribution I have been able to take part in an innovative project that is improving the educational outlook of those who are less fortunate both in the United States and my home country of Paraguay.*

As these testimonials show, the undergraduate and graduate students involved in the project deeply care about the altruistic goals of greater OLPC the project and are excited to apply the skills they are learning in the classroom. Further, more formal evaluation of the students’ learning outcomes is planned to start in the Fall 2009 semester as well as research into the cost savings Paraguay Educa finds though involving students in the deployment and support projects.

**Future Plans**
The students and faculty at UW-Madison are working closely with both Paraguay Educa and the Paraguayan government to organize a pilot program that would aim to support and fund five undergraduate and graduate students from Wisconsin to move to Asuncion, Paraguay for three months over the summer 2009 to work as unpaid interns for Paraguay Educa. The proposed program would benefit both XO deployments in Wisconsin and Paraguay. The Wisconsin OLPC Project would benefit by providing students with an incentive to volunteer on the project in order to get training. It would also give the UW students the opportunity to apply the skills learned in their courses in an international work experience. Paraguay Educa will also benefit greatly by the skilled labor the UW students because it would expand their workforce by an additional 50% or from 11 staff to 16 including UW students. The UW students will give Paraguay Educa the ability to work on development projects that will help them prepare for the future growth of the project which would have been impossible within their current staffing constraints.

Finally, the overall objective of the joint project is to develop and expand the collaborative relationship between UW OLPC, OLPC Skidmore and Paraguay Educa. The overarching, common goal is to create a model working relationship that would demonstrate how academic institutions can benefit by pairing up with OLPC projects in developing countries to provide them with support in the form of skilled student labor. Once the project is more established we feel that the research being conducted will help stimulate a move within other educational institutions within the US to consider offering students incentives in the form of course credits and funding to work on other like-minded OLPC service learning projects. Funding for this project is currently under discussion from many different organizations such as the University of Wisconsin-Madison Chancellor's Office and the College of Engineering. The National Science Foundation will also be considered as another funding source.

Conclusion

Overall, the One Laptop Per Child project has been very successful at both the elementary and collegiate education level. The successful learning opportunities provided to college students was identified in the pilot study conducted in Wisconsin during the summer of 2008 and has continued to demonstrate the educational value of the project as seen by the increasing amount of support being given to the from the academic institutions and governments in which the projects are located within.

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