Laptop Recycling Project:
A Service-Learning Experience

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Abstract

This paper describes an interdisciplinary humanitarian project initiated by the Electrical Engineering Department at Arkansas Tech University. The project goal was to provide solar powered computers to disadvantaged students in areas where resources were not available for them to otherwise have computer access. It also incorporates environmental aspects of recycling old laptop computers and powering them with solar energy. This project occurred during the 2008-2009 school year upon receipt of a University Student Interdisciplinary Research Grant for $10,000. The project, initially referred to as the "Solar Laptop Project," was an attempt to involve many faculty and students from different departments while incorporating as many of the ABET defined a-k student outcomes as possible. Eleven members of the faculty/staff and seventeen students participated on the project team. Team members represented five of the University's Colleges (Applied Sciences, Arts and Humanities, Business, Education, and Natural and Health Sciences) and in particular seven academic departments (Computer and Information Science, Electrical Engineering, Foreign Language, Speech Theater and Journalism, Management and Marketing, Physical Science and Curriculum and Instruction) in addition to the Alumni Office. This project was an attempt to create an atmosphere which fostered the experience of engineering in a global, economic, environmental and societal context; where students worked with other students and faculty from different disciplines. Additionally the goal was to create a spirit of service where engineering and other students would learn by experience the culture of sharing their abilities and talents with others beyond the boundaries of their individual comfort zone. Major project deliverables were the following: design of a solar battery charging unit; a marketing plan including press releases, website, project brochures, and speaking engagements; testing and repair of donated laptops; educational software package; a bi-lingual user's manual; delivery of computers to point of use. Guatemala was selected because of contacts in the area.

Background

Requirements for engineering accreditation have changed significantly beginning when the ABET Board of Directors adopted the new *Engineering Criteria 2000* (EC-2000) in 1996[1]. This change came as a result of the engineering community realizing in the 1990's that the world was changing in a revolutionary way due to technology and a change of direction from national security to international economic competitiveness[2].

As a result, engineering faculty of accredited programs constantly grapple with how to ensure graduates achieve the ABET defined a-k student outcomes in their curriculum. For a little over a

decade engineering education programs have transitioned from not only teaching the fundamentals of engineering theory, experimentation, and practice to also being relevant, attractive and connected[2].

Although many are familiar with the requirements, for clarification, the ABET accreditation requirements are presented.

Engineering programs must demonstrate that their students attain the following outcomes:
(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.[3]

Historically engineering programs developed strong curricula for a, b, e, and k. The majority of the outcomes; c, d, f, g, h, i, and j are more elusive for incorporation into typical engineering curricula and assessment.

One solution to the difficulty of integrating the soft skills dictated by ABET in the a-k student learning outcomes is the involvement of engineering students in service learning projects such as the Solar Laptop Project. "In engineering, service-learning has the potential to help gain the skills necessary for lifelong learning and for practicing in a manner cognizant of professional and civic responsibilities."[4]

Project Overview

The purpose of this project was a humanitarian effort to recycle and repair used laptop computers; design and install solar powered battery charging systems, and install/design educational software and deliver initial units to needy children. This project was a multi-faceted educational experience that integrated multi-cultural, multi-disciplinary, environmental awareness and global social responsibility.

Project Team and Responsibilities

Faculty from each department recruited students to work on the project under their guidance. Student response was exceptional and their contributions resulted in many improvements to the initial project plan. The following includes only the major activities of the staff, professors, and their students. The amount of time, effort, and contributions of each participant far exceeds what is summarized in this paper.

Dr. Patricia Buford, Associate Professor (now Head, Department of Electrical Engineering), initiated the project; secured the grant; formed the faculty and staff team; supervised the electrical engineering students; served as project coordinator. Electrical Engineering students designed and built the solar battery charging systems, helped install software, packed computers for shipping, and many other untold duties.

Dr. David Hoelzeman, Associate Professor of Computer and Information Science, designed and supported the project webpage. His Computer and Information Science students examined and evaluated all the donated laptop and desktop computer systems; researched the software/operating system; and identified and installed Ubuntu[5] as the choice of educational software.

Dr. Ramon Magrans, Professor of Spanish, Head, Department of Foreign Languages and International Studies; and his student tested the software and prepared communications for the students in Guatemala.

Dr. Gwen Morgan, Professor of Elementary Education, was part of the project management team and through her efforts obtained the donation of used laptops from a major accounting firm in Houston, TX.

Dr. Hanna Norton, Associate Professor of Journalism (now Department Chair/Assistant Vice-President Distance Learning); and her students created the project logo; prepared and disseminated multiple press releases; assisted in the preparation of the description of the development webpage; prepared a video documentary; and produced, directed and conducted an interview about the project on Tech Television (a TV station at Arkansas Tech University which is available to the cable-subscribing households of Russellville, Arkansas).

Dr. Jeff Robertson, Professor of Astrophysics and Head, Department of Physical Science (now Dean of the College of Natural and Health Science) and his student worked with the electrical engineering students on the power requirements for the project's computers.

Mrs. Kristen Smith, Major Gift Development Officer from the Development Office, served as liaison to the Development Office.

Mrs. Carla Terry, Administrative Specialist III, served as procurator, administrator, etc.

Dr. Kim Troboy, Professor of Management and Dr. Loretta Cochran, Associate Professor of Management and Marketing; and their students assumed the project management and planning. Additionally they developed a marketing plan, prepared project documentation; proposed and coordinated the E-Waste Recycling Drive; and entered the project in the 2009 Tulane Business Plan Competition.[6] Students rebranded the project as "ATU CONNECT" (Companies Opening New Networks to Educate Children through Technology). These students were also responsible for coordinating the presentation of the project at the Arkansas Tech Senor Honors & Student Research Symposium.

Mrs. Connie Zimmer, Associate Professor of Secondary Education, approved the educational software selection.

The one-year project was approved in October and the two months remaining in the first semester were spent forming and meeting with the "dream team" of faculty and students. These meetings proved invaluable as students and faculty contributed their ideas to refine the work breakdown structure of the project. Parallel processing of all the major tasks was the only way to ensure most of the project completion by May.

Embedded Project Activities

E-Waste Recycling Drive

Student suggestions were very imaginative and productive. An example of this was a student proposing that Arkansas Tech host an E-Waste Recycling Drive for the Russellville community. The thought that a recycling drive would not only serve the local community but would also be a way to call attention to the project. It was hoped that this would be a way to receive donated laptops.

The students contacted the organization, Green Source Recycling, who works in conjunction with the Arkansas Department of Environmental Quality. A representative of that department in Arkansas State Government agreed to be a partner of our organization and our efforts to go green with the use of recycled technology for educational purposes.

The two day drive was held the first weekend in February. The results were that two fifty-three foot tractor trailers and an extra flatbed truck were filled with electronic waste as a result of this initial drive.

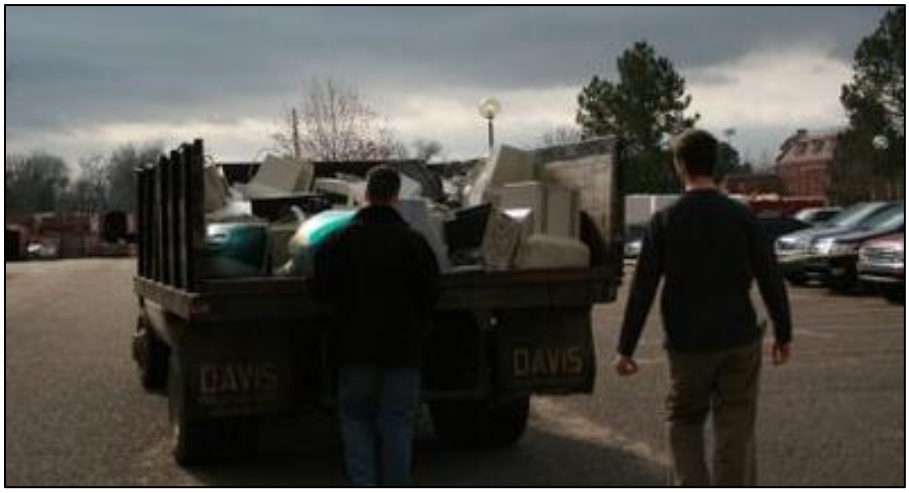

Figure 1 Students prepare to unload e-waster delivered by a local business.

The recycling drive that began with this project has been conducted annually since that time and is in itself a service to the Russellville community. Student volunteers from SIFE (Students in Free Enterprise) organization, the ATU Student Chapter of the IEEE, and others continue this project.

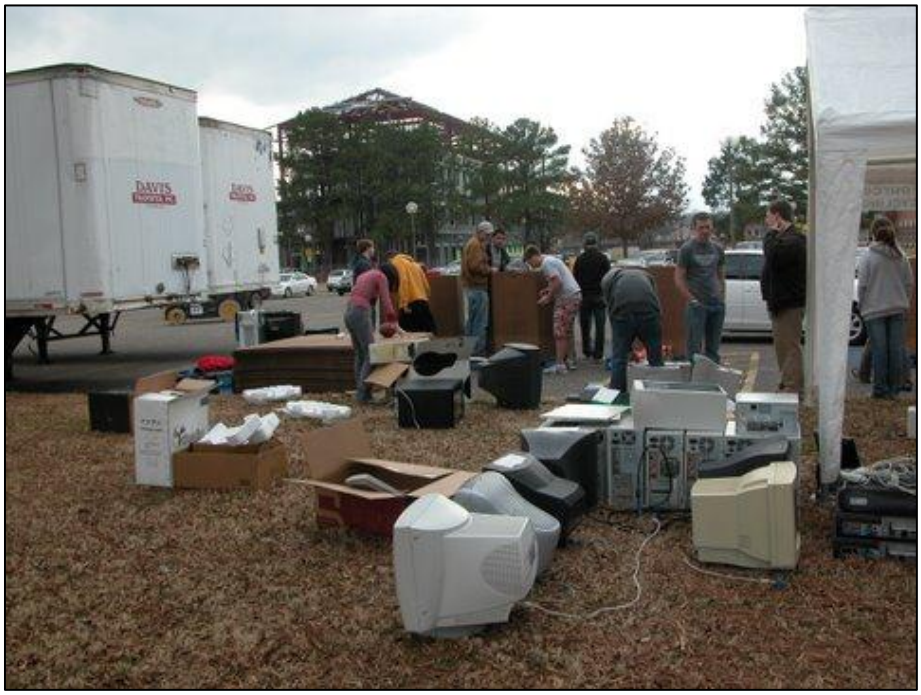

Figure 2 Triage area for computer donations during E-Waste Recycling Drive

Computer Systems for Johnson County Westside High School

During the recycling drive, a call was received from a teacher from Johnson County Westside High School in Coal Hill, Arkansas. The teacher had read about the project in the newspaper. She asked if we would consider her class as we distributed computers. To use computer applications for her students, she would often divide the class and send students to other rooms in the school. Since desktops worked for her environment, the Arkansas Tech students immediately began salvaging desktops, monitors and several printers during the recycling drive. As computers were being dropped off for the recycling drive, electrical engineering and computer and information science students ran diagnostics on the machines. Computer components were salvaged and reassembled into usable working units. Project students delivered these 18 computer systems and five printers to the high school. In fact, one of the Arkansas Tech Students was an alumna of Johnson County Westside High School.

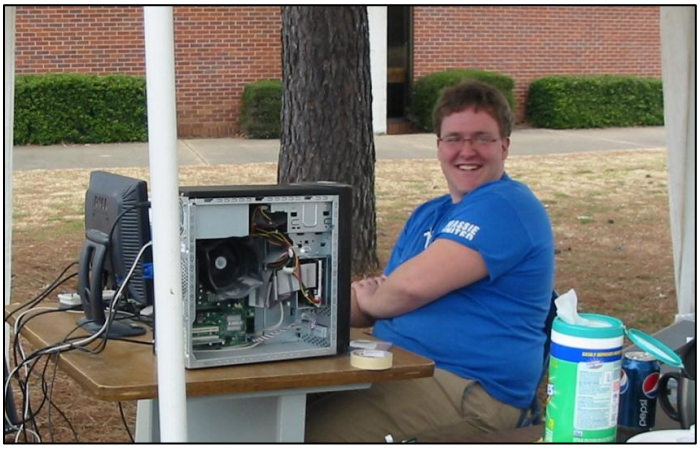

Figure 3 Drew Piechocki (EE) tests and repairs systems during the E-Waste Recycling Drive

Figure 4 Donnie Leitmeyer (EE) delivers desktop units to Johnson County Westside High School

Lessons Learned

As with all good intentions, there are often unintended consequences and this project was no exception. But, the positive outcomes vastly outweighed the frustrations and difficulties.

Technology

The engineering students' designed and built a prototype that worked for a solar battery charging. The system for the laptops proved technologically feasible but cost prohibitive. Accordingly, the goal of solar powered could not be met within the budgetary limits of the project, and the computers had to be furnished with standard recharger units. Also, collector size was a factor in the application especially with shipping considerations.

Recycling

The recycling drive as earlier stated produced a plethora of used electronic items including computers. Unfortunately, the drive only yielded a few laptops that were in such disrepair that they were unusable. Gratefully, through the networking of various faculty members on the project team, two large corporate donations yielded enough laptops for the project. Because corporate donations yielded several of the same model laptops, software installation was eased.

Through this process we received several donated laptops, but unfortunately, these generous donations did not include chargers. A majority of the funds of the project were used to purchase new batteries and charging units for the computers.

Selection of Laptop Recipients

One of the difficulties with this project was actually transporting the computers to Guatemala. As originally outlined in the project, the laptops would be delivered by project students to Guatemala. Unfortunately, by spring, the University determined that travel to Mexico, South and Central America would not be supported due to safety issues.

Another option for delivery was through missionary churches. A faculty team member stated his church worked with an orphanage in Guatemala in the fall but by spring, this church no longer sponsored travel to the country. Through other missionary churches, fourteen computers were delivered to Guatemala. The number of computers was limited by the 50 pound limit by the airlines and funds remaining for import tariffs.

Conclusion

The mapping of the electrical engineering students' service learning experience: Solar Laptop Project to ABET student learning outcomes.

(a) an ability to apply knowledge of mathematics, science, and engineering

Project electrical engineering students applied the theory and concepts from their courses to the design of a solar battery charging system.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data
Project electrical engineering students designed and conducted experiments with each component of their recharging system as well as the integrated system. Experiments included collecting and analyzing data from the solar collector; the laptop recharging system; and their interface between the collector and the laptops.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
Project electrical engineering students were given the real world open-ended problem to design a solar recharging system for a laptop computer that would be shipped to Guatemala within a budget. These students were part of a team which not only used their engineering skills to design the solar recharging system but also examined the broad social, political, and environmental constraints of providing laptops to the Guatemalan community. Additionally, they learned about the economic, social, political, environmental and ethical aspects of recycling e-waste as well as adapting recycled computers for the students in Coal Hill, Arkansas.

(d) an ability to function on multidisciplinary teams
The four project electrical engineering students met, worked, and produced results as part of a team of seventeen students with eleven faculty supervisors from five university colleges and seven academic departments.

(e) an ability to identify, formulate, and solve engineering problems
Project electrical engineering students were required to identify the problem of providing power for laptop computers. Students were challenged to design a battery charging system using the renewable energy source of solar power. They followed the standard process of design including literature review, modeling, prototyping, and testing. Their system worked as designed but because of the physical size, cost, and shipping constraints the solar portion of the project proved unfeasible. Also, students worked very hard testing, troubleshooting, and rebuilding desktop computers for reuse.

(f) an understanding of professional and ethical responsibility
As the project progressed, the project electrical engineering students processed their professional and ethical responsibilities as engineers to use their abilities for the benefit of others. This reflection and exercise of service to others deepened their commitment and responsibility to the profession. This project like other student work has a limited applicability to ethics as articulated by the NSPE Code of Ethics for Engineers.[9] Relevant areas of the code which apply to this project are: Preamble and Part III. Professional Obligations, sections 1.a., 1.b., and 2.a.

(g) an ability to communicate effectively
Project electrical engineering students communicated both verbally and in writing through several venues: meetings, activities, project reports, design presentations, and a project presentation at the Arkansas Tech Senior Honors and Student Research Symposium. Their contacts included individuals outside of the university such as the Arkansas Department of Environmental Quality; employees of Green Source; high school faculty and staff; members of the Russellville community, etc.

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
Project electrical engineers used their abilities to make a difference in the lives of adults and students in their state and children in another country. They broadened their education by learning about a community and their needs that live beyond their normal boundaries.

(i) a recognition of the need for, and an ability to engage in life-long learning
Project electrical engineers realized that to complete this project they had to learn skills and knowledge beyond their classroom experience. This project established awareness that they did not learn everything they needed to know in class, which is the basis of lifelong learning.

(j) a knowledge of contemporary issues
This project provided electrical engineering students with a direct involvement in contemporary issues in a broader context than their comfort zone.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
Project electrical engineering students were constantly challenged to use all of their techniques, skills, and tools from the classroom and apply these abilities to solve a real world problem.

Trade-offs of this project are no different than other projects. The success and quality of the project is related to scope, cost, and time[8]. In retrospect, this project was too large for both the time and budget. The scope increased with both the e-waste recycling drive and the delivering of desktops to a regional high school. Yet, these were two of the most attainable and satisfying aspects of the project. The scope was reduced by only creating a prototype of the solar recharging system rather than building multiple solar units for transport to Guatemala. The scope was also reduced when it was determined the students would not travel as part of the project.

The cost of the project was kept within budget once the scope was reduced by eliminating the solar powered component and travel. The travel to Guatemala would have been the realization of the work of the project for the students but delivering the desktops to Coal Hill, Arkansas, and observing their students' excitement and gratitude provided a fraction of that benefit.

Time constraints reduced the quality and deliverables of the project. The project approval notification was received on October 14, 2008, and the project funding ended on June 30, 2009.

Because of interruptions in the school year including finals weeks, the break between semesters and students graduating, the schedule was reduced to only six months of actual work. Essentially, the schedule was only six months to complete the project. At the conclusion of the project, many of its deliverables were just at the point of producing results such as the webpage and almost edited documentary. It was unfortunate that the project budget and time could not be extended an additional year with overlapping classes of student team members.

In conclusion, although the project was not perfect, the implications of its benefits left an indelible mark of all those involved. The project legacy is an annual community E-Waste Recycling Drive for the community of Russellville.

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Biographical Information

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