2006-1376: SERVICE-LEARNING PROJECT AND TECHNOLOGY-TRANSFER TO BENEFIT DEVELOPING COMMUNITIES

Martha Garcia-Saenz, Purdue University-North Central
Associate Professor of Building Construction Management. Engineering Technology Department. Purdue University North Central Campus.

Maria Consuelo Garcia Alvarez, Universidad La Gran Colombia
Professor, Civil Engineering School, La Gran Colombia University. Bogotá, Colombia.

Service-Learning Project and Technology-Transfer to Benefit Developing Communities

Abstract

This paper presents student's experiences from a service-learning and technology-transfer project that helped a poor community in Bogotá, Colombia. The project connected science and technology to help solve the social issue of poverty. This paper discusses the student's knowledge prior to the project and the impact the project had on students learning. Additionally, it will expand on the topic of student empowerment by making a difference in poor communities through the application of solar energy.

Introduction

In 1997, 35.1% of the population in Bogotá, Colombia lived below the poverty level. By 2003, this statistic had increased to 52.3% due to population displacement from small, rural towns to urban areas. This displacement of population was primarily due to violence and people seeking to better their lives through improved jobs and educational opportunities.

Local government projections forecast a deficit of 500,000 housing units in Bogotá by the year 2010. At least 55,000 new housing units per year are needed to satisfy the current demand, maintain the current deficit, and avoid illegal activity by pirate developers. In the past, illegal activities have occurred when city authorities did not expand the city limit and new land to develop was in short supply. This led groups of displaced people to invade county land and pirate developers to sell land without utilities.

To solve the housing shortage, Bogotá's authorities are doing two things. First, they created Metrovivienda, a company owned by the city to develop land within the city with all of the necessary utilities, recreational and social areas. Metrovivienda buys land and once developed it sells it to organizations, cooperatives and builders. Secondly, the federal and local governments are providing a one time subsidy for families that qualify for it. The subsidy was created in March of 2003 by the National Housing Fund (Law 555, 2003) and is based on the minimum monthly wage of US $150 dollars per month. If the house cost less than US $7,250, the subsidy is US $3,800 and if the cost of the house is between US $7,250 and US $12,700, the subsidy is US $ 2,500 dollars.

Housing is a complex concept that responds to one of the most basic necessities for a family. The housing structure offers lodging, shelter, protection, intimacy, satisfaction, and comfort. In every part of the world, it is known that humans need better quality of life where they can interact in a safe and comfortable environment. Government function is not to provide living space, but to specify the minimum requirements to guarantee quality of life, a comfortable space to interact with the family and other members of the community.

Minimum specifications are necessary because there are economic, social, cultural, and political limitations when designing housing for low-income families. Unfortunately, many builders think that families only need space where poor people can sleep. It is like designing for second-class citizens with different needs. Designers easily forget that they have the obligation to design spaces where quality of life is a factor.

Electric and hydraulic minimum specifications for the social interests housing are very poor. The lack of water heaters is a common denominator; electric power capacity in most of the cases is reduced to 3 KW, and water services for kitchen and bath include only cold-water connection with no provisions for the future improvement of hot water. Future installation of hot water becomes expensive and almost prohibitive for poor families. Dreaming about enjoying a warm shower for children and the elderly is practically impossible. Pipe installation is an involved process since most floors are steel reinforced concrete, and interior and exterior walls are fabricated with concrete blocks or bricks.

When a family decides to install an electric water heater, they need to begin by increasing their power capacity. Then they need to install new conduit pipes for wires, new distribution board, and circuit breakers. The actual electric water heater cost around US $600. This is about four months of the family income. In the case of a gas water heater, the heater is more expensive, costing the equivalent of six months of income, in addition to the costs for the hydraulic installation. The cost of solar water heater systems available in the open market is around US $1,750. It is almost three times the cost of an electrical system and doubled the cost of the gas system.

The idea for the project

The main idea for this project came up after an inventory of low-income housing in Bogotá, done by the same authors of this document.[1] The study's main focus was to design more comfortable houses from a thermal point of view, but finding that these low-income houses did not have water heaters, gave the authors the idea for the project presented in this document.

Students from an "Installations for Alternative Energies" class at the School of Civil Engineering of La Gran Colombia University had the opportunity to apply some what they were learning about solar energy on a project that at the same time would significantly improve the lives of low-income people. Student had to go beyond learning concepts about designing, building, and installing solar water heaters. After identifying the best solution to improve quality of life with alternative energy, the professor decided upon a technology-transfer for the students' service-learning experience.

Service Learning is defined as "integrating a community service experience of students with their academic study so that learning is enhanced"[2]. Service learning enhances the learning process, which is a fundamental goal of undergraduate programs. Service learning is a type of experiential education where the students learn through real world problem solving while meeting a community's needs.[3] The participation of the students in a community service project shows them how knowledge in science and technology can help solve social problems. Service learning is more than volunteerism or community service. According with the previous

definitions, two parts are necessary to have an opportunity to work together: a community need and a learning environment. Providing low-income families with access to hot water was the identified need. Students' learning about alternative energy sources was the objective.

Technology Transfer is a process where existing knowledge is utilized to fulfill public or private needs to improve living standards. It is knowledge transferred to a third party from the one with the know-how. Technology transfer can be considered in the school environment as a structural process of learning where the student is capable of transforming the knowledge into actions to benefit others, in this case a poor community. Successful transfer of appropriate technologies can contribute to community development and enhance the learning process for the students.

The Project

The students' project consisted of designing a solar water heater system that uses recycled materials and can be installed in stages. The project included writing a booklet to teach low income families how to build and install the system. The booklet also teaches people how water heaters work in the city of Bogotá. This effort helps improve people's quality of life without a significant financial burden. These booklets were then distributed to the different housing coops to make this information accessible.

The project encouraged students to think independently and creatively. They had a chance to work on non-technical skills such as effective communication appropriate to the audience. They had the opportunity of working in small groups (three people), and sharing their ideas with others as to the best approach. In the end, they all gave oral presentations and saw how other groups approach differed. One of the most positive experiences was getting to share what the project meant at the personal level and how it impacted them.

In the end, students improved their understanding of the complex trade offs between economic, environmental, and social aspects. They were able to determine the feasibility and sustainability of a solution for an existing problem in the community. Students improved their understanding of the social and cultural context of science and technology transfers.

Student Background info

Students who took part in this experience where taking a class of installations for Alternative Energies at their senior year. In class, students learned about the process of heating water using a solar collector; how to size the solar collector and select their components, the proper sizes for the pipes and the tank. They studied the specifications for solar water heaters from the "Unidad de Planeación Minero Energética"[4] (UPME – Energy and Minerals' Planning Unit) and the related standard norms from ICONTEC (Colombian Institute of Technical Norms). Additionally, they learned about the effect of geographic location on solar energy applications. Students studied the massive and still operational solar installation (more than 13,000 units) of water heater systems installed in all developments of the Banco Central Hipotecario (Central Mortgage Bank) in the eighties[5]. The differences in design, capacity, inclination and orientation with respect to the sun, gave the students an idea of how solar water heaters work in Bogotá.

Bogotá is located in a privileged zone, at latitude 4 degrees, 39 minutes north, and an elevation of 2,640 meters (8,661 Feet) above sea level. This location is privileged because: days and nights have practically the same length, and as a result solar energy balances between earnings and loses. There are constant temperatures year round that depend on elevation above sea level. Given the elevation of Bogotá, temperatures are close to 12^{o}C (54^{o}F) during the day and close to zero degrees (32^{o}F) early in the mornings all year round. Solar collectors in places located in the northern hemisphere need to face towards the south. Solar collectors in places located in the southern hemisphere need to face towards the north, but places close to the equator do not need to follow these rules closely; every thing works there.

Students Design

Students in their design concluded that given the actual cost of solar water heater and the difficulty of finding subsidies from the government, a simpler solution had to be found. To make the project viable, government needed to increase the minimum specification for low-income housing, which begins by establishing minimum building requirements. For example, it is cheaper and easier to install hot and cold water pipes to the kitchen and bathrooms during the construction phase than to retrofit the dwelling later on. By laying the ground work, buyers can later install a hot water system in stages following the instructions given in the student's booklet.

The first stage in providing a solar water heater is a provisional installation in order that a family can first get access to warm water during the day by simply adding a black hose extended over the roof with one end connected to the cold-water terminal and the other to the hot water terminal, warm water can be provided during sun hours. In this case the roof acts as a collector that transmits the energy by conduction.

Every group provided a different approach. For example, a group proposed to cover in plastic the area where the hose is located to capture solar radiation. Another proposal consisted of having different sections of the hose connected in series with one or more small tanks painted black to increase the capacity of water to be heated. Another idea was to locate the hose under the roof when it is built with micro-concrete tiles to use the concept of roof-collector and heat the water with the energy radiated from the roof. The calculated expenses for these solutions where around US $20, but the costs can be reduced significantly when recycled materials are used.

At the second stage, the system can be improved by using the concept of the green house effect. This consists of building a box (collector) of 2 m^2 out of recycled wood, painted with black wand covered in transparent plastic or glass. Transparent plastic work, but is required to be changed at least once a year. The bottom of the box needs a metallic laminate area to increase the heat transfer and the hose has to be replaced with copper pipes in a spiral form. The cost of this improvement could be around US$50, but it can vary depending on the materials selected. Recyclable materials are easy to find in Bogotá that is why no more than the previous value is expected. To reduce the loss of heat it is better to insulate the box. The insulation is more important when the box is made of sheet metal. Families with better income can start with the collector given that it replaces the hose of the first stage.

The collector box is an improvement but the service of hot water continues only during the sun hours. To extend the number of hours that hot water is available, a third stage is necessary: an accumulator. Having a tank to store the hot water substantially improves the quality of life, because water can be used any time. To avoid damages to the system, cold water that enters the collector has to be controlled by a manual valve.

Students presented a variety of ideas with respect to the storage tank. Proposals included tanks of different materials such as metal, plastic, asbestos, and cement. Similarly, insulation material included wheat husk, bran, straw, paper, and fiber-glass. In terms of capacity, most students agree about that 30 gallons would be the right amount.

Every group agreed that the tank had to be elevated with respect to the collector in order to facilitate the movement of the hot water from the collector to the tank by the thermo-siphon effect and avoid the fluid reversing its direction during the night. Unfortunately, this step turned out to be the most expensive part of the solution, around US$100 dollars.

Half of the groups wrote in the booklet that more efficiency required a more sophisticated system of regulation through valves and registers. They explained how to protect the system from the simplest solution of covering the collector, to the most sophisticated alternative using sensors and thermostats requiring the intervention of technical labor. The estimated total cost of the system when done in the stages described was approximately US $170.00.

Student Learning and Reflections

Some differences among the groups were found. Students, who contacted people from the community to review the booklet in addition to contacting the co-op, had a better booklet than those who only contacted the co-op. During this service-learning project, it was beneficial for students to receive feedback directly from users because it allowed then to connect with customers and accomplish the technology-transfer.

After the final presentation, students had the opportunity to reflect on their experiences. Bellow are some of their comments:

- “I am glad to be an engineer because I can apply my creative talent and skills to serve the community”.
- “I never imagined that as a student, I could develop a real project like this one”.
- “It’s incredible that solar energy can have many applications and give economic solutions to the low-income families”.
- “Because we started studying the more expensive water heater system, I never thought that poor people could learn from us how to build similar but cheaper system, one that did not require any type of traditional energy to work. I can not image the benefits for a poor family being able to have a warm shower without a recurrent monthly payment to a utility company”.
- “This assignment opened my eyes to new technologies, but more importantly, the new technologies applied to the poorest families”

- "I am now aware that in my future professional life I have to design for non-traditional energies, and show people that the use of solar energy is not an extra cost, instead it is valor added, a gift from nature".
- "When I visited my grandfather he asked me many times to check the hoses on the roof. I never understood why I had to do that until I learned in class about how the heating system worked. Now it pains me because I didn't help my grandfather when he needed me."

Lessons learned from this project are common to many other projects of this kind in service learning and technology transfer:

- Frequently students realized that a problem related to poverty does not yield to a simple solution and rather, many times require multiple efforts over time.
- Students enjoyed more working on the solution of a problem that is important for a community than solving a problem that only has academic interest. It implies that solving a problem for a community has a big impact for the students' success.
- Working on a solution for a problem in a poor community requires balance between the environment, the quality of life and the economy of the families that the project tries to reach.
- Working closely with housing coops for low-income families brings the students in contact with the community that will benefit from the project.
- Service learning has been found to help students to develop technical and non technical skills, like written and oral communications while enhancing their commitment with poor communities.[6]
- Through this service learning opportunity, students were able to develop their fundamental skills while serving the needs of a local community[7]. It made the students more sensible to the problems local communities have.
- Transferring technology using non-traditional sources of energy to benefit poor communities helps the economy.
- When technology is environmentally sustainable, dynamic (adaptive based on fundamental science and engineering principles,) and culturally appropriate, it can be made and maintain by the local people, promoting self reliance and helping feed the local economy. Ideally, appropriate technology is also environmentally sustainable, dynamic and adaptive but still capable of providing immediate improvement to the lives of those who used it [8-9]

Conclusions

Involving students in community service projects helps make a difference in people's quality of life as well as gives the students the opportunity to go beyond learning concepts by applying them to solve real issues. The students had to use their analytical skills and develop a strategy for transferring technology.

The best experience about the students learning experience was the reflection part. After their formal presentation, students had the opportunity to discuss their own feelings, to reflect on what they had learned, and what it meant for them. They felt they had acquired a civic consciousness. This reflective analysis proved the internalization of the experience and its importance.

Professionals have an important role to play in developing sustainable solutions to problems of poverty, around the world. It is important for engineering students to have a better understanding of the necessities of poor people, so that they can deliver solutions that will chance people lives. Students can learn how to use technology in wise and appropriate ways to improve the quality of life and alleviate human suffering around the globe. Educational institutions can promote projects that incorporate science and technology to deliver solutions to the world's social issues.

Booklets created by some of the groups were given to housing coops to reach the families interested in the designs, but a further step will be carried out next fall: a workshop given by the students is planning in order to teach the families how to build the solar water heater in progressive stages.

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