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PLASTIC WASTE POLLUTION AND MOSQUITO CONTROL IN BANGKOK SLUMS: AN EDUCATIONAL APPROACH

An Interactive Qualifying Project Report
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science
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Abstract

The following report, prepared for the Human Development Center in Bangkok, Thailand, contains a dual prevention and cleanup approach toward curbing plastic bag pollution. The team developed a traveling puppet show and weaving demonstration to introduce over 4,000 preschoolers to the pollution and mosquito problems, and presented handcrafted looms to promote plastic bag weaving as a recycling solution. The local women's craft groups were targeted with the weaving campaign and a floor loom was presented to them.

Acknowledgements

Our project team would like to thank Professor Karen Lemone for her ideas and comments throughout our project and project write-up, and especially for traveling with us to several schools to offer feedback on our production. We would also like to thank our interpreter, Chalee, and our driver Sujik, for their daily reliability and help with our traveling puppet show. Sujik battled hours of Bangkok traffic, helped carry our equipment, and stayed for our shows. Chalee organized our school visits, and introduced and explained each production. They have been a tremendous help, and we couldn't have done our project without them.

Our project team also received special assistance from Mr. Chatchai in translating and locating many of the building materials necessary for our theatre. Ms. Kanok-on was extremely helpful to the group in the attempt to locate a suitable loom for sale in her village. We also appreciate the assistance of Mr. Suphap Aunsri, and Mr. Sakul Kongnyun, in transporting and rebuilding the loom for the women's craft group.

We would like to thank Ms. Suzanne Knight of the Flying Shuttles Weaving Studio in Providence, RI, for her suggestions toward the development of our plastic bag weaving technique, and for contributing weaving materials to the project.

We also appreciate the following people associated with the Human Development Center for their input to our project objectives: Tim Hague and Tom Crowley; and Father Joe Maier, for suggesting and funding the purchase of a loom for the Mercy Center's craft group.

Authorship

Our project team feels that we have all equally contributed to the construction of this paper. This was decided after viewing all of the combined changes that were made by each person throughout the paper.

Executive Summary

Plastic bag pollution is a growing problem in the city of Bangkok. Bangkokians use plastic bags for everything; packaging and repackaging with plastic is the everyday norm for any purchased merchandise, food or product. Excessive plastic packing contributes to the accumulation of plastic waste littering the canals of Klong Toey and the surrounding area slums in Bangkok. This environmental pollution is recognized by the Human Development Center headed by Father Joseph Maier, as a problem in immediate need of a solution.

Despite our research of the pollution problem, nothing quite explains it better than a walk through the slums. Plastic bags collect along nearly every walkway, and pile up beneath homes and schools. In some areas it's impossible to determine whether or not water lies beneath the thick layer of garbage. The sight and stench of plastic debris does more than diminish community pride. The bags harbor bacteria and destroy potential sources of drinking water. Even more notably, the plastic bags block the flow of water in the canals. The resulting pools of still water provide prime breeding grounds for disease bearing mosquito larvae, thus posing risks of dengue fever transmission to the community.

Bangkok's plastic pollution calls for action via a two-pronged approach: a canal cleanup, and a long-term pollution prevention program. Both are equal parts to the pollution solution. A cleanup effort is simple in concept: remove the bags from the canals. However, an attempt to implement this simple concept is a bold goal before it's own beginning. Substantial government funding and labor are required, chemical and

biological mosquito control must be implemented, and the area temporarily evacuated. A lengthy process fraught with loopholes requires more than several months' work by three undergraduate students possessing limited funds, and lacking political pull.

Upon examination of our resources, there seemed to be little chance of cleanup success beyond a list of researched suggestions for the production. In lieu of an incomplete or perhaps never begun clean-up-oriented project, we chose to take charge on a smaller scale. Rather than merely create a list of recommendations that, in all likelihood may never be implemented, our team chose to be successful with the second part of the pollution solution approach: a prevention program.

Our method for pollution prevention incorporates a unique twist beyond environmental awareness and recycling. Yes, there are the traditional ways to reuse and recycle plastic waste: reuse the same bags for shopping and household use; recycle old plastic bags into new ones. Yet we contrived and developed a way to reuse and recycle bags in a way that would beneficially suit nearly all residents of the slums. The bags could be cut and woven into items with marketing potential.

The traditional Thai weaving practice was utilized as an appropriate technology that would lead to plastic waste reduction. We developed several product designs including a floormat, placemat, and pocketbook. Upon introducing the concept to the HDC's women's group at the Mercy Center, the women came up with ideas that might be popular in a Thai market: a beachmat, and a sturdier version of the already woven plastic market bag.

With funding from the Human Development Center, we were able to purchase a handcrafted floor loom for the women's group. With this they could develop a quality

woven product. Father Joe agreed to hire these women for a week to develop their first products, in hopes that the weavings could be sold at Patches, the HDC's own store. Introducing a free resource to a community harboring artistic talent and plentiful labor was the route toward community development and pollution reduction. Furthermore, adding monetary value to once discarded plastic provides an incentive to reuse and recycle for reasons beyond a cleaner and healthier environment.

Despite the development of the program, it was crucial to us that we actually implement our program and not leave it as a "recommendation." We personally introduced the health risks of plastic waste pollution as well as methods of feasible pollution prevention to more than 4,000 residents of Klong Toey and Lat Prow. In addition to the women's craft groups associated with the Mercy Center, we targeted all preschool-aged children with our education program. With the aid of our interpreter, Chaumsri, or Chalee, we visited each of the 32 schools associated with the HDC's Slum Kindergarten Improvement Program, or SKIP.

Our team educated via entertainment: otherwise known as the Plastic Puppet People, we presented an educational puppet show and plastic bag weaving demonstration/activity for the children at each school. The number of presentations per school depended on the size of the school; usually the audience ranged from approximately 50 to 100 students per show.

The puppet shows were15 minute productions performed in Thai by our group, and supplemented with traditional Thai children's music. The show's characters were all children—Gek, Wit, and Bun; and the story was set with brightly colored scenes of familiar environments—a slum, a canal, and marketplace. The show served to outline the

plastic waste and mosquito problem at a level appropriate for the preschooler, and introduced plastic bag weaving as a recycling solution. The puppets and most of the theatre and props were constructed of plastic bags to harmonize with the recycling theme. The children's responses to the show varied among common reactions included laughter, and repeating and talking back to the puppets. Judging by their responses, and later information from the teachers, the children enjoyed the show. With the additional help of their teachers' explanation, most also understood the basic theme.

We performed weaving demonstrations at the conclusion of each puppet performance. Using looms we'd handcrafted to give to each school, we showed the children how the plastic bags were cut into loops, tied together, and woven under and over the strings on the loom. The looms were simple frames, lap-sized, and strung with a warp appropriate for the limited skill level and dexterity of a three to four-year-old child. Following the "reusable" nature of our weaving, we improvised each of the tools: a paintbrush to separate the warp (the vertical threads that provide structural skeleton), a ruler to hold the warp open, and a comb to beat the plastic weft (the horizontal threads that are woven through the warp).

We sat amongst the children and let most, if not all of them try beating the weft with the comb. Despite the occasional, yet understandable confusion between beating the weft and combing their own hair with the comb, the children usually understood the technique. This was the simplest task in weaving, and was usually met with enthusiastic cheers and clapping for themselves and their friends.

Our team created a survey for the teachers to fill out after the performance. Our survey was translated into Thai, and consisted of questions pertaining to the children's

enjoyment and understanding of the show, whether or not this presentation would affect the children's recycling habits, and if the teacher would promote this pollution and recycling message to the students. Though the children enjoyed the show, it was understandably uncertain as to whether or not the children would throw away fewer bags. Despite this, the teachers agreed that they would promote this message themselves.

Beyond this pollution prevention program, we have developed a series of recommendations for bag removal and biological mosquito control that we hope may be taken into consideration by the Human Development Center. Even with the "two-pronged approach," any cleanup and prevention approach takes time to implement, and faces numerous setbacks. Though introducing plastic bag weaving to the slum community was not a method for a complete pollution solution, it's a start. A simple idea that is well suited for a community can take hold with effort and time. We hope that we have initiated the start of a "weaving movement," and that the popularity of plastic bag weaving continues to spread.

1. Introduction

Since the economic boom of the 1980's, lack of knowledge in Thailand about pollution has been a major problem. The general population is unaware of the devastating effects that water pollution can have on a community. One of the major pollutants is plastic debris--primarily plastic bags. The bags inhibit the water flow creating pools of still water that provide a breeding ground for disease-bearing mosquitoes.

The goals of our project were to promote environmental awareness, and to provide a practical method of recycling the plastic bags. An educational puppet show detailing awareness and recycling was performed at the 32 schools associated with the Human Development Center of Klong Toey. It was an entertaining way to increase the children's awareness of plastic bag waste and the accompanying consequences to plastic pollution. The show included basic information about mosquitoes, as well as methods of recycling bags. Through providing people with alternative uses for the plastic bags, costly industrial means of recycling can be avoided. The reduction of plastic bags in the canal will improve water flow, and eradicate breeding grounds for disease-bearing mosquitoes.

One particularly creative use for plastic bags involves weaving them into marketable items including mats and market bags. We promoted this application of plastic bags as a means of recycling, thus preventing the bags from polluting the canals. Plastic bag weaving will provide community residents with a profitable way of improving their living conditions.

There was a weaving demonstration at the conclusion of each puppet show.

Figure 1: Weaving Demonstration

This was used to spark the children's interest in weaving. The team also targeted the women's group at the Mercy Center with the weaving campaign. If products are created with monetary value, there will be an incentive for these people to incorporate weaving into their everyday activities.

Our team has also developed possible methods for clean up and mosquito control. These proposed methods could be implemented in the future pending funding and manpower.

The first step is to make the people aware of the problem. Once the community understands that the plastic debris is dangerous to their health, a clean up process and prevention will be easier to initiate. If nothing is done about the situation, disease will continue to spread, and an already unhealthy situation will worsen.

2. Literature Review

2.1 Bangkok Slums

Bangkok is one of the major cities in Thailand. In 1992 the city had a population of more than six million people, twenty percent of whom lived in the slums (Duang Prateep Foundation, 1992). The slums are defined as settlements of low-income people occupying sub-standard housing, or merely house-like structures with no security of tenure.

Figure 2: Typical Slum

Only 37 percent of the slums are on government owned land, which means the residents are not registered and could be evicted at any time (Sasaki, 1998). Since the housing in the slums is not legally recognized, they lack public services such as standard utilities and proper sewage systems.

There are two factors that contribute to the creation of many urban slum areas. These are the "push factor" and the "pull factor." The "push factor" is the poverty of the agricultural sector due to severe drought and other problems. This leads the farmers to

leave their land for work in the city. The "pull factor" is the opportunity to work and earn money in a large city, such as Bangkok. These were the main reasons that people moved from rural areas to the cities over the two to three decades after World War II. Along with these factors, there is also a land distribution problem. As land prices increase, farmers sold their crops and joined the urban poor (Hata, 1996).

The size of a slum ranges from 42 to 2,000 families with the average size being 247 families (Sasaki, 1998). The average family income was only about 3500 Baht per month (US $140), which was 2000 Baht below the average monthly income of Bangkok households in 1996(Bangkok Post, 1997). The minimum income stipulated by the government for a family is 7000 Baht, so their standard of living is far from satisfactory (Hata, 1996).

The low income is due to the fact that many slum dwellers are unskilled laborers-often because they don't have the opportunity to get a higher education. Women and children earn money at home by making flower garlands, bamboo skewers, and different foods. The unemployment rate of slum people is as high as 30 percent (Hata, 1996).

The education problem is one of the most prominent since about 40 percent of slum residents are under age 15. Many children don't finish the compulsory six years of education even though 90 percent of children in slum areas have entered primary school. This is due to the effects of poverty on the children. Parents need to understand how important education is to the children, so that they obtain as much schooling as possible (Hata, 1996).

Only 22 percent of the slums are located on dry land. The rest are near marshy areas built on sites over polluted and foul water (Sasaki, 1998).

Figure 3: Houses Above a Canal

Many people view the slums as temporary living, and this belief results in not having basic living supplies. It is up to the slum people to better themselves because they receive little help from the government.

In 1996, the National Housing Authority devised a 10-year plan to improve the living conditions of 200,000 slum houses. So far the plan does not seem to be working. Under this plan the slum residents would either relocate or renovate their existing area. The problem with the first option is that most slum residents don't have enough money to relocate. Lack of money also hinders the second option because slum residents cannot afford to renovate their communities and the government doesn't provide enough money (Priwan, 1996). The slum condition seems to be worsening in Bangkok, rather than improving. One might question whether the government is really doing anything to help the slum residents.

2.1.1 Klong Toey Slums

The Klong Toey slums consist of many illegal squatters who are surviving with extremely poor living conditions. The name comes from the fact that there had been pandanus trees, "toey" in the Thai language, growing along the canal or "klong." These slums are built next to the Bangkok port, on land belonging to the Port Authority of Thailand, under the Ministry of Transport and Communications. There isn't a clean water supply in the surrounding area. The houses were built above the swamp using old wooden boards, lacking walkways between each other.

Figure 4: Houses on Canal in Slums

The houses are on stilts above the water with rusty zinc, wood, and even cardboard roofs. During the hot season the zinc roof creates an oven inside the house and during the wet season it leaks relentlessly. Since there is no garbage collection the water is foul and smelly. The garbage, including plastic bags, are thrown into the canals underneath the houses (Hata, 1996).

In the 1970's, the Klong Toey slums didn't have any source of childcare. There were no schools, and many children just played on the decaying wooden planks, often falling into the filthy canals. Some houses privately took care of children, charging one

Baht per day. These were not registered with the government and were operated illegally, and many of the children didn't have a birth certificate. Although these houses were only small learning places, they were greatly appreciated by the slum dwellers (Hata, 1996).

Eventually, a slum child, Prateep Ungsontham, and her sister, Pi Taew, created the "One-Baht School". At first, there were only eight children, ranging in age from two to ten years. Slowly, the girls gathered materials that could be used for desks and other school items. The "One-Baht School" reached 100 students at its maximum capacity and volunteers began arriving to help teach. This school became the Pattana Village School when it was finally granted the status of a permanent public school (Hata, 1996).

2.1.2 Chiang Mai Slums

The slums of Chiang Mai make up about 4 percent of the total population of the 150,000 people living in the municipal area. More than half of the 38 slums are on public and marginal land, and residents could also be evicted at any time since they are not registered. The largest slum in Chiang Mai has only 200 families, which could easily result in low cost improvement, if time were taken to help. Most people look down upon the slum dwellers even though it is these people who provide cheap labor to boost the economy. Although the Interior Ministry issued an order in 1996 that allowed slum dwellers to register their houses, the slum dwellers are still turned down. The slum dwellers have decided to do something about their position in society and have set up the Community Network, which is a partnership of all slums in Chiang Mai (Chanswangpuwan, 1998).

2.2 Water Pollution

Water pollution is a major problem in Bangkok that has been receiving more attention recently. Residents of Bangkok rely on the canals that run through the city as their water supply. They use the water for cooking, bathing, and drinking, as well as waste disposal. It was reported in 1996 that 7000 tons of garbage were being generated in Bangkok, and only 2000 tons were being disposed of properly (Bangkok Post, 1996).

The slum people rely on the canals more than the people in the rest of the city, which puts them in greater danger of contracting diseases. Many slum children have skin conditions due to the quantity of pollutants in the water (Inchukul and Prakan,1997). Due to a low level of dissolved oxygen, many of the bacteria, fish and plants have died, forcing fisherman to move constantly to maintain a living (Kongrut, 1997).

2.2.1 Mosquitoes

The canals of Klong Toey are heavily polluted with plastic debris. Clusters of plastic bags and other plastic products accumulate to form obstructions that hinder the flow of water. A restricted current results in pools of still water, which serve as a prime breeding ground for mosquitoes. Larvae can't survive in swift currents, but will flourish in the tepid water that collects in plastic bags. Garbage certainly clogs the canals, yet also collects water, thus serving as an incubator for the insects.

Mosquitoes can carry deadly diseases including malaria, dengue fever, and elephantiasis (Bangkok Post, 1998). During World War II, malaria killed 351 out of every 100,000 people, and now the silent killer is on the upsurge again. This time the infection is worse: multiple strains have complicated curing efforts. Malaria was once

easily curable, but now some mosquitoes carry a mutant strain of the virus that has no cure (Kongrut, 1998).

Dengue fever is the surname of the infection that results from the dengue viruses. Infection with the virus usually results in flu-like symptoms (Olsen et al., 1996). These symptoms sometimes manifest into dengue hemorrhagic fever, or dengue shock syndrome, which can prove fatal in infants and young children. The fever has been linked to Type I of the virus, yet strains caused by the Chikungunya virus have also been reported (Kongrut, 1998). Typically, dengue fever affects children less than 10 years old; however, the fever has begun its spread amongst the adult population (Bhatiasevi, 1997).

Though outbreaks of dengue fever are most apparent in provinces such as Buri Ram and Chiang Rai, "this year's fever is spreading in many other provinces, including Bangkok..." (Bangkok Post,1998). According to Dr. Chunsutiwat from the General Communicable Diseases Division, instances of dengue fever were expected to approach 80,000 in 1998. Many people take precautions against these insects between dusk and dawn; however the Aedes mosquitoes that are responsible for spreading dengue are most active during daylight hours (Bangkok Post, 1997).

Another disease called Japanese encephalitis could manifest itself in the prime conditions provided by the slum's canals. This infectious brain disease is carried by the species, Culex pipiens fatigans. The wastewater in the communities and underneath the homes is overrun with the culex mosquitoes—a 300cc-water sample could contain thousands of the pupae (Kongrut, 1998). This virus originates in pigs. According to research by Pensook Taotong, "when mosquitoes bite the infected pig, they get the virus in their saliva glands." When the mosquito bites a person, the virus is released from their

salivary glands and spreads to the human's brain tissue and spinal cord, ultimately leading to brain damage and death (Kongrut, 1998).

2.2.2 Planning Mosquito Control

The Public Health Ministry attributes the rising infection rates partially to El Nino, "The longer the weather remains warm, the more mosquitoes multiply, increasing the spread of tropical diseases," explains Nara Nakwattananukul, the director of the disease control department. While nothing can be done about the weather, something can be done about eliminating the breeding grounds in the canals. Eradicating the mosquitoes at their source is the best way to curb a potential infestation (Bhatiasevi, 1997). Mosquito control has been investigated in many countries.

In her article, "Slums at risk from deadly mosquitoes," Jittawadee Rodchareoen and her research team at Chulalongkorn University, have developed a means of exterminating the mosquitoes that spread Japanese encephalitis. Their research focuses on the biological extermination of these disease-bearing culprits. The team made an effort to avoid resorting to chemical substances as a solution, because the culex mosquitoes develop resistance toward chemicals (Kongrut, 1997).

Her team developed a biological control method that involves dropping bacillus sphaericus bacteria into the affected waters, allowing the bacteria to destroy the culex pupae without consequence to the environment or other living species. Jittawadee's research has proven that the bacillus sphaericus destroys 90 percent of the culex pupae. The Bangkok Metropolitan Administration has been approached with this methodology.

The control methods used in the US to curb malaria breeding mosquitoes are methods applicable to the destruction of most disease-bearing mosquitoes. The key

factor that most control methods have in common is to attack the culprits at their source. In this case, still waters provide perfect breeding grounds for disease bearing mosquitoes. In the United States, whenever a waterway is, "impounded for navigation, power, recreation, flood control, or any other purpose in a malarious region, the resulting lake may create a public health hazard...unless appropriate measures for malaria prevention and control are carried out" (Bangkok Post, 1987).

It is important to make an accurate portrayal of the problems that relate to malaria transmission. The epidemiological, biological, and engineering aspects of malaria prevalence and production should all be carefully considered. An effective malaria control plan should incorporate, "measures directed at the mosquito vector, measures directed at preventing contact between man and the malaria mosquito, and measures directed at the malaria parasite,"(Bangkok Post, 1987).

To attack the malaria mosquito, the program coordinators would divide the mosquitoes into two groups: larvae and adult mosquitoes. To tackle the larvae, the breeding habitat could be eliminated through filling and deepening or dewatering the area. Permanent alteration of the breeding habitat involves clearing or marginal draining of the area. Repetitive treatments include water level management and control of surrounding vegetation. To control the larvae, chemical treatments such as DDT, paris green, oil, and pyrethrum are often used. Another control method may incorporate the use of bacterial predators (Harrison, 1978). Methods to combat adult mosquitoes must be frequently repeated. These include residual house spraying, house air spraying, and area air spraying—all with DDT.

To prevent contact between man and the mosquito, mosquito proofing with bug sprays is one semi-permanent method. Depopulating the area or restricting land use to daytime occupancy is another effort to reduce the chance of contact. To take measures against the malarial parasite, patients and carriers should be repetitively treated. Antimalarials such as doxycycline are good choices for preventative medicine, while chemoprophylaxis is one treatment often used on infected patients. Even with these treatments, "the most reliable method of control is to eliminate permanently mosquito-breeding areas or to render them unsuitable for the production of mosquitoes"(United States Public Health Service, 1987). Adult mosquitoes are difficult to eradicate once they are airborne, and it is even more difficult to successfully protect man from these air-born disease-bearing culprits.

For any malarial control program, the waterway needs to be carefully evaluated, as some control methods will work better than others under certain environmental conditions. For example, if the waterway is in a mountainous region, where the population is sparse, the malaria control problem isn't too difficult. Antilarval measures of clearing, marginal drainage, shoreline maintenance, and the application of larvicides should be adequate. Conversely, flat regions that surround waterways are usually well developed and highly populated. "The flat topography increases the anopheline production potential and limits the effectiveness of water level management. These factors tend to create a very complex malaria control problem, particularly in regions where malaria is endemic" (Bangkok Post, 1987).

A clean-up method alone would not eliminate a mosquito epidemic. Exterminating the existing mosquito larvae would merely provide a short-term solution.

The implementation of an education program could reduce ignorance by providing everyone with information on pollution, environment preservation, and health conditions caused by disease-bearing mosquitoes. A clean-up effort and long-term prevention program will solve the problem. The water needs to be kept moving, and the garbage that collects water eventually needs to be eliminated.

Singapore and Malaysia have successfully reduced disease-bearing mosquitoes. Both countries beat the mosquito plague long ago; everyone was required to keep their homes free of mosquito larvae. If not, they were punished with fines and even jail sentences (Bangkok Post, 1998). While law enforcement may not be the answer, the apathetic attitude toward pollution and mosquito infestation needs be altered. Everyone needs to make a significant effort to eliminate all breeding grounds for mosquitoes. This means, "emptying pools of still water, whether in small pots, jars, bottles and other areas where they breed" (Bangkok Post, 1998).

Most of the residents of Klong Toey are uneducated about the dangers of disease-bearing mosquitoes (Peary, 1998). The slum residents in Bangkok deal with bothersome mosquitoes all the time, and suffer from 50-100 mosquito bites a day. Jittawadee of Chulalongkorn University, says, "That is quite alarming if the mosquitoes carry an infectious virus."

2.2.3 Pollution Contributors

Another factor that adds to the pollution in the canals is the use of taxi boats. When the boats run at high speed, they stir up sediment, which depletes oxygen and dissolves into the water making the conditions worse (Kongrut, 1997).

Figure 5: Taxi Polluting Canal

If the boats were to travel at a normal speed, they would add oxygen to the water, making conditions better.

The pollution in the canals was thought to worsen during the dry season of 1997. Due to the drought caused by El Nino, the water released by the Bhumibol and Sirikit dams has decreased. The decreased water volume in the canals leaves the water stagnant, enhancing disease production. There will be enough water to flush out the dirty water from the canals, but not the pollution (Antaseeda, 1998).

2.2.4 Wastewater Treatment

An industry has three possibilities for disposal of process wastewaters: (1) they may be treated separately in an industrial waste treatment plant prior to discharge to a watercourse, (2) raw wastewaters may be discharged to the municipal treatment plant for complete treatment, or (3) industrial wastewaters can be pretreated at the industrial site prior to discharge from the industrial site and thus, prior to discharge in the municipal sewerage system. Joint treatment of domestic and industrial wastewaters is

advantageous. Only one major treatment plant is required, which is economically more appealing (Viessman and Hammer, 1998).

Three categories of wastes should be excluded from the municipal sewers: those that (1) create a fire or explosion hazard, (2) impair hydraulic capacity, or (3) create a hazard to people, the sewer system, or the biological treatment system. Many of the industries in and around Bangkok discharge such wastes. This results in fires that destroy living areas as well as toxins, which harm the people (Viessman and Hammer, 1998).

Conventional wastewater treatment consists of preliminary processes (pumping, screening, and grit removal), primary settling to remove heavy solids and floatable materials, and secondary biological aeration to metabolize and flocculate colloidal and dissolved organics. The waste sludge that is drawn from these unit operations is thickened and processed for ultimate disposal (Viessman and Hammer, 1998).

There have been steps taken to treat wastewater, but unfortunately lack of funding has hindered many of these. A wastewater treatment plant has been proposed and should be functioning properly by the year 2002, but it may be too late by then. At the rate the pollution is being produced, waiting five years to begin the cleanup process could prove useless. Businesses treat wastewater on their own but not to the degree that is needed. They don't consider where all of the pollution goes, because they don't have to deal with the consequences since it gets dumped nearest the poorest and least powerful people of the nation. The businesses are already complaining about the excessive cost of the wastewater treatment plant, even though they are paying more to treat their water on their own. Suchint Phanapavudhikul of the Water and Environment Consultant Corp said "it would be cheaper to provide financial support to help them (large plants) upgrade their

facilities than to build a new central treatment plant." Companies are wondering why a central plant is needed if it would be cheaper and more cost efficient to upgrade their own (Inchukul and Prakan, 1997).

2.2.5 Water Treatment

Water treatment of the canals and other sources would provide potable water that is chemically and microbiologically safe for human consumption and has adequate quality for industrial users. Municipal water quality factors of safety, temperature, appearance, taste and odor, and chemical balances need to be satisfied in order to obtain potable water.

In 1997, Bangkok launched a program to clean up the canals by treating sediment. This step was taken because the canals are polluted not only by the contaminated water, but also by the sediment on the bottom. Water and sediment samples were collected by BTG Golder and were used to determine which substances contributed to the pollution. The process that will be used to diminish the pollution is called Contaminated Sediment Treatment. It will involve injecting oxidants into the body of sediment to reduce foul smells and help normal bacteria to decompose organic waste, which leads to better water conditions. A pilot project was supposed to begin in the past year, but no information has been found yet (Kongrut, 1997).

2.3 Human Development Center

The Human Development Center, or HDC, has been a great resource for the people of the Klong Toey slum. It is a non-profit organization that does everything it can to help the people of Klong Toey. Today, the HDC serves the slum by helping them survive fires, floods, evictions, unemployment, drug and alcohol abuse, and AIDS (Human Development Center, 1996).

Father Joe Maier founded the HDC in 1973 when he realized that few of the children in the slum were going to school. The center began as a single kindergarten designed to provide the children with a fundamental education. Now, 25 years and 55,000 kids later, the HDC has expanded to 32 schools, an adult vocational program, an AIDS hospice, social work outreach, shelter for homeless boys and girls, soccer league, credit union, and plans for a legal aid clinic (Human Development Center, 1996). Currently, 4,000 students are enrolled in the schools and there are 110 teachers employed by the HDC (Bangkok Post, 1998). Most of the staff are slum dwellers as well. These workers are people who grew up in the slum and continue to live in it. Although the staff is underpaid, they know they are helping themselves by educating their community.

There are several programs run by the HDC that are meant to better the society. The HDC is in charge of several sports leagues within the slum, including soccer and volleyball. For kids to be happy, they need a chance to get out and play. One of the most important programs of the HDC is their emergency response program. Natural disasters or fires can often wipe out large sections of the slums. The HDC reacts by providing what it can for material to build new house-like structures.

The Slum Kindergarten Improvement Program (SKIP) is another important program run by the HDC. SKIP teaches students "basic literacy and self-awareness; proper nutrition and basic hygiene are also stressed and this is coupled with a program on values." (Human Development Center) This valuable program stresses good manners and respect, both for themselves and others"(Human Development Center). SKIP also offers its students at least one meal per day.

Figure 6: SKIP Children at Lunch

There is a more advanced program for students that are particularly talented, allowing them a chance to attempt school at the college level.

The HDC is a non-profit organization that is run solely on donations, and the center also receives support from the Cardinal Archbishop of Bangkok. All the money received by the HDC goes toward increasing the quality of life of the people of Klong Toey (Human Development Center, 1996).

2.4 Duang Prateep Foundation

The Duang Prateep Foundation is a non-governmental organization that began in 1978 with only 5 people working for it. Now, it has a staff of over 100, 20 full time volunteers, and numerous part time helpers. It is a charitable organization that is headed by Prateep Ungsongtham Hata. Khru Prateep was able to start the DPF when she won the Magsaysay award, totaling US$ 20,000, for social services. Khru Prateep has lived in the Klong Toey slum since she was a child. She managed to attend secondary school by saving her wages and earning a space at a college. Realizing that most slum children don't get the chance to attend school, she built her own in the slum. At the age of 20, Prateep went against the government and prevented her community from being evicted. She was able to accomplish this due to her schooling and her determination to help her people (Duang Prateep Foundation, 1992).

Most of the DPF staff are slum dwellers who want to better the living conditions of others as well as themselves. The DPF staff and the slum dwellers are constantly exchanging ideas and information to improve living conditions. The DPF is located in the Klong Toey slum in a building that was erected in 1992, allowing easy accessibility for the slum dwellers. The DPF not only works with the Klong Toey slum but also in rural areas of Thailand. They have found similarities in the urban and rural poor that can be overcome (Duang Prateep Foundation, 1992).

The DPF has 22 projects, which are categorized into 5 areas of operation. These are education, health, social services, human development, and emergency funds (Duang Prateep Foundation, 1992). Each project allows the slum people to involve themselves in the well being of the community. The primary projects deal with the children of the

slums. The DPF provides financial support to the education of approximately 2000 children. The schooling ranges from kindergarten to university level for gifted children (Parlaman, 1996).

The DPF also has many projects for teenage boys and girls. These help in discouraging drug abuse, petty crime, and prostitution. Events are held frequently that allow the teenagers to take part in something positive. These range from organized sports to crafts groups for the young women. The Duang Prateep Foundation has helped many slum dwellers further their education and help themselves and their community (Parlaman, 1996).

2.5 Environmental Awareness in the US and Bangkok

The United States population in general is aware of the need to preserve and protect our land, air, and water resources. Despite the excessive wrapping of consumer goods and the increase in garbage output, recycling programs abound, and children receive ecology education in their schooling. Christine Veltri, a student teacher, mentions the vast resources for children to learn about pollution prevention and environment conservation, "The Internet is a good resource, there are plenty of resources, including people as sources of information. One local Worcester school has a classroom whose entire science section is centered around learning about their environment" (Christine Veltri, 1998).

There is a multitude of informative children's literature, which illustrate the wave of pollution this country faces. The November 1998 issue of *Kids Discover* was entitled "Garbage." The entire magazine illustrates a variety of landfills and spotlights facts such as, "In just one day, Americans toss out around 150,000 tons of packaging material. This amount would fill about 10,000 tractor-trailers. If all the trailers were lined up end to end, they would stretch for 120 miles"(Scher, 1998). The children's book *Reuses—2,133 ways to recycle and reuse the things you would ordinarily throw away*, outlines the growth of garbage from 1900 to the present, and offers thousands of potential recycling solutions. Clearly, despite the fact that the US is still pumping out garbage, nearly everyone is aware of the problem.

However, in third world countries such as Thailand, environment preservation is not a priority. Bangkok merchandise is heavily wrapped in plastic, much of which ends up in local waterways. Plastic bag pollution is especially widespread in Bangkok.

Figure 7: Plastic Bag Pollution

According to Richard Peary, a resident of Bangkok, "plastic bags are used for everything." Street vendors sell sodas "to go" in plastic bags complete with ice and a

straw. Any foods sold are bagged and bagged again. "Cut-up fruit will be put into a bag, and then the 'fruit bag' will be put into another bag....any food you'll take home will be wrapped in at least a half-dozen bags" (R. Peary, 1998). Part of Thai apathy toward pollution seems rooted in ignorance.

Peary explains that most of the Thai residents are under the assumption that pollution prevention and recycling programs are for rich nations. "What Thai resident would oppose the construction of a factory, that though it polluted the canals, would provide thousands of jobs?" Bangkokians are generally unaware of the detrimental impact they have on themselves every time they toss out a piece of garbage. According to Peary, most Bangkokians don't realize the personal impact of man's poor environmental housekeeping. "Slum residents in Klong Toey focus on survival, and immediate needs, not on long term environment conservation," states Peary (R. Peary, 1998).

Man's existence is threatened by the way he has treated the environment and its natural resources. Environmental awareness is crucial for major change to take place. A society that has been well taught about the environment is much more likely to encourage research and development, recycle, and change the bad habits that harm the environment. (Gega, 1998) There is a general lack of knowledge in ecology, and teachers in Bangkok don't focus on conservation in the classroom as much as those do in the United States. It hasn't been shown to most Bangkokians that if they pollute, they will be affected. Liken this thought to a Philadelphian who is to support the conservation of maple trees in Vermont. That conservation will not directly improve the citydweller's lifestyle. "Most of the children in Klong Toey have never seen a field or forest," explains Peary (R.

Peary, 1998). On a day to day basis, all the slum residents see is concrete, and houses built nearly on top of one another. Why would they understand the importance of saving a natural environment—when their environment is so unnatural?

2.5.1 Environmental Education for Children

The environment in its narrowest sense is our immediate surroundings, while on a larger scale it is the ecosystem that encompasses the entire earth. Either way, some of the best possible facilities for teaching environmental studies are available to all schools whether they are urban, suburban, or rural. In effectively utilizing the school grounds, teachers and children can examine the natural forces as they relate to their situation. Temperature changes, precipitation, air currents, pollution, disintegration and decomposition, plant and animal relationships, and people relationships are things that occur everywhere, but their intensity of effect vary with the locality.

With younger children especially, environmental education should include elements of recycling, pollution control, and social education. The children need to be exposed to these ideas while they are young; this will provide them with a solid foundation that will lead to change.

The mothers in a household play an important part in educating their children about environmental awareness. The perception of the environment begins in the home and a child's immediate surroundings. The home, community, and school are all significant parts of a child's environmental education. Many women don't receive the correct environmental education so it is difficult for them to pass it on to their children. Most of the appreciation for the environment begins in pre-primary institutions while

mental alertness begins at the age of 10. An environmental ethic must be established so that children can benefit from the actions they take for the environment.

School grounds almost always reflect the neighborhood in which they are located. The hard-topped play area of a metropolitan school is touched by pollution, noise, and overcrowding in the same way as the streets that surround it; similarly, the bare soil of a hillside school develops gullies that may also affect nearby farms.

School grounds can provide the right atmosphere for teaching the concepts needed to develop responsibility for one's environment. A child needs to be aware of the interrelationships in the natural world, and to develop concern for the misuse of this planet. Hopefully this knowledge will inspire the child to contribute to the care of the environment.

The classroom topic can initiate a trip outside. "Where do most of the earthworms on our school ground live? How can we find out?" "What kinds of pollution problems exist here at the corner of Main St. and Broadway?" Children will enthusiastically respond to these types of challenges, because they love to discover answers for themselves. Back in the classroom, conclusions can be drawn, stories written, and charts made. A follow-up session will bridge the gap between observation and understanding.

Environmental education involves becoming aware of the surroundings that are influenced. In order to teach effectively, clear goals must be established. Here are some possible goals while teaching environmental awareness.

- Become aware of responsibility towards the environment and participate in it.
- Change a person's pattern of behavior by teaching them attitudes, values and facts.
- The coexistence of humans, plants, animals, and inanimate objects.

- Allow students to adopt attitudes and hold opinions on social developments. (Briceno and Britt, 1988)

According to Kathleen Winsor, a certified teacher and guidance counselor, one sixth-grade class in Massachusetts conducted a survey of school incinerator ash. Together with a junior high school, the students collected more than 1,000 signatures on a petition that resulted in community action. Several classes in a grade school in Kentucky experimented with new vegetables in their school garden, and influenced the type of crops produced in the area (Kathleen M. Winsor, 1998).

Whatever the project, it's best for the environmental study to be pertinent to the child's own life. It would be foolish to expect a resident of a ghetto coping with a score of problems to care about a downtown park that he or she will never be able to use. Change seems most imminent when it will affect oneself. When Thomas Jefferson wrote and spoke about crop rotation and careful management of the soil in the late 1700s, few people listened because there were millions of acres of land available for the taking whenever a farm wore out. During the next 150 years, increasing numbers of people became concerned about land use, but it took the dust storms of the 1930s to usher in the Soil Conservation Service, which brought about an almost universal program of good farmland management.

2.5.2 Constructivism

Constructivism is a theory about knowledge and learning; it describes both what "knowing" is, and how one "comes to know." Based on work in psychology, philosophy, and anthropology, the theory describes knowledge as temporary, developmental,

nonobjective, internally constructed, and socially and culturally mediated. Learning through this perspective is a self-regulated process. There is a conflict between existing personal models of the world and new insights posed in education. A student can become familiar with these different viewpoints through social activity, discourse, and debate. Eventually students can construct new models of reality, "a human meaning-making venture with culturally developed tools and symbols," (Sutton,1996).

Traditional means of learning involve the notion that, "meaning can be passed on to learners via symbols or transmission, that learners can incorporate exact copies of teachers' understanding for their own use, that whole concepts can be broken into discrete subskills, and that concepts can be taught out of context" (Fosnot, 1996). On the other hand, a constructivist view of learning suggests an approach to teaching that gives learners the opportunity for concrete experience. Through experience, students can search for patterns, come up with their own questions, and develop their own models, concepts, and problem-solving strategies.

2.6 Appropriate Technology

The world's population is distributed throughout regions with a wide variety of environmental, ethnic, social, and cultural differences. Approximately one-quarter of the world's population is considered developed, while the remaining population is regarded as, "developing, undeveloped, Third World, emerging, or low income"(Dunn, 1978). Most of the people of these regions have a low standard of life. Despite efforts to introduce technology to these regions over the past five decades, the average growth has

been slow. On the other hand, the developed countries' economic growth continues to expand, widening the gap between them and the developing countries.

With the rise of mass communications, there has been an increasing awareness of the differences in the standards of living. There have been numerous efforts to launch productive development programs, and most have been directed toward the expansion of large capital plants. These plants require chemical and steelwork, road and dam construction, airports and power stations. While mass production is often the means toward an economic boom, it is usually only successful in major towns and cities where the population is educated. Most of the poverty-stricken people in developing countries live in rural areas; yet even those that live in the city are often uneducated.

However, each region has its own source of potential economic power: the traditional practices and arts of their culture could be turned into income. Intermediate Technology, now referred to as Appropriate Technology, was proposed by Dr. E.F. Schumacher as a self-help approach to development. (Dunn, 1978). Dr. Schumacher initially presented his ideas in March 1964 at a seminar entitled, "Technologies for Small Industries in Rural Areas," which was organized by the Indian Planning Commission at Hyderabad. The Appropriate Technology concept focuses on using the power of a particular community through its own resources and local skills. A developing area would not have the funds to support the construction of a work place as a developed country could, yet there would be plenty of labor and time. The jobs would be specifically created for this ready-made workforce. Appropriate Technology begins with small industry, and as the industry grows, the community develops. As money fills the workers' pockets, they can afford better equipment. Meanwhile their work has increased

their skill level enough to use the more expensive and productive equipment, thus expanding their industry.

In general, the major aims of Appropriate Technology attempt to improve the quality of life of the people, maximize the use of renewable resources, and to create work places where the people currently live. The working solutions should satisfy the following criteria: employ local skills, materials, and financial resources; be compatible with local culture and practices; satisfy local wishes and needs. And the basic requirements for sustainability and thus community development are obviously food, water, clothing and shelter; health care, hygiene, and sanitation; education and training. (Dunn, 1978).

The following quotation from Dr. E.F. Schumacher is an effective summarization of his Appropriate Technology concept:

> *If you want to go places, start from where you are.*
> *If you are poor, start with something cheap.*
> *If you are uneducated, start with something relatively simple.*
> *If you live in a poor environment, and poverty makes markets small, start with something small.*
> *If you are unemployed, start using your labor power; because any productive use of it is better than letting it lie idle.*
> *In other words, we must learn to recognize the boundaries of poverty. A project that does not fit, educationally and organizationally, into the environment will be an economic failure and a cause of disruption.*
>
> (Dunn, 1978)

2.6.1 Introducing Appropriate Technology into Primary Schools

"A general criticism of education in developing countries is of the lack of training in practical skills," (Dunn, 1978). Children in developed countries have experience with

the use of devices, whether it be through playing with their toys, or using domestic devices such as a can opener, or "helping" their parents with household repairs. Even small children that are presented with a nut and bolt can unscrew it. However, this background experience is often lacking in developing countries, and the educational contribution of this experience is usually not considered (Dunn, 1978).

Schools can be utilized as a means of introducing new technology or development in a community. The need for simple tools used for educational purposes and in industry opens up a new demand for local craftsmen. The value of these tools and of their practical use should be understood by teachers and introduced to their students at their appropriate level (Dunn, 1978).

In general, the same phenomena should be applied to secondary schools. A local university can be of special assistance. For example, the Physics Department of the University of the West Indies set up a Schools Science Unit that provides equipment designs and training and technical back-up service for science teachers. Some of the simple equipment suitable for school science laboratories include: measuring equipment, a bio-gas source for Bunsen burners, and a solar still that provides distilled water.

2.6.2 The Appropriate Technology Association (ATA)

The Appropriate Technology Association is non-profit organization that promotes appropriate technology for the improvement of society. In 1985, the ATA started a project called the Local Weaving Development Project (LWDP) in Thailand. The primary goal of the project was to assist rural women in the northeast (Isaan) provinces of Thailand by providing them with leadership skills and to help them become financially independent. The program works to improve the living conditions of the women by

bringing back the lost craft of weaving. The women are trained in natural dyeing and weaving techniques, which help to develop markets to bring in much needed income. Today, 500 women from 24 villages take part in the program.

Traditional weaving techniques have been passed down through generations of Thai women. By reverting back to the traditional dyeing and weaving techniques, this project is bringing back a sense of pride in local history and cultural arts.

The ATA has helped several villages in Northern Thailand by enhancing the quality of life and self-reliance of the women. The project is well rounded as it addresses problems of poverty, environmental awareness, and women's leadership.

2.7 Weaving

Education on environment preservation would naturally include the encouragement of recycling. The craft of weaving plastic bags is one way to recycle plastic debris. Weaving involves interlacing threads or other materials at right angles to each other. The vertical threads that provide the structural "skeleton" for weaving are called warp. The weft is the set of horizontal fibers that are woven through the warp. Choosing warp and weft will determine the woven design. Weaving is a product of the imagination-- an individually designed intricate mix of textures, colors, lines, spaces, form, and rhythm.

Weaving is like any art form—it portrays the expression of ideas. Many Asian cultures use rug weaving to express religious values for instance. According to Eiland's book, *Chinese and Exotic Rugs*, there are a number of symbolic objects and animal forms that can be divided into religious categories. "The eight Buddhist symbols of happy

augury are perhaps the symbols most often seen on rugs, and they may occur individually or as a group," explains Eiland. Some of these symbols include the "pair of fish" and the "closed vase." The paired fish suggest abundance, prosperity, or fertility. The closed vase contains a heavenly elixir and implies an enduring peace and harmony.

While these symbols do belong to Buddhist iconography, they are general enough within Asian culture so that non-Buddhists find meaning to the images. "Their appearance on a rug does not prove that the rug has some religious function or was woven for a Buddhist"(Eiland, 1979).

Both children and adults can have fun experimenting with different styles of weaving, and in using unlikely materials for weft and warp. Strips of paper, felt or cloth can be used; reed, raffia, and burlap are also quite common according to the book, *Weaving without a Loom* (Rainey, 1966). Tufts of cotton and corn husks, and even fungi, alfalfa, and cattails can be used to accentuate a weaving. The choice list of weaving materials is endless.

Using plastic bags as a weaving material is a creative possibility with more than one benefit. Plastic bags can be transformed into beautiful sturdy weavings, and weaving waste is a recycling effort that will help to preserve our environment. Weaver Ann Gerlach wrote "Weaving with Recycled Bags," in the *Countryside and Small Stock Journal* (Gerlach, 1994). Ms. Gerlach's daughter explained the concept of weaving plastic over the phone. Plastic bags can be woven together with the same technique used in making rag rugs (Gerlach, 1998).

The use of plastic may also be incorporated into methods such as inkle strips, tablet strips, and hooked, braided, wrapped cord, and clip rugs. A few of these techniques

can be done without a loom--but rugs made tapestry-style for example, need to be done on a loom. Looms are basically rectangular or square-shaped structures with pegs. Therefore, homemade looms can be easily constructed from picture frames or sturdy boxes (Seagroatt,1972); larger looms can be fashioned out of bed frames, or by banging nails into the back of a door for an upright-style loom.

Weaving can be done with the hands, but tools should be used for better accuracy and a tighter weave. Each of the tools can be improvised. For example, any work done on a loom will require some sort of portable beater to beat down the weft—a heavy table fork could do the trick. Weaving isn't a costly craft—some of the most intricately woven oriental rugs were done on primitive looms using recycled cloths (Eiland, 1979). This hands-on craft can be enjoyed on a variety of levels: from simple weaving and rug hooking, to intricate tapestry weaving and jewelry making.

2.8 Puppetry

Puppet shows using poems or stories that are already known are good ways to entertain children. By using a dramatic poem or story that has minimal changes or omissions a child will be able to easily relate to the puppet show. Folk tales and story poems are prime examples of this because they have fast paced dramatic qualities. If the show could be pantomimed or dramatic action added, more meaning can be taken.

2.8.1 Types of Puppets

There are many different types of puppets. Shadow puppets are as early as man and were thought to have been used by the cavemen in describing their hunt. They were

first used for entertainment purposes in China. They are the more popular of the puppets, especially in Thailand. They are usually flat figures, which are cut in profile from cardboard or other stiff material. They can be attached to a rod for a better view. They can be held in front of a back drop or screen that is placed over a table. Shadow puppets can also be used as silhouettes if they are located behind a screen with a light shining onto them (Ross, 1972).

Hand puppets are another type of puppet which are seen quite often. This consists of a hollow figure that is moved by putting a hand inside and moving the fingers and wrists. They were used in the Church in the Middle Ages to dramatize stories from the bible. They eventually became too vulgar and were banned from the churches (Ross,1972).

Puppet shows in Shakespeare's England were called motions and the operators were called motion men. The most famous of these were Punch and Judy. Punch was called Pucinello in 1600 and he was thought to have inherited his hump and hooked nose from an ancient Roman clown (Ross, 1972).

A final type of puppetry is the pantomime. This form is a way of conveying thoughts and emotions through acting. This is done using expressive body movements with little or no talking. Pantomime later developed into drama. The commedia dell'arte was a group of traveling actors who acted wherever there was an audience. They often stopped in the marketplaces of Italy (Ross, 1972).

2.8.2 Puppets in Nursery School

When planning puppet shows for nursery children, different factors should be considered. Puppetry has less value for children of this age, so it could become harmful.

The children already have their own make believe worlds that they retreat into if their lives become too disturbing. A puppet show could be confusing unless it meets the child's specific needs. If children are allowed to see the puppets as they are being built, they could be enjoyed more as well as being less frightening. Young children can become scared if they see lifeless puppets after a show. This is because the children saw the puppet with a life of its own and they don't understand that someone was actually moving it. It is best if puppets are put away before a child can see it (Wall, 1965).

Only one or two puppets need to be used for entertaining nursery children. These puppets should be very simply made. Children should see that they too can make these puppets. If the puppets are too elaborate then the children will not be able to relate to them. This could lead to less enjoyment of the show (Wall, 1965).

Nursery rhymes must also be kept like the children know them. If a nursery rhyme becomes too dramatized the children won't recognize it and will become scared. Frightening situations should be cut out of all puppet shows. The puppets should do familiar things for the children.

Another way to entertain children during a puppet show would be to incorporate events, which take place in the lives of the children. One must make sure that puppet shows are only used occasionally, so as not to deprive children of the other valuable learning experiences that they can gain from nursery school (Wall, 1965).

Children can make their own puppets but it is not recommended that they be used for a puppet show. They should only be played with by the children themselves. These puppets can be made from just about any material that is around. One of the simplest methods requires only a cardboard tube of some type, or the lid of a matchbox. Paper

and cotton can be attached to form a face and hair. Clothing can be made from different colored paper or material. Other methods of making puppets can involve small paper bags or small vegetables and fruits. When a teacher introduces puppet making into a classroom they should be aware that only a small group of children will be able to make puppets at a time. This is due to the fact that each child will want to create a puppet that meets his or her needs. These puppets may not appear to represent anything to adults but they will resemble the make believe characters in the child's mind (Wall, 1965).

2.8.3 Creating Puppets

There is an enormous range of types of puppets that are suited to puppeteers of any age, and any degree of work needs, and any level of craftsmanship. There are many types of puppets, some of which include glove puppets, rod puppets, shadow puppets, and marionettes.

The "glove" type of puppet consists of a hollow head that is then attached to an empty cloth 'body.' The base of the body is open for the performer's hand and forearm to reach inside. The 'body' should be fairly loose on the puppeteer; the hand should be left flexible for better control and maximum puppet movement and agility. The opportunities in decorating the puppet are constrained only by the limits of the person's imagination.

The rod puppet is similar to the glove puppet, except that a rod is inserted into the hollow head, and the body is built up. It is important to have a well-designed head. There are a variety of versions in head construction. One idea involves drilling a hole into a block of wood, and inserting the rod into the hole; another idea is to simply pad

the end of a rod with a ball of material. "For certain puppets, a wire cage is very good, particularly if it is necessary to give support to an extremely elaborate costume" (Wall, 1965). The rod itself should be as long as possible, at least 12 inches, "to give easy support to the puppet and prevent unnecessary fatigue for the manipulators" (Wall, 1965). This works well if the puppet is to remain fairly static—as a bystander character for example. However, if the puppet is to be very active, a shorter rod will provide better control.

Shadow puppetry needs only three elements: a source of light, an object to display, and a screen to take the shadow. The screen can be constructed from a rigid frame such as a canvas stretcher or picture frame, and covered with a semi-opaque colorless material—a white window blind or cotton sheet. The light should be placed behind and slightly above the center of the screen. The larger the screen, the further back the light should be situated. If rod controls are used the light is sometimes placed below instead of above the screen, and in front of the showman, "but in either case it must be so placed that no shadows of the operators are cast forward" (Wall, 1965). Objects can be cut from cardboard into simple silhouettes, and can be "jointed" for mobility. For the best clarity, these objects should be held close to the screen for well-defined shadows.

Marionettes are the highest form of the puppetry art. The marionette requires more advanced construction, and skilled hands to control the puppets' movements. However, "the heights of imagination, fantasy and caricature to which the marionette can rise are far above those possible in other forms....for many puppeteers, the marionette is the final stage" (Wall, 1965). Marionettes are jointed figures controlled

from above by wires or strings, and may vary in size from a few inches to a few feet. Though marionettes usually approximate human features, the heads are usually larger, and some limbs may be disproportionately large for certain purposes. "A marionette is designed, made and strung to do certain things only, but to do these things well" (Wall, 1965).

2.8.4 Constructing a Theatre

The two main objectives in building a theatre include screening the showman, and revealing the puppets so the audience can best see. A showman must be hidden so that the audience can accept the puppets as "real." If the showman's feet or hands were to peek out during the puppet performance, the audience's imaginative powers would be ruined. The puppets on the other hand, must be seen by everyone. They should be held up in a confined, framed space to enhance the focus on their actions.

A puppet theatre may include a shelf for puppet props, and curtains can also add to the effect, because scenery can be changed behind them. "The sight of closed curtains rouses the greatest curiosity in any audience..."(Jones, 57). At "curtain down" the suspense builds as the audience wonders what will happen next, and at "curtain up" they are captivated with the development of the story.

Before a showman plans his theatre, he needs to consider the location of his shows. If the show will always be given in the same place, a large permanent theatre could be built. If it is a traveling show, something lightweight and easy to erect is probably best.

A theatre can be improvised in limitless ways. A card table can be turned on end and either draped with a cloth, or put in a doorway with the table end facing out. Two

chairs can be arranged back to back with a board laid across the tops of the chairs and draped with a tablecloth. An armchair could be set into a corner with a large picture frame atop its back and leaning against the two adjacent walls; the front of the chair could be draped with a cloth. The armchair can also be used as is, with the showman crouching on the chair holding his puppets up over his head facing the back of the chair. A screen is another novel idea for a theatre, and can also be used as is.

Though a permanent theatre can be more cumbersome, it may be more suitable if the showmen have only limited set up time. A simple theatre for beginners can be constructed from a wooden box. The base of the box can be knocked out, and a length of the base about four inches wide should be sawed off. This piece can be nailed to the underside of the box so that it projects forward as a shelf or stage. Next, a proscenium, or frame, can be cut from cardboard and attached to the front of the stage. A slit can be sawed in lengthwise at the rear of the theatre so that a rod with a sheet of scenery can be inserted into the backdrop. The theatre can be placed on two chairs or tables, and draped with a curtain or cloth (Jones, 1957).

2.8.5 Scenery

Scenery serves the purpose of creating an illusion of where the story takes place. Using different scenery for each scene of the play lends variety and adds interest to the act. It is most effective to make the images bold and colorful, with minimal detail. For example, a yellow circle placed high in the scene, and vertical brown stripes with green blobs atop at the base of the scene will suffice for a sun and trees. A far away audience will miss detail, and less elaborate images will ensure that the scene is clearly what it was meant to be (Wall, 1965).

Almost any paper or cloth can be utilized as a surface for scenery. A showman may decide to applique houses or fields using different textured materials. Painting with an acrylic-based paint is another option that is superior to almost any other drawing or painting material. Pencil, crayon, marker, and water color do not show up as well, and oil or charcoal are difficult to work with because of the long drying time.

Scenery can be pinned to the backdrop, or hung on long rods and lowered into the back of the theatre. If the theatre is a box-like structure, then white paper or posterboard can be cut to fit the back of the box, and clipped or velcroed in place. For panorama plays, another type of scenery can be done on a roll of paper, "it is possible to have the whole background of the story on a long roll of paper" (Jones, 1957).

However, shows with continuous action don't often allow for scene changes, and can benefit from a simple black backdrop. The black background encourages the audience to use their imagination, and the brightly dressed puppets will stand out from the dark surroundings. Sometimes a black backdrop can enhance the focus on the story line as well. Shakespeare used this device in all of his plays, and "many of his loveliest lines would have been lost if Elizabethan stages had been equipped with the paraphernalia of modern theatres" (Wall, 1965).

A black backcloth is also very efficient in hiding the showman. If the theatre is placed so that no light falls on the showman from behind, and is directed instead at the front, then the puppeteer is completely invisible to the audience, yet can see the puppets through the cloth from his or her position behind the theatre (Wall, 1965).

2.8.6 Props

Nearly any article could be transformed into a puppet prop. Carts to push, toys to play with, telephones to ring, can all add realism to a play. The collection of props should have one thing in common: they should all be relative in size to the puppets, i.e., "the tree will be large enough for the puppet to hide behind, and the teacups exactly right for drinking puppet tea" (Wall, 1965).

The props must be altered to suit the puppets. A puppet can't lie easily in bed, as a doll could for example. It has a long arm, or rod attached to it, and must be able to get in and out of bed. The bed could have a hollow base then, and could be covered with a quilt or blanket. The puppet could enter and exit through the bottom of the bed (Wall, 1965). Houses, castles and palaces can be cut from cardboard, and the archways could be bent backward so that the outside end is free for the puppet to pass through. Moving carts and cars and boats can be constructed and placed atop a card folded in half. This contraption can be slid along the length of fishing line. Puppets can put their heads through the window and glide the vehicle along, or the vehicle could be attached to more line and pulled by the showman.

2.8.7 Special Effects

Exaggerated actions, and song and sound, are the key criteria for an entertaining play. A show will lose its magic if the puppets merely say their lines by rote. "A three dimensional effect is achieved by (1) action, (2) speech, (3) music. Too much of any of these would spoil the balance of the performance as you will realize if you imagine a play [to be] all action, all speech, or all music" (Jones, 1957).

Nearly every theatrical show has some kind of music. "Even the old time silent film had a piano rattling away as the gold wagon was chased by hordes of Indians" (Jones, 1957). However, music that doesn't coincide with the puppets' actions should only be used between scenes to fill in time. Puppets should always mime the music—either sing or use tiny instruments out front. Another way of making music is to have the puppets use instruments that actually play. Clashing cymbals, tiny jingling triangles and bells, and even drums, xylophones and pianos can be used. The instruments can be attached to the puppets hands with elastics, and the drummer and xylophonist can have tiny sticks sewn to the sleeves of their clothing. The piano can be played with your two fingers, a.k.a. the puppet's hands.

Other sounds can be created with only your own ingenuity setting limits. "There are some old, old tricks, such as rattling trays for thunder, shaking a quarter filled box for rain, knocking coconut shells together for horses' hoofs, and splashing a bowl of water for noises on the seashore" (Jones, 1957). Sounds can also be made with the showman's own foot and mouth. One could stomp about, or put on a tap-shoe, and whistle or cluck the tongue.

2.8.8 Nang Yai

Nang Yai is the great Thai shadow play. This type of puppet performance involves manipulating puppets made of cowhide in front of a backlit white screen; music and narration are also integral parts of the play. During the reign of King Rama II of the early Rattanakosin Period, it is said that the play, "shook the whole city." The puppetry's widespread appeal encouraged the royal court's master craftsmen to create a set of Nang Yai puppets. These puppets were called Phra Nakhon Wai, or "Shaking the City."

Approximately 180 years ago, Phra Nakhon Wai were used in celebration of royal functions and special occasions.

Unfortunately, Nang Yai is a dying classical art in Thai culture. A fire at the National Theatre damaged some of the puppets, which resulted in an end to Nang Yai performances in 1960. As time went on, the great shadow play lost its public appeal, and the puppets that survived the fire were left at Bangkok's National Museum.

However, recent efforts to revive the play have proven this lapse in puppet popularity to be a temporary one. In honor of King Bhumibol Adulyadej's 50th anniversary of his accession to the throne, government agencies and the private sector joined forces in 1994 to launch a restoration program for the Phra Nakhon Wai set of Nang Yai puppets.

Twenty-eight master craftsmen and artists of the Fine Arts Department's Traditional Arts division cooperated in this restoration project. The materials used to make the Nang Yai puppets included cowhide, rattan, momordica leaves, soot, Chinese inks, glutinous rice flour, and acetate plastic. The artists used chisels, whetstones, mortars and pestles, and various molds as tools for their puppet construction and repairs.

The Phran Nakhon Wai project involved the restoration of 352 damaged puppets, and the construction of another 100 puppets to illustrate the war between Sattasul and Wirunchambang. This production was adapted from an episode of Ramakian, the Thai version of the Indian classic Ramayana. The project began in December 1994, and ended in May 1996 in time for the Golden Jubilee celebrations that ran through December of that year. This restoration project served as a phenomenal revival and conservation of Thai shadow play, thus promoting the significance of puppetry as a Thai art. Both the

play and the craftsmanship of puppets are parts of Thai national heritage that must be passed on to future generations.

3. Methodology

The project objective was to reduce plastic bag pollution in the Klong Toey canals. The methodology focused on implementing a long-term plastic waste prevention program. The procedure included educational puppet shows and promotion of weaving plastic bags as a means of recycling.

Figure 8: Excited Child Weaving

The weaving demonstrations were appropriate technology for an underdeveloped area such as Klong Toey. Appropriate technology is defined as using the power of a community through its own resources and local skills. The puppet shows were a way to promote the weaving as appropriate technology. These shows were suitable due to their popularity in Thai culture.

Both puppeteering and weaving are significant arts of Thai culture dating back to King Rama II. Using puppetry is an extremely cost-efficient method of educating Klong

Toey children about plastic bag pollution and introducing weaving as a solution. This is one of the main reasons why weaving and puppetry fit the description of appropriate technology. The project team also developed recommendations for bag removal with incorporated mosquito control to ensure the safety of a cleanup effort.

3.1 Education Program

The educational program was age-appropriate and targeted the 32 schools run by the Human Development Center. Basic concepts of environmental awareness were conveyed, and practical means of improving their environment through cleanup and recycling were provided. The primary method of recycling involved the use of plastic bags in weaving.

The puppet shows (using puppets hand crafted from plastic bags) encouraged the children to use less plastic as well as reuse plastic bags for both domestic use and for weaving purposes. Weaving was taught after the puppet show and the children were encouraged to experiment with plastic bags on handmade looms.

Figure 9: Children Weaving

With the aid of an interpreter the team also explained reasons why it is important to use less plastic and to recycle plastic bags. This presentation combined with the puppet show and weaving demonstration was the three-pronged approach toward conveying dumping of plastic waste.

Demonstrations were an effective way to present information to the people of Klong Toey. The project team also presented the plastic bag weaving techniques to the women's group at the Human Development Center's Mercy Center. The best part about the demonstrations was that the team was able to interact with the people. They were able to ask the team questions, and it was useful for the team to get feedback from them.

3.2 Developing the Play

The play was developed to educate the children of Klong Toey on the plastic bag pollution and mosquito breeding in their environment. The show encouraged the children to use less plastic and to reuse their plastic bags. Recycling plastic into crafts was promoted as a feasible way for them to help solve the problem. The children were in preschool and elementary school, and ranged in age from three to approximately ten, with the majority of children aged three and four.

Before the show began, Chalee, the project teams' interpreter gave a brief description of the show. This enabled the children to understand what was happening throughout the show even if they had difficulties understanding the project team.

Figure 10: Chalee Describing Plastic Bag Problem

Chalee briefly described the problems with plastic bags in the canals and also that mosquitoes breed in the plastic bags.

The story line begins with three children characters in Klong Toey: two girls, Gek and Bun, and a boy, Wit. The three begin to notice the clutter of plastic bags where they live, especially in the canals by their homes. The characters also get bitten by mosquitoes, and wonder aloud where the mosquitoes are coming from.

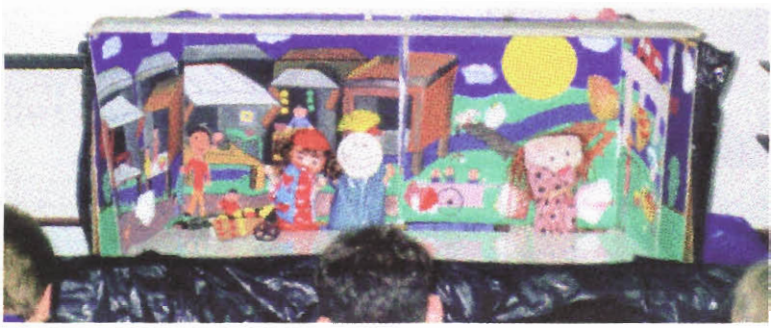

Figure 11: Scene One of the Play

The scene changes to mosquitoes in their plastic bag homes in the canals. One mosquito explains that water gets inside the plastic bags on the ground and in the canals, and that a wet plastic bag is a perfect home for him and other baby mosquitoes to live. The children characters enter the scene and notice that the mosquitoes are everywhere and that they are

living in the plastic bags. Wit gets bitten and says that he feels sick. The children decide that if there are fewer plastic bags in Klong Toey, the mosquitoes will have to leave town, and they won't get bitten anymore.

The story does not include the details of dengue fever (the virus transmitted most often by mosquitoes in Klong Toey). The team believes it is most appropriate for young children merely to be introduced to the idea that mosquito bites can make people feel ill. Outlining the risks of dengue transmission would only serve as a scare tactic that would alter the theme of the play. Details on disease transmission could also initiate unnecessary fear of mosquito bites in the children. The story line's focus remains on introducing the problems plastic bag pollution can cause, and what they, the children, can do to help.

In the next scene, the children are at the market in Klong Toey and begin to implement their ideas on how to use less plastic. Gek says that she doesn't need a plastic bag for what she buys; Wit says he will reuse the plastic bag he already has for his purchases. Bun remarks that she will save her plastic bag to make crafts. The other two are interested to see and learn about what she can make, and so a visit ensues to Bun's house to see what can be crafted from plastic bags. Bun shows Gek and Wit her crafts, and everyone examines the woven goods: a floormat, a pocketbook, necklace, and Thai flag. Bun explains the basic weaving technique, and then goes on to say that she will try to sell her crafts at the market. The three agree that "plastic bags are great for crafts."

The final scene is a "cleaned up" version of Klong Toey—the first scene minus the plastic bags. The audience is supposed to believe that because the children have been using less plastic, and recycling and reusing what they do use, there are fewer plastic

bags in Klong Toey. The characters remark on how nice Klong Toey looks, and that they save their bags for crafts. Wit mentions that he makes crafts at school with plastic bags. The children also note that because there's no plastic bags to be filled with water, there are no homes for the mosquitoes. The mosquito enters the scene and tells the audience that because he has lost his home, he will leave Klong Toey. Wit also remarks that he has recovered from his mosquito bites. The play ends with the three children celebrating about how they made the plastic bag litter and mosquitoes go away.

The play follows a simple storyline that is supplemented with dramatic action and scenery to compensate for the puppeteers' lack of expertise in the Thai language. The show lasts approximately ten minutes, which is an appropriate amount of time that just fits the attention spans of the youngest audience members.

3.2.1 Writing and Translating the Script

The script was written in English at a level understandable to children as young as three, yet hopefully lively enough to entertain those as old as ten. The script was translated into Thai with the aid of Chalee and Nina, workers for the SKIP program at the Human Development Center. A member of the project team spoke the English line into a tape recorder, which Chalee and Nina followed with the Thai translation of that line.

The team repeatedly listened to the tape and attempted to phonetically transcribe the Thai translation. The translation needed to include the five tones of the Thai language: high, mid, low, rising, and falling. It was difficult to note the slight change in tone, yet highly important, since a word or phrase spoken in Thai with the wrong tone would alter the meaning of the word. There were also sounds that are completely foreign

to the English language, such as the combination of an "l" and "r" sound. The taped translation was very rapid, and the quality of the recording was low. There were phones ringing in the background and other Thai conversations going on while Chalee and Nina spoke. Due to time constraints for Chalee and Nina, this was the best they could do for the project team.

The project team considered making a tape of Thais translating the different puppet lines to clarify the story telling. Yet, despite the difficulties, the team decided to learn the Thai themselves. This way the play would be more authentic...and also proved to be more entertaining for the audience. The group sought help from Manny Lertpatanakul, a WPI student, who is fluent in Thai. Manny graciously listened to Chalee's taped translation, and corrected the group's phonetic transcription of the script.

Figure 12: Translation of Script

The group practiced the Thai lines with the help of individual copies of the taped translation and the phonetically translated script. They also practiced for Thai workers in their dorms at Chulalongkorn University.

3.2.2 Building of the Theatre

Building a theatre for the puppet show was a process that required a lot of thought and effort to complete. In Bangkok, it was very difficult for the project team to locate all of the tools and parts necessary to build an effective theatre. Even when the materials were found, transportation of the merchandise was a problem. As a result, the team had to improvise and design a theatre that could be built with the available resources.

The primary segment of our theatre was made from a cardboard box that was bought from a maintenance person on campus. The box was cube-shaped, and had previously been used as packaging for a Panasonic TV. First, the top and the bottom of the box were removed. Next a vertical cut was made along one of the edges of the box unfolding into four equal squares that are connected. The two middle squares formed the back of the theatre, while the two end squares folded in to form an angle slightly greater than ninety degrees with the middle squares. This created a U-shaped backdrop with three sides that was sufficient to hang the scenery. A piece of cardboard was glued along the back to prevent instability.

In a puppet show there has to be a space in front of the scenery for the puppets to perform. To create this space, the entire back half of the theatre had to hang over the end of the table. The next problem the team solved was to counter the weight of the backdrop and scenery that would be hanging over the end of the table. This was done by placing a heavy piece of wood on top of the backdrop.

Finding something like this was easier said than done in Bangkok! The project team asked some of the locals, but no one seemed able to explain where to find a lumberyard. The team checked under buildings and around construction sights but could

find nothing. With the state of the economy in Bangkok, the homeless use any solid piece of wood to build some type of shelter. At this point, the team was stumped and didn't know where to look. They only had one alternative- ask the doorman at SASA*! The man that works at the desk always seemed to have a solution when the team came to a dead end. Sure enough, the team asked him and about ten minutes later, he came back with exactly what was asked for. The piece of teak wood had a price of 200 Baht.

Figure: 13 Cutting of Teak Wood

For a puppet show to be effective, it is best for the puppeteers not to be seen by the audience during the show. For this reason, the team had to construct a barrier to hide from the audience.

*Sasa International House is the dormitory on Chulalongkorn University where the advisors and some students lived during their stay in Bangkok.

Figure 14: Behind the Puppet Show

Keeping with the theme of recycling plastic bags, the walls were constructed from black garbage bags. The bags were glued to three separate two by fours that were obtained from the doorman at SASA.

3.2.3 Scenery

Many steps must be taken in order to create scenery that is appropriate for a puppet show. For our show, four different scenes were created to coordinate with the script. Much thought and preparation was put into forming these scenes. The team believed it was important to consider how the audience would perceive the backgrounds. Since the show was aimed at an audience of young children, it was imperative that the children could recognize the scenes. The team also made sure that nothing in the scenery would frighten the children because the show was for entertainment and educational purposes.

While it was important to keep the children entertained, the team also had to get across the lesson that we were trying to teach. This lesson was that *by reusing and*

recycling plastic bags, there would be less pollution around their houses. This would in turn lead to *fewer mosquitoes* and *cleaner living conditions*. It was very important that the scenes conveyed this message.

Color

Our team used water-based paints to paint the scenes. There was a basic set of six colors: red, blue, white, black, yellow and green. With these colors the team could create many other colors by using combinations of the paints. For example, since we needed a lot of brown for the houses, we combined red, yellow, green, and blue. This may appear to be easy but in order to make the scenery flow from piece to piece the team had to create large amounts of similar colors. This became difficult when colors other than the base colors were formed.

Figure 15: Painting of Scenes

Painting

The team applied the paints with paintbrushes. There were three different sizes that were used according to the size of the piece being painted. Since the paints were water-based, it was easy to clean the brushes in between the changing of paints. Once the background was painted, we used a black permanent marker to outline some of the items.

Figure 16: Outlining of Scenes

Scenes

The first scene that was created was made to resemble an area of the slums. This scene contained many closely spaced houses, which were painted in basic colors, such as brown, gray and black. The interior of each house was different, to create a more realistic effect. Most houses contained people doing various everyday tasks. Some of these tasks were eating, selling various items, sleeping, and cleaning. There were dogs scattered throughout the scenes, which is characteristic in real life. A man selling items at a cart can be found in one section of the scenery. Also included in the last slot is an overpass with cars, trucks, and buses driving along. Many of the slums are located near major highways, making this scene a realistic reflection of the children's environment.

The first scene was also used for the third and fifth scenes due to the complexity of the background and the time needed to construct such a scene.

Figure 17: Scene One

Miniature plastic bags were attached using Velcro. The bags were used during the first and third scenes, but the fifth scene changes. Since the fifth scene is supposed to represent the cleaned up community, the bags were removed to reveal flowers painted underneath. The white bits of Velcro were white flowers, and there were also red flowers. The bags were removed before the scene so the resulting background looked much cleaner than the previous two.

The second scene was supposed to resemble a canal cluttered with plastic bags.

Figure 18: Scene Two

Blue represented the water, the green represented the grass, and the brown represented the sand in between the two. Green weeds were painted over the blue paper to add a better feeling of the water. Red fish were placed throughout the scene. Also in the scene were plastic bags that were glued on. There were mosquitoes popping out of many of

these bags. This was done to show the growing mosquito population that breeds in wet plastic bags. A large mosquito puppet was created for this scene using cardboard.

The third scene used the background from the first scene. Props were added to this scene to add interest. These props consisted of a cutout of a man made from cardboard and a cart, which was also made from cardboard. This scene was meant to teach that one doesn't always need plastic bags when buying something and old plastic bags can be reused.

The fourth scene was meant to represent the house of one of the puppets.

Figure 19: Scene Four

Inside the house was a window with curtains made from plastic bags. Next to the window was a mirror that was created using silver wrapping paper. On each side of the mirror, items were hung which were created using plastic bags. Leftmost was a pocket book, which was made by weaving the plastic bags and gluing them together and attaching a strap. Rightmost was a Thai flag which was made by cutting strips of red, blue and white plastic bags and attaching them to a piece of cardboard. In front of this scene was a basket that was turned upside down to represent a stand. On the stand was a necklace made from plastic beads and a floor mat woven from plastic strips.

As mentioned above, the final scene was the same as the first and third. This scene displayed Klong Toey after cleanup.

Figure 20: Scene Five

The plastic bags were removed from the Velcro and flowers remained where the bags had been.

Construction Process

Overall, the construction of the scenery was a long and tedious process. Scene two was created on the back of scene four, so one scene had to dry before the other could be started. Using a glue gun to attach all of the decorations to the background became a little dangerous. If the glue became too hot it would burn right through the plastic bags, resulting in a messy looking background.

The use of bright colors and relatively basic scenes helped to keep the children's attention. The team hoped that if the speaking didn't attract them, the pictures would. Everything that was placed on the background resembled their everyday life. This would help them relate to the problem, and maybe they would begin taking action.

3.2.4 Puppet Construction

The puppets for this play were carefully constructed to suit the story line and especially to suit a young audience. To incorporate the play's theme of recycling plastic bags to reduce plastic waste, the puppets were created out of plastic bags. Since the

puppeteers would be working from beneath a portable theatre, the *glove puppet* was chosen as the most appropriate style of puppet to work with. *Marionettes* would have required a larger theatre that couldn't be easily carried through the narrow pathways and sometimes unstable ramps throughout the slums. *Shadow puppetry* is popular in Asia but was also eliminated as an option. This form of puppetry would have required complete darkness, which is impossible to replicate in a schoolroom with permanently open windows.

The glove puppet allows the puppeteer to maintain good hand flexibility, making it easier to implement puppet motions such as clapping, pointing and bowing.

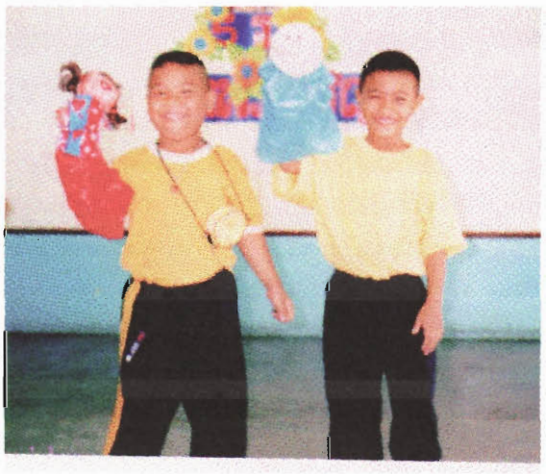

Figure 21: Children with Puppets

Glove puppets are easy to put on and remove, making it easy for the puppeteer to switch to another puppet. A puppet can remain on the hand while holding a microphone for oneself or another puppeteer who is manipulating two puppets, supporting the theatre, changing music, and preparing props and scenery when necessary.

Each of the puppets varied slightly in design, and very much in decoration, but nearly all of the materials used in puppet construction were recycled plastic materials.

Figure 22: Puppet Construction

The glove part within the puppet was made of either a small rectangular box, or from a sturdy plastic scissors case. The heads of two of the puppets were composed primarily of a plastic bag stuffed with crumpled plastic bags. The stuffed bag was shaped into a ball around the top of the glove within, and tied at the neck. One of these puppet's heads was constructed using the back of a plastic doll's skull as a base for the bag stuffed with plastic. The faces were decorated with plastic eyes cut from a plastic doll or "googly" eyes. Plastic checker pieces were used as noses; mouths were cut from plastic or cardboard. The puppets' hair was composed of plastic fibers; the hair and features were attached to the head with the use of a glue gun. One puppet had a happy and sad face cut from plastic on different cardboard circles. The heads were attached to the glove base with Velcro that allowed for easy exchange.

The bodies of the puppets were composed of plastic bags turned upside down so that the puppeteer's hand could be inserted into the opening of the bag. The fingers reached up inside the head and out of holes cut into the sides of the bag. Either one or two bags were used to outfit the puppets in shirts, skirts, dresses, etc. The clothes were decorated with assorted plastic scraps to create buttons, etc.

Several *rod-style* puppets were also used. Though rod style puppets cannot imitate real-life mobility as well as the glove puppet, they were easily manipulated and the size can vary from smaller than the "hand-sized" glove puppet, as large as several feet tall and wide.

The rod puppets were simple structures cut from cardboard which were painted to create characters, which include a mosquito, five baby mosquitoes, and a vendor. The vendor and large mosquito were glued to pieces of PVC piping cut into rods. The baby mosquitoes were attached to the plastic bags in one scene so that they appear to be popping out of their plastic bag homes.

3.3 Survey

A survey following each show was an excellent way for us to obtain feedback about the puppet shows. The survey consisted of five simple questions that could be answered on a numerical scale. This scale ranged from one to five, with one being equivalent to no (bad) and five equivalent to yes (good). The team chose this format because it seemed to be the easiest for the teachers to understand and didn't leave room for open-ended answers. The survey was translated into Thai and handed out to one teacher at each school. A self-addressed stamped envelope was left with the survey allowing the schools to send the survey back to the project team at no cost. The questions on the survey are as follows:

1) Did you (teachers) enjoy the show?
2) Did the children enjoy the show?

3) Do the children like the weaving with bags?

4) Will you (teachers) continue to teach plastic bag awareness?

5) Do you think the children will throw away fewer bags?

Since the questions we asked were straightforward, the answers should provide us with accurate answers. The teachers were able to take as much time as they needed in filling out the survey and returning it to us. Through the analysis of the survey answers, we were able to predict if our puppet shows would have an influence on the children's understanding of plastic waste pollution.

3.4 Weaving

Plastic bag weaving is appropriate technology for a developing area like Klong Toey, and provides the slum dwellers with a practical way to reuse plastic bags. Weaving silk and cottons is a large part of Asian culture, and religious symbolism is often reflected in Asian rug weavings. As an incentive to weave with plastics, the slum dwellers were encouraged to market their creations. Craft groups from the Klong Toey area already sell their crafts, and plastic bag weaving is another art with marketing potential. Plastic floor mats, beach mats, plastic ornaments and plastic jewelry can be marketed, encouraging more people to be interested in weaving with this free and plentiful resource. The reuse of plastics in weaving could lead to the reduction of plastic pollution. In addition, a community interest in plastic weaving may unwittingly lead to a greater awareness of the detrimental effects of plastic pollution on the environment.

Weaving technique and the equipment and tools used for weaving can be primitive or highly technological. The art can be adjusted to suit the personal needs of a homemaker or the production needs of a carpet company. Either way, many enjoy the art of weaving. At the Flying Shuttles weaving studio in Providence, RI, disabled people weave rag rugs and sell them. Through observation and experimentation at this non-profit weaving studio, our group determined that weaving could be introduced in Klong Toey with a minimum of materials and skills. Looms can be constructed from picture frames, or slabs of wood with two rows of nails. Cord, string, or carpet string is strung between the rows of nails to create a warp, or "skeleton," for the weaving. The project team also developed a method of cutting and connecting the plastic weft. The plastic bags were cut horizontally into 2-inch wide strips, thus creating plastic loops that could be connected together to form the weft (or weaving material that is woven through the warp.) Plastic bags of any shape or size can be transformed into weft.

Figure 23: Weaving Demonstration

The tools used in weaving can be creatively improvised. We've used a plastic rod (used to open blinds) as an oversized "needle" to push the plastic bag weft through the strung warp, and kitchen tongs to pull the weft completely through to the other side. A

paint mixing stick can conveniently hold the warp open, and a large comb was used to beat the weft together for a tighter weave. Because the imagination is the only "funding" limit for weaving tools and materials, this craft is widely available to the people in Klong Toey.

The flexibility in the styles and patterns of weaving allows for both children and adults to weave at a variety of levels. Children can thread the plastic weft in an "over and under" pattern through the strung warp.

Figure 24: Children Weaving

Their projects may include small ornaments and placemats, and they can use their imagination to create other items such as belts, purses, and simple jewelry. Adults may want to expand the project to a larger scale, and weave ornate floor coverings. Plastic bags can be braided and knotted in numerous ways before constructing the weaving. The plastic weft can then be woven into a variety of patterns using different colors to formulate imagery. Weaving can be as simple or as complex a craft as one would like to make it.

3.4.1 Weaving as Appropriate Technology

Given the problem of plastic waste pollution and a rising mosquito population in Klong Toey, it was imperative to introduce some type of technology to eradicate the problem. However, large-scale solutions such as pumping systems and chemical and biological control take time, labor, and money.

A small-scale attempt at pollution control can be more effective if it requires minimal resources. It can also usually sidestep government policies for example, and begin right away. An appropriate technology such as plastic bag weaving, utilizes the available resources and skills of a developing community to advance their economy and help curb pollution. The people of Klong Toey are already familiar with weaving as it is part of their culture. Many are talented artists and craftsmen, given that they sell strung flowers, hand-crafted pots and pans, and hand-carved windchimes, toys, etc. Introducing plastic bag weaving is appropriate technology: it is a craft with monetary value to boot, and provides the incentive that's needed to clean up Klong Toey's plastic waste.

3.4.2 Providing Looms

The team performed weaving demonstrations for two groups in Klong Toey. Each of the puppet shows at the schools was followed with a weaving demonstration and the HDC's women's craft group's monthly meeting was targeted. The demonstrations served to promote weaving as appropriate technology for both adults and children. Ultimately, weaving plastics could reduce plastic waste pollution and curb the mosquito population in Klong Toey.

The adults could utilize this new skill combined with their own craftsmanship to produce a marketable product. The children could experiment with the weaving, and the loom could serve as an educational toy. Children aged three and four are in the process of developing fine motor skills to coordinate drawing and cutting with scissors. This hand-eye coordination is improved with simple arts and crafts that require intricate hand movements and the use of tools.

Unlike children of developed countries, most children in developing areas are not exposed to tools and mechanical devices, and this unfamiliarity makes them less apt to innately understand the use of them. For instance, the average preschooler in the United States could put together and take apart a nut and bolt, while the average child in Klong Toey may not be able to. This lack of skill became apparent during some of the weaving demonstrations. The children were shown how to beat the weft of the weaving with a comb. However, when they were handed the comb to try beating the weft, many of them combed their hair instead. Being unfamiliar with the use of tools made it more difficult to understand that a comb can be used as a tool for other things besides its intended use. Having a loom in the classroom to practice on, will help to develop these skills while promoting the ideas of recycling plastic waste.

3.4.3 Loom Construction

Each of the looms given to the Klong Toey groups were designed and constructed by the project team. After each demonstration, one was given to the respective group. The team hoped that by leaving behind the means toward producing plastic bag weavings, it would spark the group's interest to begin plastic bag weaving; thus

promoting an appropriate technology for community development and pollution reduction.

Figure 25: Loom Construction

The looms were designed for the preschool-aged beginner weaver, keeping in mind both the level of understanding, and the limited dexterity of that age group. The looms are one foot by one foot, or "lap-sized." The square shaped loom provides for a more attractive finished product, than the usual rectangular shaped weavings made on lap looms. The rectangular weavings need to be sewn to other weavings. Two by four-inch strips of wood were cut into one-foot long segments, and sanded smooth. They were assembled into a frame shape, with the two side pieces lying flat, and the two end pieces nailed to the sides in a standing position, and reinforced with glue.

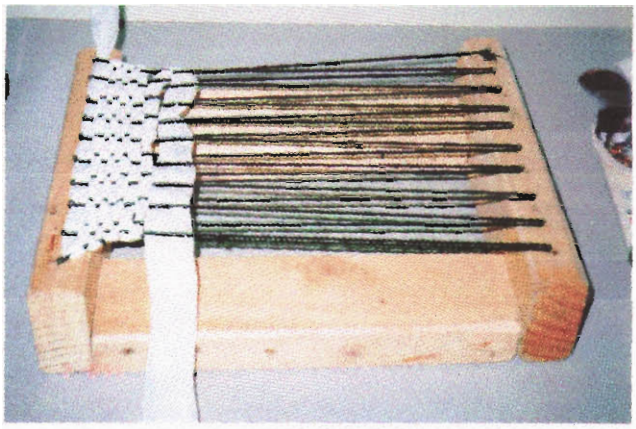

Figure 26: Handmade Loom for Each School

Each of the end pieces had tack nails nailed into a row at one-inch intervals. These intervals were approximately two to three times as large as that of the average loom, making it easier for a child to maneuver the plastic loops over and under the warp. Carpet string was strung on the nails from one end of the loom to the other, thus creating a warp for the plastic weft.

3.4.4 Purchasing A Loom

As part of the team's weaving campaign, plastic bag weaving techniques were demonstrated and discussed with the women's craft group at the HDC's Mercy Center, a shelter and meeting place for local women and children. The women suggested some additional ideas for woven products with marketing potential, and seemed excited by the prospect of additional income. To initiate a "weaving movement," it was important for the team to leave the women with more than a mere list of suggested plastic products. To provide the means toward implementing plastic bag weaving as a recycling solution and income generator, the group presented the women with a permanent floor loom.

Two weeks before the conclusion of the project, Father Joe Maier suggested that the project team consider building a more permanent floor version of their lap-sized loom, and offered to provide funding for the materials and outside labor. The team considered all options—time, money, and construction/weaving skills, and determined that buying a loom would be the most effective plan. After finding nothing in Bangkok, and examining high price lists on the web, the team spoke with Mr. Chatchai and Ms. Kanook-on, or Nam, receptionists for Chulalongkorn's SASA international house. The two suggested that the team purchase a loom from one of the local villagers in Lap Buri, Nam's home village.

The project team visited the village, and worked on weaving techniques with Ms. Konook-on's mother and several other local women for a couple of days.

Figure 27: Nam Working on Loom

The group experimented with four-pedal and two-pedal floor looms, and determined that a two-pedaled design would suit their plastic weaving needs. After deliberating and negotiating over a variety of looms, and experiencing numerous miscommunications due to the language barrier, it was apparent that purchasing a loom without a previous order was a difficult task. Despite the group's limited time, a

functioning two-pedaled floor loom measuring approximately 10 feet by 7 feet was finally purchased for an affordable 7,000 baht. With the help of Nam's friends, local police chief Mr. Suphap Aunsri, or Mum, and carpenter Mr. Sakul Kongryun, or Guon, the loom was dismantled and the pieces were numbered for later assembly.

Figure 28: Disassembled Loom at HDC

Using Mum's pickup truck to transport the loom, the group traveled several hours to the Mercy Center in Klong Toey, Bangkok. The group assembled the loom in a wide-open area on the second floor of the center, and Guon strung the warp of the loom, making the loom ready for work.

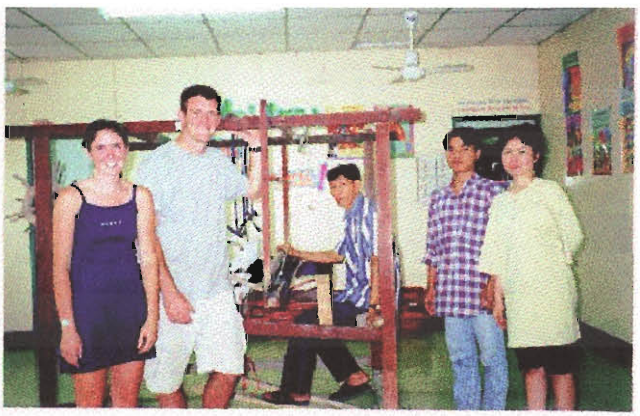

Figure 29: Completed Loom

The project team experimented with the plastic bag weaving techniques they'd formulated back in the United States at the Flying Shuttles Weaving Studio. These techniques were shared with the Mercy Center crafts groups, and the ideas were met with enthusiasm from the women.

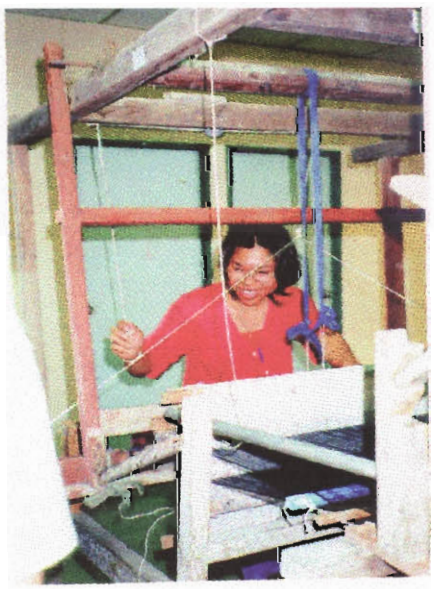

Figure 30: Woman at HDC Using Loom

By providing both product suggestions and the tools to produce them, the team hopes that plastic bag weaving will be more than a recycling solution for these women, and grow into a productive business.

3.5 Canal Issues

3.5.1 Plastic Bag Removal

We describe three methods for removing the plastic bags from the canals. Two of these are currently infeasible due to high cost. Because the Klong Toey slum community doesn't have extra money to spend on the cleaning up of the area, they would not be able

to afford these cleanup methods. Funding from an outside source could cover the cost, but not many organizations are willing to help the slum dwellers. Obtaining such funding could become a project in itself.

Method One

The first method for removing the bags is the insertion of screens into the canals. These would gather the bags into one place for later removal. A coarse screen consists of a set of vertical bars separated by a distance of 1 to 3 inches. The velocity of the particles entering the screen should be less than 3 feet per second, to prevent the bags from shredding. A screen also has a mechanical rake, which is used to clear the material that has accumulated on the bars. The accumulated material is removed and disposed of by land burial or incineration (*Venice of the East*, 1998). However, even if a screen could be introduced into the Klong Toey slum, an organization is needed to professionally remove the collected waste.

Method Two

A second method would be to insert a pump into the canal. This would force the water to flow, thus alleviating the bag buildup. Unfortunately, this could lead to a worsened water pollution situation: while pumping the water will lead to the movement of the bags, it will also cause sediment to rise from the bottom of the canal. The bags would then have to be collected at a site located further down the canal. This collection process would have to take place at a screen of some sort (Hammer, 1998). Since pumping the water also requires a screen, this process would become a rather costly solution.

Method Three

The final method for cleaning the canals is for the slum people or hired maintenance crews to gather the bags. The debris could be extracted from the canals using rakes with extended handles. This task may seem simple enough, yet in reality it is more complicated. Since the bags are infested with disease bearing mosquito larvae, there would be a health risk involved both for the workers and the people living in that area. The workers would need protective gear and toxic waste containers for the plastic debris. Some of the nearby homes may also need to be temporarily evacuated and sprayed with insecticides.

3.5.2 Mosquito Control

It will be a priority to ensure the safety of the slum dwellers, and specifically the health of those who will remove the plastic debris. Therefore, a method of mosquito control must be integrated with the plans for plastic bag removal. Disease bearing mosquito larvae accumulate in pools of still water caused by plastic bag buildup. In Klong Toey, mosquitoes spread several strains of dengue fever. Thailand and other Asian countries have utilized control methods including larvicides such as Abate, as well as Malathion fogging sprayed via aircraft. Though these methods proved successful in the short term, the mosquito population resumed expansion within just weeks (Luft, 1996). In addition, chemical control isn't the safest method for a highly populated area. Since the canals in Klong Toey run near, or even beneath some of the homes, all chemical control methods have been eliminated as options.

Biological control can reduce dengue-spreading mosquitoes without causing harm to the environment. And most importantly, this would be the safest method of control for the people of Klong Toey. We propose the use of four methods as possibilities for biocontrol: the use of predatory fish (Clarias fuscus), plankton management, Bacillus bacterias, and the mold Lagenidium giganteum. The first three organisms consume mosquito larvae; these predators need only be released into the water environment (Kerwin, 1994). The Lagenidium giganteum is a water mold that parasitizes the larval stage of mosquitoes. However the success of this method will obviously depend on how well the mold spores can survive the water conditions of these canals.

Though all four control methods should be experimented with, the L. giganteum seems to have the most potential for success. The L. giganteum has been proven to attack most species of mosquitoes in fresh water in the United States, and seems worthy of an experiment in the Klong Toey canals of Bangkok. The mold is quite durable in that it resists desiccation and abrasion, and multiplies for years (Kerwin, 1997).

L. giganteum is "host-specific." For instance, if a spore comes across a water beetle or a dragonfly, it will avoid the insect and swim on to search for a suitable host. In general, the mold infects its larval host by its motile biflagellate zoospores that recognize the chemical signaling on the epicuticle, or outer skeleton, of mosquitoes (Kerwin, 1997). As soon as the spores attach to the epicuticle, they inject themselves into the larva and spread throughout the body of the host (Figure 18).

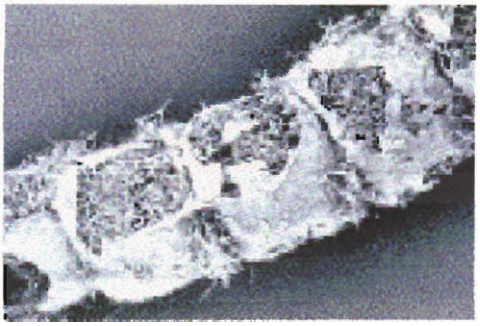

Figure 31: L. giganteum

The mold flourishes in temperatures from 16 °C to 32°C, so the temperature of the canals will be a factor in the effectiveness of this mold. However, the mold has an amazing life cycle, "the sexual stage of the L. giganteum can remain viable in a dehydrated state for at least 7 years." This means that the spore can continue to recycle itself even if its habitat is dried out for months or years. L. giganteum is also a cost-efficient means of control, it can be grown in large fermentation tanks using an inexpensive (culture) media (Kerwin, 1994).

Once a method for removing the bags is determined, there is still the problem of what to do with the bags. The bags will be useless for all purposes and must be properly disposed of. Due to the potential for the debris to harbor disease, the bags can't be disposed of in an ordinary fashion. Before the bags can be put into a landfill, or transported for incineration the mosquito larvae must be destroyed.

3.6 Improving Environmental Awareness

The adults and children of Klong Toey have developed a mental model of "environmental awareness" based on what they have been exposed to. Bangkok is a "plastic bag society," everything is packaged and repackaged in plastic, and plastic debris

pollutes the streets and canals of the city. There is little money for garbage pick-up and recycling programs, and many of their plastic products end up in the canals. It is this familiar environment that shapes their personal model of "environmental awareness." Just as US citizens cannot conceptualize the notion of garbage discarded everywhere, Bangkokians don't appear to be familiar with the earth-friendly practices that are common in the United States and Europe.

In educating the slum dwellers on environmental awareness, it was important to present, rather than dictate the concept of environmental improvement. Relaying the benefits of cleaning the canals and of long-term pollution prevention to the community will encourage environmentally friendly behavior. It will be especially important to clearly outline the risks and implications of dengue fever which directly result from breeding grounds provided by wet plastic bags.

The danger of dengue fever is a health risk that could be reduced and eventually eliminated in Klong Toey with the reduction of plastic bag pollution. The community needs to know that if they help to remove the plastic bags from the canals, they expose themselves to the risk of contracting dengue fever. In removing the bags from the canals, a mosquito control plan needs to be implemented. The difference between chemical and biological control methods needs to be outlined, and the advantages and disadvantages to both should be carefully explained. In addition to creating a healthier environment, pollution reduction would instill pride in the Klong Toey community.

4. Results and Analysis

4.1 Survey Analysis

The team received 50% of the surveys distributed. The results are shown in the following table.

Question 1- Did you enjoy the show?
Question 2- Did the children enjoy the show?
Question 3- Did the children enjoy weaving with bags?
Question 4- Will you continue to promote plastic bag awareness?
Question 5- Do you think the children will throw away less plastic bags?

School	Question 1	Question 2	Question 3	Question 4	Question 5
1	5	5	5	5	3
2	3	3	2	5	5
3	4	5	5	4	5
4	4	5	4	5	5
5	4	4	3	5	3
6	4	4	4	5	3
7	5	5	5	4	4
Average	**4**	**4**	**4**	**5**	**4**

The first question received an average response of 4 out of 5. The second question also received an average of 4 out of 5. These two questions made it clear that although our puppet show was designed for younger children, the teachers were also amused. This was the effect that we had hoped for, so the answers to these questions corresponded to what we had expected.

The third question varied the most with answers ranging from 3-5. From the experience the team had with the children and the weaving, we thought that the children always enjoyed the weaving. They were always very enthusiastic about trying it themselves and seemed captivated when it was being shown to them. Since the project

team was not aware of how the children acted on an everyday basis, the excitement they showed toward the weaving may have been normal in their everyday life. They could exhibit the same excitement towards everything that is newly introduced to them. Also, not all of the children had a chance to use the loom. This could have lead the teachers to give a lower answer, since not all of the children could respond to the demonstration. The fourth question received almost entirely fives. This provided good feedback to the team because this showed that the teachers were interested in continuing plastic bag education. If the teachers continued to promote plastic bag awareness, the children in turn would be more likely to use less plastic bags and recycle the ones that they do use.

This leads directly into the final question, which received answers of 3 and 5, but not 4. This shows that from the teacher's perspective, there is a greater chance of the children throwing away fewer bags. This was the ultimate goal of the project team and an average of 4 was pleasing.

4.2 Analysis of a Portable Theatre in Use

The portable design of the theatre was crucial for the nature of the traveling show. The puppeteers traveled by bus, by pickup truck, and on foot. Transporting a show by these means made it necessary to create a lightweight load. The project team could not have handled carrying an elaborately designed theatre with numerous props. Our simple theatre could be dismantled into parts that could be carried by the team all at once. For each show, the team needed to bring several long boards, a curtain rod, a folded backdrop, a loom, and a bag of puppets and props.

Yet even when the team's theatre was stripped down to the bare necessities for a show, there were a variety of travel troubles, including new ones every day. Often the puppeteers were sprinting after "Bus 7," burdened with backpacks stuffed with hand made looms. Though always early for the bus, it was unusual for the bus to stop exactly at the bus stop where we were waiting. When it did stop, or slow down enough to qualify as a "stop," we'd leap onto the moving bus, hoping to avoid crushing our large mosquito puppet in the closing doors.

Fortunately, the team was able to store most of our equipment at the Human Development Center, which avoided unnecessary lugging of equipment around. After each morning's initial half-hour or so wait in the garage of the center, a pickup truck was designated to carry our group and our stuff, and our interpreter Chalee was ready to go. The theatre and puppeteers fit into the back of each of these trucks with little or no room to spare.

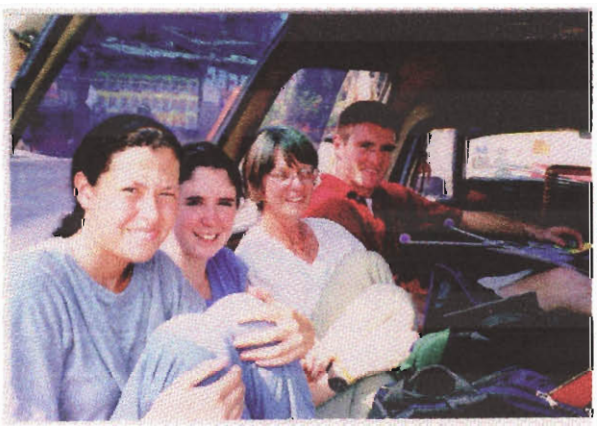

Figure 32: Traveling In the Truck

Often the travel to the school involved a substantial walk within the slum to get to the school building. Chalee carried a loom for us and led the way, while the three of us

carried the components to our theatre. The team couldn't have carried any more than we had. The walk through the area sometimes included railroad tracks and rocky ground. The spaces between buildings were only a few feet wide at some points, and there were ramps constructed of thin wooden planks that bowed with the weight of our theatre and us. We tried to step on points of the ramps marked by support beams so that we didn't crash through the ramp into the canal. One member of our group stepped through a walkway and water rushed up underneath his feet while carrying the boards for our theatre. Though the residents usually kept the walkways remarkably clean, sometimes there was litter and dog feces, and dogs to step over.

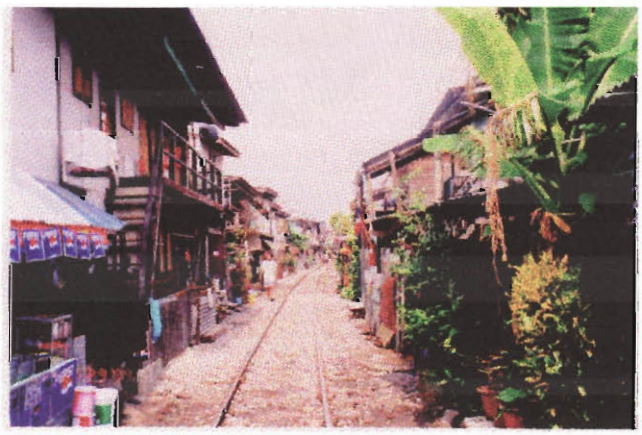

Figure 33: Pathway in Slum

The portable theatre could be dismantled and reassembled in just minutes, which suited the puppeteers' limited setup time. The portable design was easy to assemble, and we improved on our set-up procedure with the practice of each additional show. Upon our arrival, the teachers began seating the children in rows, and we strove to have everything set up by the time they were all sitting down.

Figure 34: Children Setting up for Show

Though the children were usually quietly waiting, more than 5 minutes of set-up time makes even the most patient four-year-old lose interest in the proceedings. With large groups normally ranging from 50 to 150 three and four year olds, it was important to keep the entertainment rolling. Maintaining the children's attention was absolutely necessary in attempting to educate them about plastic bag pollution.

4.3 Analysis of the Show's Effect on the Audience

Unlike traditional puppet shows, the audience saw the entire set up of the show they were about to see. This was unavoidable because each of the schools consisted of one large room. However, the team thought this was appropriate for the young audience. Those that may have been frightened by puppets speaking a strange Thai dialect were reassured by watching the components of the show being put together by the people that would be behind the scenes.

Chalee prefaced each show with an explanation to the audience of the plastic bag pollution and mosquito dilemma in their environment.

Figure 35: Chalee's Explanation for Students

This served to set the stage for the show, and to clarify the main points of the educational message if the puppets' dialect was too confusing.

The show begins with the puppets saying hello and introducing themselves, and oftentimes the children would respond to the puppets' greeting, with "So wah dee khun khun" (Hello friend). Sometimes the children remained silent throughout the show, but more often than not there was laughter, and the children would repeat some of the words the puppets would say, such as "yoong yoong" (mosquitoes), "toong plastic," (plastic bag), and "Tay Mahg," (very cool). At the majority of the shows, the children laughed when the market guy puppet came out. That puppet had no lines and was the smallest and least decorative, so their response was surprising to us. Perhaps their laughter was precisely because this puppet looked a little ridiculous with his puffy black hairdo and taped up arm (due to a lot of wear and tear from all his shows.)

Other than this, there were no specific points where the children would laugh or talk. In fact, the points of response to the show varied with each playing! However certain lines received more attention than others on average did. Some of these lines included "We are made of plastic bags!", "Ouch!" (when Wit gets bitten by a mosquito),

and when the mosquito tells the audience how much he likes his wet plastic bag home. However, it was obvious that responding to the show was "trendy." It was never just a few voices, it was the whole room saying the same thing or laughing together. Evidently when one would respond, the class would catch on and join in.

During the scene changes the team played music to keep the audience occupied for the 30 seconds to a minute it took to switch the backdrop and props. The children really enjoyed the music and at some schools this resulted in the audience "rocking the house" with 150 voices chanting and singing in unison. The team could never have imagined how much fun scenes change could be!

The show ended with the puppets rejoicing over their cleaned up environment. The three yell out; "Loi tum dee lau!" (We did it!) The puppets thank their audience, and Chalee indicates to the audience that the show is over, so the clapping begins. At this point we'd thank our audience, introduce ourselves, and begin the weaving demonstrations.

4.4 Analysis of the Weaving Demonstrations

After the puppet show, the entertainment focus switched to the weaving the puppets mentioned in their show. We passed around the woven floormat that the puppets "made," and demonstrated the plastic bag weaving technique on one of our handcrafted looms. One of the team members would cut a horizontal strip from a plastic bag and attach it to the plastic weft on the loom. Another one of us utilized a paintbrush as a tool to separate the warp of the loom, and then threaded the plastic weft through.

Then we demonstrated the simplest part of weaving: beating the weft down with a hair comb.

Objects found in the classroom and at home were used as tools in these weaving demonstrations. This showed that nearly anything can be used to weave—weaving is something that everyone can have the opportunity to try. Furthermore, simple and familiar objects used in ways other than their intended use initiated interest in a young audience.

Because beating the weft is the simplest and probably the most enjoyable part of weaving for a child, this step was chosen for the children to try. Even with so many children, and only one or two looms at a show, many could take a turn with this short and easy step.

Initially the children were often timid about taking the comb to weave. This was partially due to the language barrier—sometimes they didn't understand that we wanted them to try it if they'd like to. But even with the teacher explaining to them that they could help weave, sometimes no one wanted to be the first one! Usually within seconds of one child taking the comb, another would reach out for it. Once one or two of the children had beaten the weft, nearly everyone wanted to try it. One or two of the team members would go around the room and kneel down among the children, giving as many of them turns beating the weft as possible.

Figure 36: Weaving Demonstration

The child would then usually do it on his/her own, and the team member would praise her with, "Chi yo!" (Hooray!), "Tay Mahg!" (Very cool!), or "Soy mahg!" (Very beautiful!). Often the children would repeat these words for the young weaver, or clap for one another. Some needed to be encouraged more than others. In this case, the team member would show the child again how to do it and then guide their hand through the motion. The children would encourage their friends who were more timid, and cheer or compliment them when they tried the weaving.

Sometimes the children would get very excited, and those that couldn't see what was going on would understandably stand up and try to push their way through to the front. Before the group got too rowdy, we'd encourage them to sit down by patting the floor and sitting down ourselves. The language barrier wasn't usually a problem for crowd control. At ages three and four, a child is more apt to watch and pay attention, rather than to listen and pay attention. Any parent, babysitter, or teacher would agree to this. Words spoken to an overly excited child go in one ear and out the other. Nearly anything other than, "one, two, three…" (or "nueng, song, saam…") ever works. If a

teacher instead resorts to silence with a look or a hand motion, i.e., finger to the lips for quiet, or doing the requested task themselves, i.e., sitting down, they get more attention, and hence better results.

Figure 37: Excited Children After Show

At the conclusion of each weaving demonstration, the project member gave the children the loom they had just worked on to keep. Judging by their excitement, and the fact that children love any new object, (anyone knows that even pots and cardboard boxes are great toys to kids if they are new), we can safely assume that the children will play with the loom. Even if nothing gets "woven," the children understand that plastic bags can be used for crafts.

4.5 Plastic Bag Crafts and Pollution Reduction: An Analysis of the Child's Sense of "Cause and Effect"

The show and weaving demonstration introduced the issue of plastic bag pollution in their environment, and showed the children that they can help reduce the pollution by using bags for weaving. The ultimate goal of this portion of the project was to instill this idea.

It will take some time for most of the children to come to this understanding: *that there is a connection between their actions and improving their environment*. However, this is the age at which they begin to form the mental relationship between cause and effect beyond their physical senses. (Prior to this age they understand the cause and effect of hitting or pinching and the resulting pain, for example.) Part of the reason children make these relationships at ages three and four, is because they are forming their first sense of independence and control outside of their dependence on their parents. Therefore it is a most appropriate time to introduce them to the fact that they can help to improve their environment.

4.6 Analysis of Thai Culture in Relation to the Project

There are many aspects of the Thai culture that should be taken into consideration when analyzing the effects of the project. One key component is that many Thais are hesitant to say negative things. This could be why many of the surveys were answered in a positive fashion. The Thais don't like to offend people and would rather give an answer that is pleasing rather than give the complete truth.

The language barrier also played a large part in our puppet show. Although the group members tried to learn the correct Thai pronunciations, it was obvious that the children didn't understand much of what was being said. The children still enjoyed the puppet show, but they didn't comprehend as much as the team had hoped for.

Another key component was the difference between performing a puppet show for children in the United States and children in Bangkok. If this puppet show had been

performed in the United States, the children would have had a better understanding of what was happening. Since the Thai children aren't exposed to much environmental awareness, it may have been hard for them to understand the puppet show.

Overall, the team was pleased with the reaction they received when performing the puppet show. Everyone involved was very kind and helpful. We hope that the children benefit in some way from the educational lesson we presented.

5. Conclusion

5.1 Summary

Bangkok faces widespread plastic bag pollution that inhibits the flow of local canals. In addition to destroying potential sources of drinking water, the still stagnant waters provide optimum breeding grounds for mosquitoes. Unfortunately, local rates of dengue fever coincide with the rising mosquito population.

The project team approached the community's plastic pollution problem with a dual approach. A list of recommended cleanup methods including screening, raking, and pumping the canals was presented to the Human Development Center as viable means of future pollution control. The use of biological control is also strongly recommended to reduce the mosquito population in conjunction with plastic waste reduction. It appears that implementing a series of biological control would work best. The most fitting of these methods would be the Lagenidium giganteum, which is a water mold that parasitizes the larval stage of mosquitoes. It has already been proven to attack and reduce populations of mosquito larvae in the United States. This control method is inexpensive, harmless to the slum community and requires little follow-up.

The second part of the approach involved the implementation of a prevention program. Utilizing the concept of appropriate technology, plastic bag weaving was introduced as a recycling solution suitable for the local community. The project team promoted plastic bag weaving and environmental awareness to 4,000 preschoolers

attending schools associated with the HDC, and additionally presented their message to the local women's craft groups associated with the HDC's Mercy Center.

The team developed and performed a traveling puppet show and weaving demonstration that educated the children about the plastic bag pollution in the canals, and promoted the use of weaving as an alternative to basic recycling methods. At the conclusion of each puppet show, a plastic bag weaving demonstration was held and the children were encouraged to participate. Looms handcrafted by the team members were left at each school in the hopes that the children would continue weaving.

The weaving campaign was also introduced to the women's craft groups, and the team suggested several ideas regarding the production of woven products with marketing potential. In addition, a floor loom was presented to the women with the implied purpose of initiating a "plastic bag weaving movement" among the group.

The project team has implemented a long-term prevention plan that could eventually suppress the area's plastic bag pollution. Along with this, a clean up program must be established to effectively reduce the plastic waste in the canals. Though any cleanup and prevention "two-pronged approach" takes time to implement, introducing an appropriate technology such as plastic bag weaving may provide the spark that leads to Bangkok's pollution solution.

5.2 Recommendations and Future Work

Many of the answers that were received represented a positive response as to the educational effectiveness of the puppet show and weaving demonstration. In order for the children to remember what they saw in the puppet show it is important for them to receive follow up education in plastic bag pollution and recycling. If the teachers don't

present lessons that involve plastic bag awareness, it is unlikely the children will remember what they were taught. They may pick up bags and recycle them for the first few weeks, but eventually the novelty will wear off.

In order to accomplish a long-term cleanup effect, the team recommends a group to follow the initial program the team began, and continue teaching plastic bag awareness and weaving. By leaving a loom at every preschool, we have provided the equipment necessary for the children to practice plastic bag weaving. It is important for the teachers to promote the weaving in their classroom.

In addition to preschoolers, primary school aged children should receive education about plastic bag awareness. If plastic bag awareness is promoted throughout the schools, there is a greater chance that the children will remember what was taught to them. Teachers must continue to teach how detrimental polluting the environment is, and how simple recycling can be.

The project team proposes that the HDC hire people to teach and encourage the plastic bag weaving to villagers as well as the schools in the future. Ten to fifteen people need to be hired for approximately two weeks to promote the weaving so that the people can learn how to weave effectively. It would be ideal for these people to have larger, more permanent looms than the ones we have been using with the children.

A physical cleanup in the slums also needs to take place. This will take a lot of time and effort but the end product is bound to pay off. This could be a possible IQP project for WPI students next year. If government funds can be solicited, the slum dwellers would be more likely to clean up the area surrounding their homes. A project such as this could build from our project by setting up collection boxes for plastic bags.

Large yellow bins could be set up for plastic to be recycled, and it could be arranged for the government to empty them out two or three times each week. Just as with the weaving, the slum people need only a small incentive to recycle the plastic bags.

Introducing environmental awareness and plastic bag weaving to the slum community was the start of a pollution solution, but reducing plastic waste debris is a long-term process. It is imperative to continue the pollution prevention program, and to implement a future method of cleanup.

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Simple weaving techniques without a loom. We will use these ideas to weave items from plastic bags.

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Descriptions of different puppets and uses of poems in puppetry

Sasaki,Hitomi. "Urbanization Transition and its Impact in Thailand". University of Michigan. Retrieved November 11, 1998 from the World Wide Web http://www-personal.umich.edu/~wddrake/sasaki.html

Many useful facts about the slums of Bangkok as well as water pollution in the canals

Scher, Linda. (1998 Nov.). "Garbage." *Kids Discover*, pp. 1-19.

Different uses for garbage as well as activities

Seagroatt, Margaret. (1972). *Rug Weaving for Beginners*. New York: Watson-Guptill Publications.

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Father Joe Maier's dedication to the programs at the HDC

Thurstans, Shaun. (1996, Nov4). Plastic Bag Campaign Update. University of Tasmania. Retrieved November 11, 1998 from the World Wide Web. http://www.utas.edu.au/docs/societies/list/green/bags.html

Charging a fee for plastic bags in Australia

UNICEF House. (1990). Children and the Environment. New York: UNICEF House.

Discusses environmental awareness and education

United States Public Health Service. (1987). Malaria Control on Impounded Water. Washington D.C.: U.S. Government Printing Office.

Forms of malaria control

"Venice of the East". Bangkok University Home Page. Retrieved November 15, 1998 from the World Wide Web. http://www.bu.ac.th.thailand/venice/html

Discusses the different canals in Thailand and their uses

Viessman, W., Hammer, M. Water Supply and Pollution Control. California: Addison Wesley Longman, Inc.

Discusses water treatments and different pollution control methods

Wall, L.V. (1978). The Puppet Book. London: Faber and Faber Limited.

Discusses the effects of puppetry on children

Weber, Jill. (1976). The McCall's Book of Rugmaking. New York: Simon and Schuster/The McCall Pattern Company.

Gives examples of both simple and complex weaving patterns

Pages cropped in original

IQP/MQP SCANNING PROJECT

George C. Gordon Library
WORCESTER POLYTECHNIC INSTITUTE

Appendix A

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Appendix B

Script: English followed by Phonetic Thai Translation

Speakers: "C" denotes Cathy, "W" denotes Wes, "S" denotes Seana
Tones are indicated as:
no punctuation or symbol: medium tone
underscore: low tone
exclamation point: high tone
the letter u: rising tone
question mark: falling tone

C: Hi boys and girls!
Sa wa_ dee dek dek

W: There are a lot of plastic bags outside, aren't there?
Mee toong (?) pla(u)stic_ ye(u) yaa(u) kahng(!) nog(!) chai(!) mai(u)

S: For sure. Plastic bags everywhere make problems for us.
Ow lah_. Toong(?) pla(u)stic_ mee tuk(u) hang_ mot_

S: We have a show about it for you.
Lau ja me gahn sadang kong(?) mun hi(!) porg(!) ter do

W: Is it a funny show?
Mun ben gahn sadang tee(!) sanook_ mai(?)

S: For sure!
Ow lah_.

C: Enjoy the show!
Lau ma lorm(!) sanook_ gun

Scene 1

C: Look at this mess of plastic bags!
Mong bi tee(!) kwam yoong(!) yaang(!) kong(?) porg(!) toong(?) pla(u)stic_

S: The plastic bags are everywhere!
Toong (?) pla(u)stic_ mee tor(!) tuk(!) hone(?) hang_

W: The bags are also in the canals near our houses!
Toong(?) ja me nie klong glai(!) bahn(!) kong(?) lau

A: Ouch!
Ouch!

S: Oh no! Mosquitoes!
Yaah(!) laaw(u) yoong yoong
W: Where are the mosquitoes coming from?
Yoong lau_ nee(u) mah jak_ nie(?)

Scene 2

C: Water gets inside the plastic bags that are on the ground, and in the canals. A plastic bag with water in it is a perfect house for me to grow up in!
Nam(u) tee(!) you_ nie toong(?) pla(u)stic_ tee(!) you_ bon peun(u) laa(u) nie klong. Nam(u) nie toong(?) pla(u)stic_ ja dee sum(?) rup_ you_ nie bahn!

W: And we have more baby mosquitoes here. They like to bite people very hard!
Laa(u) lau mee loog(!) yoong mahg(!). Mun chawb(!) gut_ kon.

S: Oh no! Mosquitoes are everywhere! They live in the wet plastic bags!
Mee yoong mahg(!) tee(!) nee(!). Mun you_nie toong(?) pla(u)stic_.

W: Ouch!
Ouch!

C: Uh oh. Wit got bitten and sometimes mosquito bites make us sick.
Wit toog_ yoong gut_. Bahng krang(u) tum hai(!) mai(!) sabai.

W: I'm sick.
Chun(?) mai(!) sabai.

S: We need to make the mosquitoes go away!
Lau ja tum yahng_ rai hai(!) yoong bai.

W: If we get rid of the plastic bags, the mosquitoes won't have a place to live.
Ta(!) lau jutgahn wah(!) ting(u) porg(!) toong(?) pla(u)stic_ yoong gaw(!) ja mai(!) mee tee(!) you_.

C: And then they can't stay here and bite us!
Yoong gaw(!) ja mai(!) mee tee(!) you_ laa(u) yoong gaw mai(!) sah(?) maht(!) tee(!) ja gut_ lau dai(!)

A: Yeah!
Chai yo(!)

S: Let's start now! No more plastic bags on the ground or in the canals!
Lau mah lerm(!) gun don nee(u) lui. Lah cah doey tee(!) mai(!) ting(u) toong(?) pla(u)stic_ bon peun(u) leu(?) nie nam(u).

Scene 3:

W: I don't need a plastic bag.
Chun(?) mai(!) jum ben tee(!) dong(!) chai(u) toong(?) pla(u)stic_ peur(!) ja sai_ kong(?)

C: I am going to reuse this clean plastic bag that I already have.
Chun ja chai(u) toong(?) derm tee(!) me you_

W: Good idea! We should all use less plastic bags!
Ben kwahm kit(u) tee(!) dee. Lau nah(!) ja chai(u) toong(?) hai(!) mun noy(u) long.

A: Use less plastic!
Chai(u) toong(?) pla(u)stic_ ow wai(u) peur(!) tee(!) ja mah chai(u) nie git_ja gum.

W: What crafts can we make out of plastic bags?
Lau ja ow toong(?) mah chai(u) git_jagum a_rai gun dee.

S: Come with me to my house and I will show you!
Mah gup_ chun(?) see_ laa(u) deaw(?) ja sa(?) tid(u) tee(!) doo wah(!) ja tum yangai

Scene 4:

S: See what I've made out of plastic bags!
Hen(?) mai(u) wa(!) lau dai(!) tum a_rai gup_ toong(?) pla(u)stic_

W: Wow! A floor mat!
Wow! Do pah(!) long peun(u)

S: No! Ha ha! This is a pocketbook!
Mai ha ha! Do see_ nee(u) ben gra_bao(?)

W: Very beautiful!
Soy(?) Mahg(!)

C: Very cool!
Tay(!) Mahg(!)

S: And a necklace made from plastic bag beads!
Sai(!) kaw jarg_ toong(?) pla(u)stic_

W: The Thai flag!
Tong chahd(!) thai.

C&S: Oohhh!
Oohhh!

C: We can make so many things from plastic bags!
Lau sah(?) maht(!) tee(!) ja tum lai(?) yarng_ jarg toong(?) pla(u)stic_

S: We are made from plastic bags! Ha ha ha!
Door lau aing gaw(!) mah jarg_ toong(?) pla(u)stic_

W: How do you make these things?
Lau tum sing_ kong(?) porg(!) nee(u) yahng_ rai

S: One way is weaving with a loom.
Yahng_ neung_ tee(!) lau sah(?) maht(!) tee ja chai(u) gup_ toong(?) pla(u)stic_ keu ow mah sahn(?) gun.

C: You cut the plastic bags and put them through the strings. It's easy to weave with plastic bags!
Lau dut_ toong(?) pla(u)stic_ laaw(u) gaw(!) sah(?) maht(!) tee(!) ja chai(u) cheurg(!) sod_ dong glarng. Tum ngai(!)

S: I will try to sell my crafts at the market.
Num nai sing_ tee(!) chun(?) tum bai kai(?) tee(!) da laht_.

C: How much?
Tow(!) rai_

S: Twenty baht.
Yee(!) sip_ baht_

Scene 5:

S: No more plastic bags on the ground or in the canals!
Ja mai(!) mee toong(?) pla(u)stic_ laaw(u) bon peun(u) reu(?) wah(!) nie mah(!) nam(u)

W: Klong Toey looks so nice now!
Klong Toey do soy(?) jing jing

C: We save our bags for crafts.
Lau sah(?) maht(!) tee(!) ja gep_ sa_som(?) toong(?) pla(u)stic_ awai(u) peur(!) tee(!) ja mah tum git_jagum.

W: At my school we make crafts out of plastic bags.
Tee(!) rong rearn pom(?), pom(?) chai(u) toong(?) pla(u)stic_ nie gahn tum git_jagum reu(?) bah dit_ sing_ kong(?) dahng_ dahng_

S: You are made of a plastic bag! Ha ha!
Kun gaw(!) tum jarg_ toong(?) pla(u)stic_ mearn(?) gun ha ha!

W: There are no more plastic bags to get filled with water.
Ja mai(!) mee toong(?) pla(u)stic_ tee(!) ja hai(!) sai_ nam(u) ick_laaw(u)
S: No homes for the mosquitoes! Yay!
Ja mai(!) mee yoong dahm bahn(!) laaw(u).

C: I have no house. I don't want to stay in Klong Toey anymore!
Chun(?) mai(!) mee bahn(!), chun(?) mai(!) yarg_ ja you_ tee(!) Klong Toey ick_ laaw(u)

S: We won't get bitten by mosquitoes anymore!
Lau ja mai(!) toog_ yoong gut_ ick_ laaw(u)

W: I am not sick from mosquito bites anymore!
Lau ja mai(!) mai(!) sabay praw(u) toog_ yoong gut_

S: Yay! No more mosquitoes and plastic bags everywhere!
Dee jung lui(!) Ja mai(!) mee yoong reu(?) toong(?) pla(u)stic_ tah(!) doy hen(?) ick_ laaw(u).

A: We did it!
Lau tum dai(!) laaw(u)