Letter from the field
Igniting scientific curiosity in the AMAZON

by Richard Novak

A chlorophyll and cellulose shag carpet stretches out to the horizon, past the cauliflower thunderheads, across a land punctuated only by oxbows of ancient tributaries of the Amazon River. I look out the plane window and see a wound of bare red clay glaring up through the soggy atmosphere, a sign of a logging or mining camp; it's hard to tell which since rain and bulldozers erode the naked earth equally well here. Tin roof huts huddle in a makeshift village. As the wing flaps go down and the engines slow to a pleasant hum, the raw earth gives way to occasional patches of papaya and manioc, and later the trash heaps that go hand in hand with an outpost city. The juxtaposition of rich landscape with squalid living conditions reminds me why we, a group of graduate students, teachers, and professional engineers called Future Scientist, decided to come to the Peruvian Amazon.

The term "resource-poor" can be a misnomer for the Amazon basin: it is not necessarily the resources that are lacking but rather the knowledge of how to best utilize them. Although natural resources abound, some communities still lie in a precarious balance with disease, malnutrition, and inadequate energy. In the Amazon, it is common for over one third of a rural community to become sick with serious transmissible disease during a typical year, yet it is just as common to see adults and children collecting river water for cooking right next to floating toilets. A mother will burn firewood gathered from the forest to boil water for her children's meals, not knowing that the resulting indoor pollutants are likely to cause lung cancer and other pulmonary diseases. The presence of technology alone is not sufficient to solve existing problems. For example, a new generator donated to a town by the government will break down, with no one capable of maintaining or fixing it.

The majority of Future Scientist members had previously been involved in various science outreach programs, such as Community Resources for Science in Berkeley (see *BSR* Fall 2009), and many of us wanted to apply the principle of education as a means of change a little farther from home. We wanted to start an organization that would foster science and technical education in order to kick-start local utilization of the available resources and, eventually, sustainable local entrepreneurship.

While we are certainly not the first organization to promote sustainable development in resource-poor countries, Future Scientist is unique in that it focuses explicitly on education. Education is vital for a society's success. We decided on the following approach. First, identify a region where resources are underutilized because of a lack of science education. Next, develop low-cost solutions and lessons designed around new technologies in order to demonstrate the practical benefits of science and engineering, and encourage community participation in installation and maintenance. Finally, establish sustainable programs in local schools that couple technological solutions with financially sustainable business models.

Building an office in the jungle

Through friends, we made arrangements to work with the Casa Girasoles Boy's Orphanage in the village of Puerto Alegría near Iqui-

PHOTO: JERIC SANTIAGO; GRAPHICS: ASAKO MIYAKAWA

tos, Peru. The orphanage director, Gene, was interested in using solar power for lighting and other applications such as powering a laptop or a television set and radio. Because they had already identified a solution that would address their needs, we were able to focus on developing science lessons and installing solar panels rather than spending time evaluating various solution options. We brought small solar panel teaching kits to demonstrate to both students and adults how light can be turned into a practical resource. Solar electricity lessons were complemented with ones on solar heating to show how simple solar ovens can be used for cooking.

On our first day there, as the morning mist evaporated under the tropical sun, we began to collect the tools and materials for installing solar panels on the roof of the director's house. Two orphanage assistants ran off into the rainforest and returned with a custom-built ladder made out of slender tree trunks and branches nailed together. The robust acrylic panels we designed and built to withstand the demanding journey to the Amazon were unpacked and the kids watched in amazement as we showed them how the panels could power a fan to cool them off in the heat. They laughed as we clambered up the ladder for the first time, trying not to think about the precarious ladder or the searing tin roof. Once there we quickly realized that the panel installation would require equipment beyond the limited assortment of tools at the orphanage.

We set out for Iquitos the next day to purchase a drill, wood for a frame, and countless bolts, screws, nails and wiring. The whole city was a Home Depot, and we ended up visiting seemingly all of it to find the materials necessary for a solar panel installation. We got to work cutting the two-by-fours into a frame that could support the solar panels on the roof and allow them to withstand wind and heavy rain. Under the watchful eye of a group of boys, we hauled the completed frame up a makeshift ladder and bolted it to the tin metal roof. Gene urged the boys to pay attention to our work and learn what he perceived to be extremely practical skills. One of the boys climbed a nearby lemon tree to get a better view and watched as we began to wire panels together and measure the output. Our idea of introducing scientific concepts and practical engineering know-how through hands-on projects was working.

Making sense of technology

During the day, when it was too hot to work on panel installation, we taught science lessons. Rick Henrikson, Frankie Myers, and I, all UC Berkeley bioengineering students, presented lessons to groups of curious boys and adults. We showed them how solar panels convert light into electricity, what electricity really is, and how it can be routed to a power outlet. Frances Bell, an electrical engineer, built solar ovens with the youngest boys and then did a cookie cook-off with two teams of older kids to demonstrate how solar energy can also be used for cooking. Bob Pollard, a biology and sustainable development teacher at the Indian Springs School in Alabama, brought his experience with solar panel installation and education to Puerto Alegría where he marveled at how much the kids wanted to learn. The boys were "starved of scientific exploration and had a real interest in the mechanics of what they were witnessing," Bob explained. Seeing the flash of understanding in a boy after he learned how the sun powered a hand-held fan indicated to all of us the power of knowledge and practical science education to enable local communities to become their own problem-solvers.

Of course, our solar panel installation project was not without its share of unforeseen challenges. The intense noonday heat expanded the plastic panels and caused their seals to leak, requiring additional reinforcement. We had to carefully avoid a large bat colony when installing wiring in the attic, and one day our work was interrupted by the boys chasing a neon-green vine snake through the grass. Finally, miscommunica-

San Francisco electrical engineer Frances Bell helps a student set up a cardboard and aluminum foil solar oven for a cookie bake-off demonstration of practical solar energy.

Future Scientist members Tyson Kim, Bob Pollard, and Richard Novak install solar panel framing on the roof of the orphanage director's house. The panels now power a laptop and TV and reduce usage of a gas-powered generator.

AMAZON PHOTOGRAPHS PROVIDED BY RICHARD NOVAK

Three boys examine water samples collected at a nearby river under a microscope. Hands-on science lessons introduced children to key concepts, such as the connection between microorganisms and water-borne diseases.

tion during the planning stage posed a problem. During the initial discussions, we were told that, above all, the orphanage needed solar lighting to avoid using the generator. We were given a rough idea of the scale of the buildings and built custom solar panels to fit those metrics. The estimates turned out to be quite inaccurate, and the primary need turned out to be food refrigeration rather than lighting. Although we were able to re-engineer the solar panel system to address some of the additional needs, the experience highlighted the importance of conducting careful needs assessments in the future. We would have been able to provide a more satisfactory result had we been able to visit the site in-person before the pilot project. Despite these setbacks, we were able to complete solar panel installation on time and provide the orphanage with a sustainable source of electricity. The night before we left the orphanage, Gene and his wife were flicking the lights on and off, testing out the benefits of solar power.

In addition to our lessons about solar energy, the rest of the team was busy with other relevant science projects. Since more than half of a typical community becomes ill during the year with various infectious diseases and parasites, we brought microscopes to show how even clean-looking water can harbor organisms that cause illness. Jana Broadhurst, an MD-PhD student at UCSF, and other team members led groups of kids to a nearby swamp to collect water and mud samples. The enthralled budding scientists examined the river water and puddle sludge under the microscope in awe. We also brought microscope slides with various disease-causing organisms, and the boys were shocked when they saw malarial parasites, roundworms, and bacteria that make them sick on a regular basis. Mei Gao, a public health student at UC Berkeley, then showed that these organisms could be easily filtered using cloth. Along with the microscopy lessons, Tyson Kim, an MD-PhD student at UCSF, and Gautham Venugopalan, a third-year UC Berkeley bioengineering student, showed the boys how a microscope works and had them build their own compound microscopes using magnifying lenses. Gautham found the kids to be extremely creative and receptive to learning about optics. At one point he observed, "I saw at least two kids make compound lens systems on their own without ever being told that it would be a good idea," a sign that relatively small effort can have a great impact.

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Let's dissect this!

The curiosity and desire of the students to understand the world around them made the teaching experience truly rewarding. The boys, true orphans as well as children abandoned by their families unable to care for them, were all raised in rough urban environments and never received the rich natural history education normally bestowed upon kids growing up in rainforest villages. Despite an unfortunate early childhood, these boys never lost the innate curiosity and desire to learn, and voluntarily attended our afternoon hands-on science lessons. When asked at the end of our stay what they wanted to be, a vast majority said "scientist" or "engineer." For the rest of the students, our lessons seemed to spur a greater desire to learn. Jaime, a 15-year-old boy from the town of Caballococha, became intent on learning English and becoming a guide or English teacher around Iquitos and would use the team members for English practice.

While the children's reactions were overwhelmingly positive, our reception by adults was mixed. Teachers from the Puerto Alegría school were fascinated by our hands-on lessons and were interested in adopting the lesson plans and materials into their curricula. They had heard of our activities from the students and were keen on contributing to the excitement. On the other hand, Gene and other orphanage caretakers disapproved of the science lessons that did not have a de-

Solar-powered fans were a big hit in the tropical heat, and allowed the kids to see the rooftop panels in action.

fined and immediate practical benefit. He encouraged the kids to participate in our solar panel work, but he did not see any value in showing them microorganisms under a microscope or talking about water filtration. He felt that education should consist of agriculture, social studies, and religion—knowledge and skills that prove immediately useful in an agrarian society.

Nevertheless, our relatively brief interaction with the orphanage seemed to unleash a torrent of learning and curiosity that was not so visible before our arrival. Toward the end of our stay, two boys beckoned me to join them under the dining hall building. From behind his back, the older boy pulled out a toad that spanned the length of his torso and said, "Let's dissect it!" We had never discussed dissection, surgery, or anatomy, and here were two kids wanting to see how a toad works. I ended up teaching an impromptu lesson on where toads live, what they eat, and how they are useful in pest control. They eventually let the toad go into the forest, but I could see that their curiosity to learn had been whetted.

Looking back, looking forward

What next? Our experience during our pilot visit taught us that the science education approach to global aid would be most effective if conducted through community schools. In Puerto Alegría and other villages, the schools are the center of the community, both geographically and socially. Every child attends the local school for at least some time, and the school offers a hub of social interaction. In addition, the school we visited had a small business based on a well-established local model, raising crops on teaching farms and selling the produce in markets as a source of supplemental revenue. In each school there is a group of motivated teachers who seek above all to help their students succeed, and as a result of their social importance, schools are perfect partners for enacting meaningful and sustainable change.

We saw the desperate need for reducing the frequency of disease, often due to improper hygiene and waste disposal. In addition, farmers in the region are confronted with nutrient-poor soil and must go to great lengths to obtain fertilizer.

As a result, we are developing a practical biogas digester for communities that would provide a hygienic site for disposing of human and animal waste. The biogas digester could convert the manure to nonpathogenic effluent fertilizer and methane, a sustainable source of cooking fuel from the fermentation process. We are collaborating with the nonprofit organization Project Amazonas to identify practical digester designs, test them out, and develop school lessons around maintaining digesters and the science and engineering principles behind them. Already one member of Future Scientist, Frances Bell, has returned to Peru to start this project. She and her colleagues are developing a practical biogas digester system to provide cooking fuel as well as fertilizer for a fish pond and farm. The project will soon be integrated into a series of workshops and lessons for adults to demonstrate how biodigesters can provide significant benefits to an agrarian community. We hope to build a large-scale digester system at a nearby school, develop a financial model for its operation, and organize a hands-on science lesson program relevant to the biogas digester.

Our first trip confirmed that an education-based approach to global aid and development is not only valid, but also practical and necessary. We are building on our initial findings and expanding our "experiment" to produce a new generation of Future Scientists that will effect sustainable global development on a larger scale.

Richard Novak *is a graduate student in bioengineering.*

About Future Scientist

What does Future Scientist do?

We provide science education and technical training for resource-poor communities to sustainably address their own needs.

How did it begin?

UC Berkeley and UC San Francisco engineering, medical, and public health students and several engineering and education professionals decided that practical education can provide sustainable solutions to social problems.

What has Future Scientist done so far?

We have begun developing a practical science and engineering education program in the Peruvian Amazon. In August 2009, we traveled to Peru as part of a pilot program to assess the science education approach and identify what works and what doesn't. We installed solar panels at an orphanage, taught hands-on science lessons, and conducted extensive needs assessments of surrounding communities.

FUTURE SCIENTIST

What is planned for the near future?

We are collaborating with Project Amazonas, a Peruvian conservation and aid organization, to develop practical biogas digester designs as a solution to waste disposal, pathogen transmission, energy, and farming fertilizer problems. Two volunteers are testing specific digester designs and identifying ways to work with schools to develop hands-on programs that would train a generation of skilled engineers and scientists to establish, maintain, and improve biogas digesters.