"2050 Challenge" Introduces College Students to Hands-On Technology Projects in Mali

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The year: 2050. The challenge: Providing clean water, food, health care, access to information, and robust economies for 9 billion people, all while minimizing the damage from climate change. To many, the task seems difficult—nearly impossible. However, for 10 students and three professors at Iowa State University (ISU), the 2050 Challenge started in 2008 in a remote village in Africa.

As we imagine the world in 2050, one thing is abundantly clear—the constraints placed on technology and society will be very different, and in most cases more stringent, than those we face today. These constraints may include high energy costs and a need for low CO_2 emissions, scarcity in other natural resources (both actual and political), and the overarching goal of equitable societies. The need for sustainable and appropriate technology is evident, where appropriate technology is defined as technology that is appropriate to the environmental, cultural, and economic situation for which it is intended. The challenge facing educators is how best to prepare our students to meet and embrace those constraints.

At ISU, the Materials Science and Engineering (MatE) and Mechanical Engineering (ME) Departments have recently introduced three integrated classes on appropriate technology and sustainable engineering. The first (developed in ME as a part of its design sequence) is titled "Design for Appropriate Technology" (ME 486) and teaches students the importance of designing feasible systems for appropriate use. The second (originally developed with a number of other engineering departments at ISU) is "Sustainable Engineering and International Development" (ME/MatE 388) and revolves around "systems thinking." The latest installment is "Applied Methods in Sustainable Engineering and International Development" (MatE/ME 389)—a three-week study abroad program based in Mali, Africa.

Richard LeSar, head of the ISU Materials Science and Engineering Department, and Kenneth Bryden, a professor in the ISU Mechanical Engineering Department, are co-creators of the study abroad

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Figure 1. (a) The village of Nana-Kenieba; (b) Iowa State student Anna Potter (right) cooking with a local woman.

opportunity in Mali. The program is in Nana-Kenieba, a small, rural village roughly 60 miles from the capital (Figure 1). The professors' goal in creating the class is to encourage students to think in terms of developing appropriate technology in constrained environments, while at the same time making a difference in the lives of rural Malians.

Mali is a landlocked country in western Africa. Gaining its independence from France in 1960, Mali is now a stable, democratic nation. Its median age is 15.8 years (compared to the United States' 36.7 years) and has a life expectancy at birth of 50 years (USA: 78.1 years).* One measure of the state of a country is the human development index (HDI), a combination of Gross Domestic Product, literacy, and life expectancy; Mali has the third lowest HDI.† A majority of the population survives on subsistence farming. Only 50% of the population has access to clean water and over one-third of the country lives on less than $1 per day‡—extreme poverty as defined by the World Bank.

To prepare for their adventure half way around the world, students attend class once a week to learn about the cultural, social, technological, and economic issues Malians face each day. Students learn that rural Mali has virtually no western medicine or energy sources, let alone electricity, and because of these constraints, the importance of appropriate technology and sustainable engineering within a developing world setting becomes more evident. A majority of class time is also spent learning about a myriad of technological problems of the village, ranging from leaky water valves to inefficient stoves.

In May 2008, LeSar, Bryden, and Kris Bryden (a music professor at ISU) took their first group to Mali—eight undergraduate and two graduate students. A majority of the first week was spent meeting with the village chief and elders to obtain their blessing to work in the village and learning about the dynamics of the village, as well as revisiting many of the current technological problems.

Kris Bryden led the women's team in learning about the daily routines of the women of the village and the challenges of cooking over an open fire. Much of the cooking within the village is done on a three-stone stove (see Figure 2a). Generally, the stoves are inefficient, smoky, and with their open flames, dangerous. Some women suffer from cataracts and/or a form of lung incapacity owing to the high count of particulates and noxious gases within the smoke. After speaking with the women and learning how far they walk for firewood and hearing horror stories of skirts catching fire, the need for a safer and more efficient stove became evident.

The students spent most of the second week listing the women's needs for the stove and discussing the various functional aspects of different stove designs and materials needed. In engineering design parlance, they were turning the needs assessment into the design requirements. Once the requirements were set, the design process began. In the end, the students decided a rocket stove (a known design for small, biomass-fueled cook stoves) made of adobe brick, clay from termite mounds, and straw to be the best design (shown in Figure 2b). The final week was spent gathering materials and building a prototype to model to the women of the village (Figure 2c). Initially, villagers were very skeptical of the design and, thus, indifferent to the concept. However, when the village women could see how well the stoves cooked, how little smoke they gave off, and an apparent reduction in the amount of wood needed, they were amazed. If the stoves can be made even more efficient, the impact on women's lives will be large—women would spend less time gathering wood and more time doing other tasks such as tending gardens or preparing goods for market. Currently there is a waiting list for 40 stoves within the village.

A second group of students worked on another challenge within the village: lighting. Owing to its location near the equator, Nana-Kenieba offers Malians 12 hours of sunlight a day—roughly 7:00 a.m. to 7:00 p.m., but when the sun sets, all is dark within the village—Nana-Kenieba is off the grid. The challenge revolved around the following question: How do we bring lights to a village without electricity? In 2007, a group within

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* *CIA Factbook*, www.cia.gov/library/publications/the-world-factbook/geos/ml.html (accessed May 2009).

† *Pocket World in Figures: 2008 Edition* (The Economist, London, 2007).

‡ *CARE International:* www.careinternational.org.uk/3220/mali/mali-statistics.html (accessed May 2009).

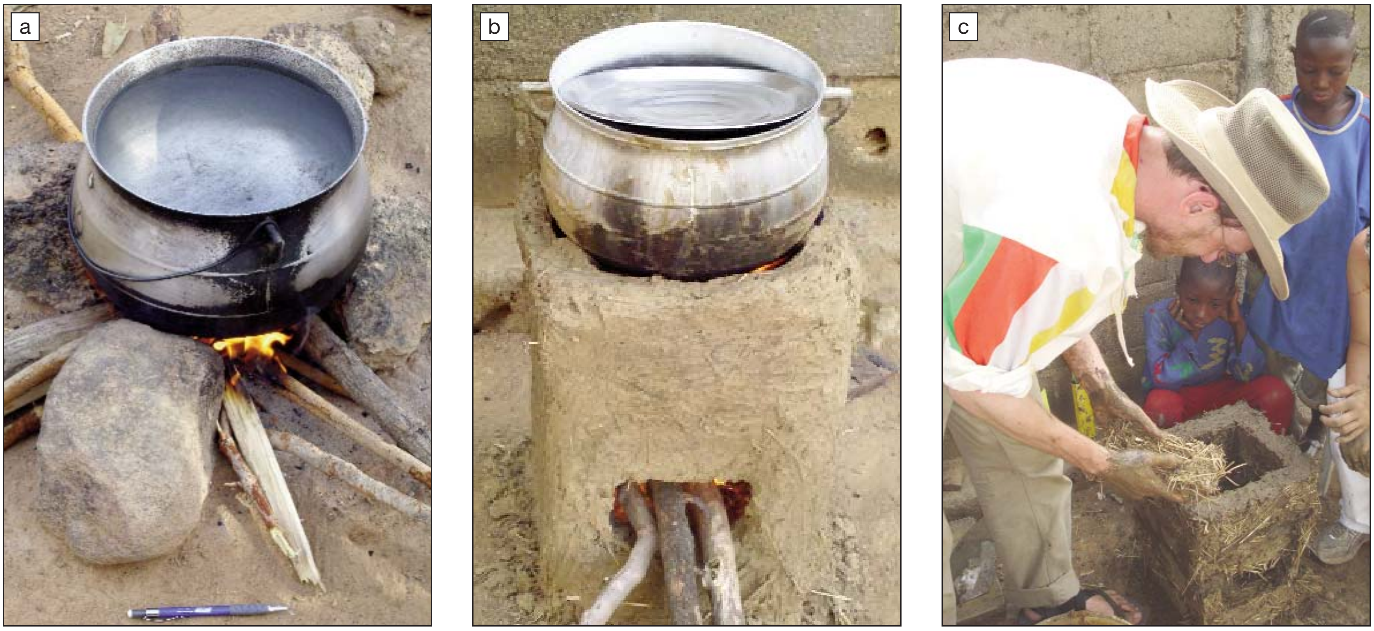

Figure 2. (a) A typical three-stone stove; (b) the completed adobe rocket stove; (c) Penn Taylor (left), former graduate student of ISU, working on the rocket stove prototype.

Figure 3. Anne M. Stockdale (right) working with Modibo Saniba, the local blacksmith, making a knife.

the ME 486 class designed a lighting system composed of small solar panels connected to rechargeable batteries and light-emitting diodes (LEDs). The result: No one used the LED lights—they could not find replacement rechargeable batteries (thus not an appropriate technology) and they did not like the quality of the light.

In 2008, another set of students revisited the lighting challenge as part of a project supported by the National Collegiate Inventors and Innovators Alliance. Since Mali has approximately 330 days of sunshine a year, and solar panels are already on site to power lights within the school and the local water tower pump, the solution was simple. A car battery could be charged by the solar panels and used to power linear fluorescent lights. All supplies are available locally—meaning a sustainable project. To test the new solution, lighting systems were set up within the village. By the end of the night, about 30 of the village elders came to the compound to discuss the systems and prices with the professors. At the end of that discussion, the villagers agreed to a plan in which families rent the batteries and lights while a local agent charges a small fee to recharge the batteries. There is a large waiting list not only in Nana-Kenieba, but in the surrounding villages as well. However, design and development work on the project continues to improve the product and manage a distribution system. A prime consideration is to engage a recycling service that will deal with the batteries safely.

It should be emphasized that the lighting program was not developed in a single visit. It has taken a few years to develop the infrastructure and coordinate research. It has also taken several trips to the village. And the work within the village continues—this is not "drive-by engineering." The projects are carefully monitored and many trips are made to follow-up on projects. Development is an ongoing process.

Not only were villagers' lives affected, but the students' were as well. I personally never thought three weeks would have such a dramatic impact on my life. How would I have ever predicted that one day I would make a knife with a village blacksmith? (See Figure 3.) Many of the lessons learned in Mali could never be taught in a classroom setting.

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