11-2010

Study Abroad Experiences in the Developing World: Opportunities and Challenges

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Abstract
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Keywords
Mechanical Engineering

Disciplines
Engineering Education

Comments
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Mater. Res. Soc. Symp. Proc. Vol. 1320 © 2011 Materials Research Society
DOI: 10.1557/opl.2011.543

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ABSTRACT

Over the past three years the Departments of Materials Science and Engineering and Mechanical Engineering at Iowa State University have conducted a study-abroad course for ISU undergraduates in a small, isolated, village in the country of Mali, in western, sub-Saharan Africa. Most, if not all, of the people in the village live under conditions that the World Bank refers to as extreme poverty. The focus of the course is on the development of sustainable technologies that are appropriate for the people in this village and villages similar to it. Our goal is to offer students a chance to develop such technologies, in the end changing how they view engineering and their role as engineers. One of the challenges of the course is how to integrate this high value off-campus experience into the on-campus curriculum. To do this we have linked two on-campus sustainable engineering courses (sustainable engineering systems and appropriate technology design) with this study abroad course. In this paper, we discuss the course in more detail, with a focus on an assessment of how well we are meeting our objectives. We shall also discuss the challenges of holding such a course and will offer some advice for those who may wish to venture along the same path.

INTRODUCTION

The world today has about 6900 million people, about half of whom live in poverty or extreme poverty by World Bank definitions.[1] By 2050, it is estimated that the world population will be between 9000 and 10000 million.[2] The potential burden on the planet from this increase in population will not, however, scale with the population increase, unless we assume that we continue to keep half the world in poverty. That the latter option is not considered viable (or moral) has been recognized by the world through the creation of the "Millennium Development Goals," approved by the United Nations General Assembly in 2000.[3] These goals focus on what needs to be done now and in the near future to fulfill the basic needs for water, sanitation, nutrition, health, safety, and meaningful work for all humans. The technological challenges of meeting these needs will fall in large part on engineers.

The increase in population over the upcoming decades will be largely in countries in the developing world. As their populations increase, and as those populations begin to share more of the world's wealth, there will be unprecedented needs for better infrastructure (e.g., clean water, transportation, etc.), better health care, more and better food, and so on. These are challenges that engineers must meet.

Iowa State University and it's College of Engineering have recognized the critical importance of meeting the challenges facing the world between now and 2050 and have made it a critical objective of the University and the College. The goal is to infuse the "The 2050 Challenge" into both the research and the educational activities of the College and University.[4] To meet that goal for our engineering students, we will have to broaden how students view engineering's place in the world to emphasize our responsibility in the creation of a more sustainable, equitable, and stable society.

Over the past three years the Departments of Materials Science and Engineering and Mechanical Engineering at Iowa State University have embarked on a program to introduce undergraduate and graduate students to issues in sustainability with a focus on the developing world. There are many reasons to choose the developing world as our focus. One reason is certainly that there are unmet technological needs in the developing world that must be addressed to reach the Millennium Development Goals. Focusing on the developing world also provides a narrower canvas on which to discuss the issues of sustainability - the complexity of a village of a thousand people with a restricted economy and a homogeneous community is more accessible than the complex interrelated economies and communities of the developed world.

In this paper we describe our program, which consists of classes held on the Iowa State campus as well as in a village in Africa. These classes are connected to each other and to non-academic student opportunities and ongoing research programs. We will outline those connections and show how they provide new information and insights. The main focus of this paper is, however, our study-abroad program in Africa. We will emphasize its role in the curriculum and discuss the opportunities it provides for a wide range of educational experiences. Finally, we shall discuss some of the challenges that such a program entails, in part as a guide to those who want to create similar experiences.

CURRICULUM

Our focus is on the introduction of students to a systems-level view of sustainability and the impact that view has on engineering. It begins with the idea that we must focus on a sustainable global society, which is a union of environmental, economic, and social (cultural) systems,[5-6] i.e., a system of rather complex subsystems. A sustainable society is one that equitably meets societal needs while maintaining the integrity of the environment and ecosystems, the economy, and the social needs of the individuals. Engineers must ply their craft with an eye on all aspects of these needs.

Our responsibility in the academy must be to educate our students in a way that increasingly reflects this broader view of engineering. How one does that in an already crowded curriculum is well-recognized problem, but the importance of doing so cannot be overstated. (An excellent book has recently been published on this topic. [7]) We have chosen to begin by teaching sustainable engineering in the context of societal systems and appropriate technology for the developing world. This choice in part reflects personal interest, but also the recognition that a sustainable global society must include the people of all countries and regions.

With this in mind, we can now put into perspective a series of interrelated courses that have been introduced in our engineering curriculum over the past few years. A schematic view of these courses is shown in Figure 1. Taken as a whole, they present a range of technical and

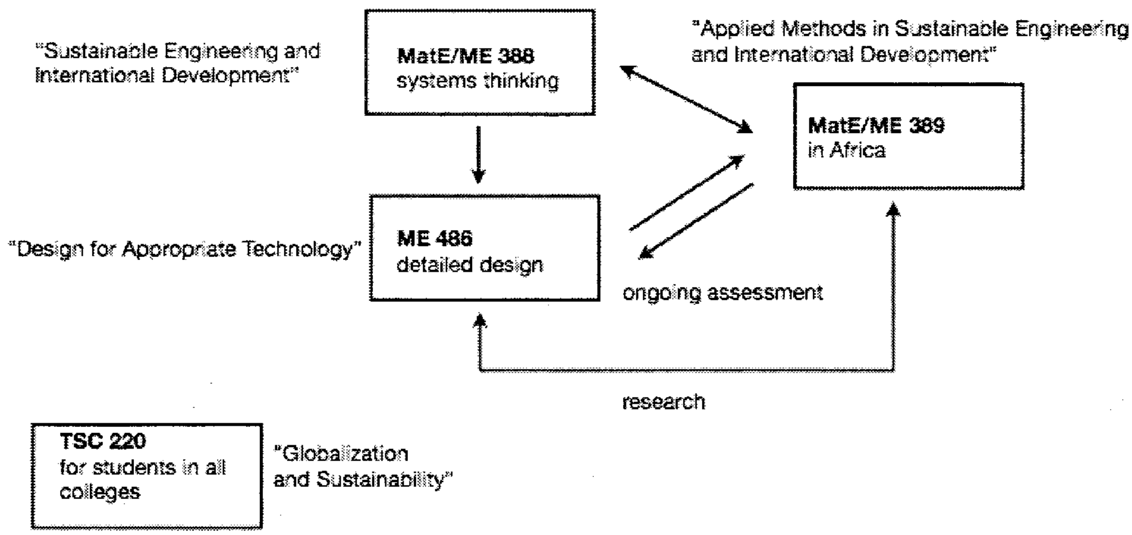

Figure 1: Schematic view of an interrelated set of courses on sustainability, with a focus on the developing world, as described in the text.

societal issues, with the balance between them depending on the class. While the courses make an interconnected set, linking to and growing from each other, they are independent and thus can serve the needs of a broad group of engineering students.

One class ("Sustainable Engineering for International Development") was started a few years ago as a collaboration between a number of departments in the college. The Departments of Mechanical Engineering (ME) and Materials Science and Engineering (MSE) have formed a section of that class that is specifically geared towards meeting the goals outlined above, incorporating complex systems, sustainability, and an analysis of water, energy, and materials issues in the developing world, with a focus on small, poor, villages. This course, while predominantly technical, contains a significant focus on economics, anthropology, etc., with a strong emphasis on social aspects of technological acceptance.

The ME course "Design for Appropriate Technology" offers a focus on creating appropriate solutions for specific applications in the developing world. Students are asked to respond to defined needs of people in poor villages. While this course is predominantly technical, its problems are motivated within a societal context.

Before discussing our third course in the sequence, the study-abroad class in Africa, there is another course that deserves some mention. Technology and Social Change (TSC) 220, "Globalization and Sustainability," is a course developed by Colleges of Engineering (the Departments of Materials Science and Engineering and Mechanical Engineering) and Liberal Arts and Sciences to serve as a cornerstone of a proposed sustainability minor degree. The course provides a broad view of sustainability, with less technical emphasis than in a typical engineering course, but with a deep focus on anthropology, economics, etc. Our first year (spring 2010) attracted students from all undergraduate colleges at Iowa State and, based on student response, was quite successful.

THE MALI CLASS

The final class in the sequence shown in Figure 1 is a hands-on, study-abroad course. Started in May 2008, "Applied Methods in Sustainable Engineering for International Development" is a summer, for-credit, class taught in a village in Mali, a country in western sub-Saharan Africa. The focus of our course is on developing sustainable technologies that are appropriate for the people in this village and villages similar to it. Sustainability in this context is not strictly resource sustainability, but also refers to the sustainability of the technology (for the time when we are not in the village) and the impact of technological changes on the local economy and culture.

Figure 2: Typical view of the village in which the class is held showing houses and smoke from the evening cooking.

The village in which the class is based has about 1000 people. The religion in the village is, for the most part, either Islam or animist. The principal language of Mali is French, though most villagers speak their local language. It is a polygynous society, with two wives being common and up to four possible. Family units are large (usually twenty or more), often consisting of bothers and their wives and children, parents if living, etc. Most, if not all, of the people in the village live under conditions that the World Bank refers to as extreme poverty, subsisting on less than $1.25 per person per day, and often much less than that in terms of cash. The villagers are subsistence-level farmers, who depend on seasonal rains for the success of their crops. There are tradesmen in the village, including a baker, blacksmith, carpenter, etc., who also farm to meet their needs. Villagers live, for the most part, in mud huts with thatched roofs (Figure 2), though some wealthier villagers may have a concrete building. Cooking is done on "three-stone stoves," outdoors in the dry season and indoors during the wet season.

The village has no electricity and its energy needs are largely met by burning wood gathered from a nearby (and diminishing) forest. There are some fluorescent lights in the village, powered by car batteries that are charged from solar panels in a project run as a local business. There is relatively clean water available from a solar-powered pump in a deepwater well, availability of which is also subject to the seasonal variation in rainfall. There is also a hand pump, which is often the principal water source. Temperatures are always warm, with highs ranging up to the mid 40s (°C) in the dry season (December through May) to the mid 30s °C in the rainy season (June through November). The dry season is truly dry, with essentially no rain for many months.

A principal objective of our course is to provide the students an environment that challenges their concept of engineering. If engineering is best described as "design under constraint" [8], then working in a village with limited technology, limited materials, and limited economics should be an ideal environment to learn about it. Other objectives are equally important, including an introduction to engineering in a culture that differs greatly from their own. We also want the students to see how they can have an impact by doing engineering, a point that sometimes is lost in the classroom. Ultimately, our goal is to give students a chance to change how they view engineering and how they view themselves as engineers. Of course, making positive changes in the lives of people in rural Mali along the way is also of prime importance,

Given this introduction, there are two issues that we want to address in describing the course. First, we want to address how we teach it, for that is the reason we do it in the first place. However, the logistics in such an endeavor are a challenge, so we will discuss those in some detail below.

The course is a three-credit class that has been held for the past three years in May right after the end of the spring semester. To date, we have taken 27 students to the village, representing most of our engineering majors. The mix of students has been good, with fourteen female and thirteen male students. The overall duration of the class (departure from and return to Iowa) is 21 days (17 days in the village). The time period of the course (mid to late May) is at the end of the dry season, with high temperatures typically in the 40-45 °C range. The class meets weekly during the spring semester, receiving lectures on Malian history and culture, being briefed on language, and having an introduction to appropriate technology in general and on specific technologies in the village (e.g., cookstoves). They are also given an opportunity to hone (or learn) their skills in plumbing, basic carpentry, low-voltage electrical work, etc. Safety is of prime concern, and they are thoroughly briefed on the risks and dangers in rural Africa, ranging from malaria and other diseases to poisonous snakes. The students are given reading assignments in the spring semester, about which they must write papers. These have included years two books written about experiences in Mali [9,10], poverty in the developing world [11], and Schumacher's *Small is Beautiful.*[12] Before we can take the students to Africa, they must also go through training from the University's study-abroad office.

Once in Africa, the students have a number of tasks and responsibilities. There is a daily lecture that discusses topics that include fundamental engineering design, culture, various technologies, etc. The students have a daily assignment to write in a provided journal about their activities and observations. These journals serve as one of our principal assessment tools. As part of that assignment, they are given a chance to list questions, which are discussed at a communal breakfast. We are joined at breakfast by our staff and translators, who are often quite involved in the discussions. Many of our best learning experiences about cultural differences comes from the sometimes unexpected answers to seemingly simple questions.

The students are also asked to do two very different types of projects during their stay in the village. One project is hands on and technical. They work in teams to accomplish a specific engineering task. The other project is to research village needs, which requires them to interact with a broad selection of people in the village.

Technical projects are done in teams and are focused on the development and implementation of various technologies. Over time we have had students work on developing and building new cookstoves, implementing a lighting project (the solar panel/fluorescent lights system mentioned above), installing and testing new designs for water valves based on locally-available materials and parts, testing a grinder design, installing and testing water pump designs, etc. Many of these technologies were designed at Iowa State in ME 486, the design-class described above. We strive to make the technologies sustainable in the village, by which we mean that they can be managed and repaired locally and do not require extensive natural resources. We also work very closely with people in the village and representatives from their local governing bodies (typically the village elders) to ensure that we are providing technologies that they actually need and want. In short, we focus on providing appropriate technologies to the village.

One of the goals of returning to the same village is that it enables us to monitor and evaluate the success of our projects. Some have been very successful. The students in 2008 began an assessment of cooking needs in the village, in which most cooking was done on a three-stone stove. After an evaluation of actual needs and use (which required extensive interviews and hands-on participation), it was decided that introducing a new cookstove design might be helpful to the women of the village, who do all the cooking and gathering of wood. It was hoped that the new stove would both cut wood use as well as soot emissions while in use indoors. It also had to be essentially free of cost, because of the lack of income in the village. We eventually decided on a mud-based variation of a standard rocket stove. We had to overcome some skepticism on the part of the village women (which we did by giving them food to cook on the new stove), but they quickly saw the advantages and our stoves are now a "hot" item, with over 60 placed in the village and a waiting list. This past May, we began an in-depth study of the actual wood use and particle emission from our stoves, which will inform a new design. Other projects have been less successful (we still have no good replacements for water valves), but the lessons learned from our assessments are guiding new technological development.

The other main student responsibility is to do research on an assigned topic on village activities needs. The outcome of this work is a detailed paper. These reports have focused on a range of topics, including water use, wood gathering and use, cooking needs, economic activity, food use and availability, food processing (e.g., grain grinding), etc. The goal is to create over time a much better description of how a village actually works, which enables us to develop a system map for the village showing the interrelation of the resources, economics, technology, and the culture of the village. This data also informs our research and teaching activities back on campus, as will be discussed below.

The students do not just work while in the village. We have dances, with music provided by local drummers, we visit a local market in a neighboring village, etc. More importantly, the village is safe and the students have freedom to explore on their own and to create their own, unbrokered, learning experiences. Indeed, the major role of the professors is to "teach lightly," i.e., to provide enough guidance to keep the students on track but to also stay out of the way so that they can learn on their own. We have translators that they can work with to talk to villagers, though many of the students learn enough of the local language to have at least some conversations on their own. We also visit a major craft market, so the students can examine and buy local Malian items.

Assessment

A major part of this course, as in any course we teach, is an assessment of how well the students are actually learning. We do that assessment in a number of ways. More standard metrics come from an evaluation of the students' output, in this case the papers written before they go to the village and the research report at the end. However, those assessments do not inform us on how the students' perspectives of engineering and its role in the developing world may have changed. We assess this aspect of the course in two ways. As noted above, one of their daily assignments is to write in a journal with their observations. We keep these journals and track how their perceptions change over time. We can see, imperfectly to be sure, how various activities correlate with those changes in perception. We also do a survey before and after the class, asking questions about engineering's responsibility in the world, its impact on poverty, etc. While our assessment instruments are not perfect by any means (and we are working to improve them), we are pleased with the results to date and are convinced that we are reaching the goals for the class stated above. One of our students has written an article on her experience, which was published a few years ago in the *MRS Bulletin*.[13]

Logistics

A reasonable question might be: What does it take to make this course possible? There are two aspects to the answer to this question. First, what must be done on campus and what is required in Mali.

The first thing that must be accomplished on campus (after getting class approval and finding students and professors) is to satisfy the University risk management program. Iowa State's Risk Management office has stringent requirements regarding student safety, especially for programs in the developing world. It is key to develop excellent relations with that office. After that, it is just the standard things, like tickets, visas, etc., that must be obtained.

Traveling to the developing world presents a number of challenges. Making arrangements ahead of time in a developing country, for example, can be awkward. Simple things like arranging for housing can be a challenge, especially in a village with little infrastructure (e.g., no phones) or a history of accommodating large groups. Even in a large city, identifying appropriate accommodations can be challenging (hotels may, for example, not accept credit cards). While some companies provide logistical support in the developing world, we have developed relationships with people on the ground in Mali and work with them to help prepare for our visit, finding accommodations, finding translators, etc. Developing those relationships was not an overnight affair. We had been in Mali a number of times before we brought a class with us and, even then, have found that everything works best if we send someone to Mali a month or so before the class to make sure things have been organized properly and then again a few days before the class arrives to handle final details. Of course, all this travel is expensive and adds to the overall cost of the class.

When we arrive in the village, we bring a rather large retinue with us. In addition to the students and the two of us, we bring another professor (female) to help us to work with women (avoiding cultural barriers) and to provide a different perspective (she is from the music department). We typically bring a research assistant, who helps in some of the projects, as well as a graduate assistant. We have had undergraduate volunteers from previous classes who pay their own way to come with us and who provide continuity between classes. We pay travel costs for a physician, who volunteers his time. If we bring N students with the class, then typically $N+7$ people actually travel to Mali. Once in Mali we typically have (depending on class size) 3 translators. We also bring a cook (and her assistant) with us from another town who has experience in cooking for large groups of non-Malians and who has been trained in food safety. For transportation, we typically hire vehicles that, as is often the case in the developing world, come with a driver. Assuming three vehicles (and their drivers), we come to the village with about $N+15$ people, where N has been 7, 9, and 11 students over the three years of the class. We also have a number of villagers helping us by providing housekeeping and laundry services. All in all, it is a complicated and expensive exercise.

INTERRELATIONSHIPS IN THE CURRICULUM

Consider again Figure 1 and its series of classes and how they are connected. The Mali class (389) generally takes to Africa technology developed in the design class (486). The research reports from the Mali class in turn provide critical information to the design class, as well as to the systems-level sustainable engineering class (388), which in turn provides system diagrams that can be used to better understand the village. Thus, each class has its role, both in education and in providing a more general understanding of village life.

There is also an ongoing research activity separate from these classes, yet benefiting from them. One of us (KMB), for example, has undertaken an extensive survey of energy needs and uses in the village, which will provide unique data needed for future development in this, and similar, villages. The assessment of stoves is being done as part of this exercise (including comparisons with existing and alternative technologies). The research activity thus plays a critical part in our assessment of technology and its impact.

We note that in addition to the classes and research, there is also room for non-academic student participation, in our case through the University's chapter of Engineers without Borders (EWB). The EWB chapter has its own projects in the village (e.g., a kiln for cookstove bricks) and plays an important role in broadening student participation.

OPPORTUNITIES AND CHALLENGES

Based on our experiences, we support the development of integrated programs such as ours, especially those that culminate in a study-abroad experience. Our students have uniformly responded positively to the experience. While we cannot say that they will be better engineers because of this class (though we would like to think so), based on their comments to us and the evolution of their thoughts as witnessed in their journals, we think they have at least developed a better sense of the broader contexts of engineering.

There are many challenges to such programs. As discussed above, they are expensive and the logistics are complicated. We have been able to raise sufficient funds to pay about half the costs; students pay the rest. However, the amount of time to plan, to raise money, to take extra trips to settle the logistics, and then the time in the classroom in Iowa and in the village (three weeks with no internet and limited phone), takes a toll on the professors. And the truth is that there are not so many professors that actually want to make this commitment. Thus there is a question of sustainability, not global sustainability, but rather the ability for such classes to be maintained over time. We are faced with that situation now, and are taking stock of the best way to proceed.

Despite these issues, there is one thing that can be said. It has been an adventure, both for us and for the students. When we outlined our goals and outcomes for the course above, we neglected to discuss one outcome - the effects that the experience of this class has had on the professors. It is not insubstantial.

ACKNOWLEDGMENTS

We want to thank the National Science Foundation's International Center for Materials Research at the University of California - Santa Barbara for their generous support of the Mali program. We would also like to thank the Departments of Materials Science and Engineering and Mechanical Engineering as well as the College of Engineering at Iowa State University for their continued support. The support of individual donors also has played a large role in our ability to offer this class. Finally, we thank our friends in Mali for their continuing hospitality.

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