Abstract - There is a sense of urgency to encourage students in the U.S. to embark on some form of study abroad experience. A whole semester or year abroad is a deterrent for many students because of the relatively large time commitment in an unknown environment and also because of concerns regarding completion of degree requirements. In this paper a short-term study abroad program is described in which students from the Agricultural and Biological Engineering Department at the University of Illinois collaborated in teams with senior engineering students in South Africa on capstone design projects. The projects were proposed by the School of Bioresources Engineering and Environmental Hydrology at the University of KwaZulu-Natal. Excursions were organized to expand student cultural awareness and understanding of agricultural practices and technology development. It was concluded that the format followed for this international exchange was very effective and successful in meeting the objectives set out for this short-term educational experience.

Index Terms – Collaborative project, international, South Africa, study-abroad.

INTRODUCTION

Most land-grant universities in the U.S. have study abroad programs organized at least at the campus level and in many cases within colleges. At the University of Illinois, both Colleges of Engineering and of Agricultural, Consumer, and Environmental Sciences (ACES) have active programs in place to encourage students to gain some form of study abroad experience. In the engineering discipline, it is well accepted that engineering plays a fundamental role in an increasingly global economy, and that it is becoming ever more important for engineers to be knowledgeable about and comfortable with other cultures [1]. However, reports show that only about 1% of Americans studying higher education go abroad as part of their undergraduate educational experience, and less than 3% of this 1% are engineering students [2]. Hence, there is a sense of urgency to encourage engineering students in the U.S. to embark on some form of study abroad experience.

The Accreditation Board for Engineering and Technology (ABET) in the U.S. has attempted to address this issue within its set of competencies specified in the EC 2000 Program Criteria. One of 12 student-learning outcomes for undergraduate engineering programs is to provide a broad education necessary to understand the impact of engineering solutions in a global and societal context.

Engineering students are less inclined to travel abroad, especially for a whole semester. A shorter-term experience is viewed as less daunting and also less disruptive. Engineering curricula typically lack flexibility with little time being available in student schedules for non-technical elective coursework that might be more easily taken in study abroad programs [1]. Mini-term abroad programs were implemented at Union College, NY, in which students were able to take courses in two different countries during periods when the college was on break [3]. Specific topics were studied at each location.

A project-based approach to studying abroad has been applied successfully by some U.S. institutions. Worcester Polytechnic Institute has established an international project-based curriculum that involves many sites throughout the world [4]. While working full time in teams, students successfully address real-world problems provided by participating sponsors at each site, and they are immersed in an unfamiliar culture. While abroad they work on projects with active consultation from a technical advisor from the sponsoring organization and they meet with their faculty on a daily basis. At the end of the project, student teams defend their work in a formal oral presentation before their sponsors and at the same time they provide a formal written final report. The benefits to the students are seen as immediate and profound, as they are exposed to disciplines outside their own and to the value systems and approaches used by others of a different culture to evaluate problems and solutions [4].

Foreign language proficiency also has been identified as a reason for lack of participation in international experiences by U.S. engineering students [1][5]. Even though they may have had foreign language instruction in high school and in some cases in college, students are often unable to acquire the fluency in a foreign language necessary for participation in more traditional study abroad programs [1].

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The most popular destinations for study abroad experience are located in Europe [6]. Less than 3% of students chose to study in Africa during 2002/2003. This can be partially attributed to there being relatively few African institutions offering study abroad opportunities. Also most of Africa comprises developing countries with limited resources. Nevertheless Africa is a continent that has a rich diversity of cultures and environments. Students who spend time there are substantially rewarded by unique experiences. South Africa is seen as having one of the more advanced economies relative to other African countries. However, it is a challenging mixture of first and third world cultures and therefore is a worthwhile destination for students studying abroad. In addition, English is one of the official languages widely spoken and used as the teaching medium in many of the universities, making it attractive for students concerned about their lack of foreign language proficiency.

Research on the impact of study abroad on careers indicates that it provides an education in many of the “soft skills” required by ABET and industry [7]. Particular skills that were identified included flexibility, appreciation for diversity, open-mindedness, being comfortable with “international”, and having a global perspective of engineering.

OBJECTIVES AND PROCEDURE

The objectives of this study abroad experience were to expose students to a different culture and to the application of technologies appropriate to South African needs by collaborating on short-term engineering design projects with South African students.

In meeting these objectives the following procedure was implemented:

1. Set up a collaboration with the School of Bioresources Engineering and Environmental Hydrology (BEEH) at the University of KwaZulu-Natal (UKZN) in South Africa to facilitate student interaction via teamwork on mutually selected capstone design projects.

2. Recruit undergraduate and graduate students from the Department of Agricultural and Biological Engineering at the University of Illinois (UIUC) during fall 2003 to embark on this study abroad experience.

3. Select projects from a list provided by UKZN and form teams comprising students from UKZN and from the Department of Agricultural and Biological Engineering at the University of Illinois (UIUC).

4. Arrange for student teams to start working on projects during spring 2004 semester and to provide regular progress reports, culminating in a written progress report at the end of the semester. Students enrolled for the equivalent of an independent study or research and design thesis course. Communication among team members on both continents was encouraged to determine project goals and tasks to be addressed.

5. Review and procure material and equipment required for projects.

6. Formulate a schedule while in South Africa that provided students time to work on their projects in collaboration with South African students and faculty, and time to embark on planned travel excursions to different parts of the KwaZulu-Natal province to experience African cultures and environment.

7. Arrange informational meetings before travel to prepare students for the visit to South Africa.

8. On arrival in South Africa execute the planned schedule and ensure students prepare both oral presentations and written reports. The students were expected to present the results of their projects to students and faculty at both UKZN and UIUC.

9. On returning to the U.S. arrange for students to complete surveys and a reflective paper about their South African experience.

10. Obtain feedback from faculty and student advisors involved with the South African visit.

PREPARATION PHASE

Arrangements for a four-week tour to South Africa were initiated in fall 2003 and nine students from UIUC signed up to go. One of these students was an M.S. graduate student, one had completed his freshman year, one had completed his junior year and the rest were senior students. Eight of the students were in the Agricultural Engineering program and one was in the Technical Systems Management program.

During the spring 2004 semester the students were divided into four teams and each team selected a project from a list submitted by BEEH to its senior students for their capstone design. Two senior South African students in BEEH had also been assigned to each of the same projects and email communication between the students at each university was established in the latter part of the spring semester. Efforts were made to identify what aspects of each project the respective team members could address. At the end of the semester a videoconference was organized to allow the students to meet “face to face” and to be able to ask questions on a one-on-one basis. This conference was successful in providing a more concrete and informal interaction between the team members of each university.

The student advisor and the assistant dean for study abroad in the College of ACES held three mandatory preparatory meetings with the students during the spring semester. The objectives of these meetings were to inform the students about travel arrangements and also have each student present a country paper on an assigned aspect of South Africa and its culture, including history, government and politics, economy, agricultural production, and background on selected cities. These meetings were found to be effective in preparing the students for the South African visit.

SCHEDULE IN SOUTH AFRICA

A schedule of the activities for each day of the visit was established beforehand and was fairly closely followed. The students spent approximately 12 days working intensively on the projects in collaboration with the South African students.
The project-based format resulted in a productive synergy and exchange between the U.S. and South African students, with respect not only to the projects but also to learning about South African customs and culture. This interaction was very much facilitated by the two-on-two team format. Camaraderie among team members was achieved in the relatively short time. The South African faculty at the University of KwaZulu-Natal were impressed by the progress made on the projects as reflected in the presentations. They expressed strong support for similar short-term project-based programs in the future. Students were able to gain a perspective of and an appreciation for the provision of appropriate engineering solutions to solve local problems subject to limited resources.

All the scheduled excursions were carried out as planned with the aid of a tour guide who happened to be an environmental lawyer who was able to provide some eco-legal instruction on each excursion as well as placing an emphasis on community-based eco-tourism. These excursions included tours of a number of game reserves in the local KwaZulu-Natal province, and visits to both mountainous and coastal areas, thus providing students with a broad exposure to South African society, culture, and its rich ecology and wildlife. Some unscheduled activities were also added during the visit that proved to be worthwhile, one of which was a visit to a sugarcane mill and to some sugarcane farms where cutting, collecting and transporting the cane were being undertaken.

**PROJECT DETAILS**

From a preliminary list of over 20 projects provided by UKZN, the following topics were selected by the students:

1. Precision agricultural systems
2. Sugarcane cutter performance
3. Micro-flood irrigation system
4. Automatic sugarcane weighing system

Two of the projects were connected to sugarcane production and all the students gained an understanding of what was involved in sugar production from sugarcane. Each of the four projects is discussed briefly below:

1. Precision agricultural systems: The students on this project spent a major part of their time out at the Ukulinga Research Farm at UKZN where the equipment and workshop facilities were situated. The students were given hands-on experience with the use of lathes, milling machines, brazing, electronic soldering, and the gluing of strain gauges, to fabricate components necessary for their project. They also were able to test the lawn mower they were modifying to be a demonstration unit for precision agricultural technologies.

2. Sugarcane cutter performance: This team investigated both modifications to existing machetes for manual cutting and a portable cutting device in the form of a brush cutter. Issues that were highlighted were the predominant manual cutting of cane in South Africa and the level of effort required for this task. They visited a sugarcane farm close by Pietermaritzburg to observe the field operations. They spent 15 minutes cutting cane in a field themselves and were able to experience firsthand the enormous amount of stamina and endurance required to cut the daily quota of four metric tons per laborer. This team also visited the factory that manufactures the machetes to discuss possible changes to the design of the handle and blade in order to improve the ergonomics and cutting efficiency. They redesigned the cutting blade for a brush cutter and were able to perform some preliminary tests with this portable motorized cutter.

3. Micro-flood irrigation system: Water is a scarce resource in South Africa and methods to improve the efficiency of irrigation systems are continually under the spotlight. Micro-flood irrigation is seen as a promising method of providing a more efficient application of water to a crop with a reduction in water losses. This team had identified a computer model in the U.S. that could be applied to such a system. They spent a large portion of time becoming familiar with the model and were able to carry out some preliminary simulations. A field plot was prepared and they performed a water infiltration rate test and dug a furrow ready for additional tests. The South African students continued with the project and obtained data to verify the model.

4. Automatic sugarcane weighing system: A means of automatically measuring the weight of sugarcane lifted by a loader was required. This team visited the manufacturer of the loader to discuss options for instrumenting the loader. A loader was instrumented by the students with strain gauges, pressure sensors, inclinometer, linear potentiometer and a data acquisition system was set up to record some preliminary data for calibration purposes.

In all four of the above projects the expectation was that the South African students would continue working on their respective projects after the American students had returned to the U.S. in order to fulfill their own academic requirements for a senior capstone design course. At the final project presentation a number of the South African students commented on the value of having the American students working alongside in accelerating the progress made on the project and making advances that were unexpected. They also emphasized the extra motivation that was provided through the interaction. Another interesting comment that was made by the technical staff was how willing the American students were to “get their hands dirty”.

During the visit, the student advisor was able to keep up to date on a daily basis as to the progress on each project on an informal basis. Planned discussions and presentations took place on three occasions:

1. On the first Monday morning a meeting was held in the School of BEEH where the U.S. and South African students met for the first time and the objectives and status of each project were reviewed.
2. At the end of the first week both the U.S. and South African students discussed project progress and goals for the remaining time.
3. A final 20-minute Microsoft PowerPoint presentation by the U.S. students of each team took place on the last Friday of the visit.

This format proved to be very effective and the students required very little encouragement in executing their projects.
The presentations were of a high quality and were very well received by the BEHEE faculty in attendance.

After returning to the U.S. each team submitted a three-page report on their projects and a further 15-minute presentation was made in the Department of Agricultural and Biological Engineering to faculty and students. Comments from faculty after the presentations were very positive. In addition to the project report and the presentation, each student completed a survey and a reflective paper. Student and faculty responses to this study abroad experience are provided in the next section.

PROGRAM ASSESSMENT

The impact and effectiveness of this study abroad experience was assessed via faculty and student feedback. One faculty at UKZN expressed some uncertainty as to the outcome, “…having never experienced student design teams working across two continents. However, the outcome was very positive for the students from both universities”. Other faculty at UKZN also expressed their enthusiasm for the short-term collaborative project format and were eager to arrange another visit. It was evident that the collaboration of students from two different universities and cultures had a positive impact on the design projects in terms of quality and innovation. Each group of students realized the value of being able to provide a different perspective and approach to solving an engineering problem in accordance with what they had learnt or experienced in their own university educational system. The U.S. students had the benefit of applying their engineering knowledge to solve a problem that was totally different than what they might be expected to face back in the U.S. This outcome helped to develop their confidence and ability to solve a broader range of engineering problems.

The students were asked to complete a survey after the visit, which included the following questions:

1. If you could do it over again, would you participate in this program?
2. Would you recommend this study experience to your fellow students?
3. What did you like the most about the program?
4. What did you like the least about the program?
5. What surprised you about the place you went to and the people/culture you encountered?
6. Comment briefly on the value and impact of working in a team on projects compared to attending a short course, for example, as part of a study abroad experience.
7. While working on the projects, if you were to pick out one single learning experience that had the greatest impact on you, what would it be?
8. Please describe in what ways, if at all, this experience has enhanced your communication, leadership, technical, teamwork and interpersonal skills, and rank these according to no effect, some effect, and high effect.
9. Please summarize your study abroad experience in two to three sentences.

It was clear from the survey results that all nine students viewed the experience very positively. All indicated they would definitely participate in the program again and that they would recommend the experience to fellow students. Two notable comments made in recommending the experience were the following:

“This international experience was a unique opportunity in that we were not only exposed to the country itself but we were given a more in depth look at the people through our interactions with the students at the university as we worked on our projects”.

“It was a great way for students to learn about another culture. It was a good mix of sightseeing/cultural excursions, and research in our field with local students. It would be especially good for first time travelers as everything was planned out and taken care of”.

What students tended to like most about the program were the opportunity to interact with students of their own age and learn their culture, and to embark on excursions that exposed them to totally unique environments. One student indicated that he was glad that he went to a country where English was the main language, which made communication very easy. The least desirable aspect of the program tended to be the long traveling time to and from the U.S. and also during excursions.

Factors that surprised the students included the high level of crime in the country, the relatively small size of the vehicles, and the impact of AIDS. Notable comments were the following:

“The high level of crime was something I had never encountered before. We never experienced any bad incidents while we were there, although everyone we met had, at some point in time, been directly affected by crime. We felt very safe throughout the entire trip, although you could tell that the country has been deeply impacted by crime”.

“I knew about the AIDS epidemic, but I didn’t realize how it impacted the entire culture so much. Also, all the farm labor is very manually intensive without the use of machinery and many of the laborers are dying of AIDS and that’s a big issue right now.”

All the students felt that working on a project rather than attending a short course had greater value and impact. The project work provided them with flexibility in using their time and they had more direct interaction with their South African counterparts. The following comments reflect the thinking of the group:

“I got much more out of this study tour teaming with students on a project than I did on my last study abroad when all I did was study the language and culture. I learned so much about the culture as well as seeing how other universities differ. I would rather study abroad and do an engineering project to get more experience than to take a short course.”

“I enjoyed the freedom we had to work in our own way and on our own time; I really felt like the American students and SA students helped and complemented each other, even though we had very different thought processes, strengths, and ways of approaching a problem.”

Key learning experiences that the students identified were strongly linked to their exposure to the sugarcane industry as a
result of excursions and design projects. They commented on the fact that the South African agricultural industry was very different than in the U.S., because the work was more labor intensive with limited machinery. One student observed that the farmers that owned the land acted as managers and did not do the work themselves, whereas in the mid-western United States the owners were usually the machinery operators and provided most of the labor. However, one student commented, “Although we may grow different crops and have different techniques, both nations have similar concerns for the future of their agricultural industries.”

In reviewing the skills that they enhanced from their study abroad experience, students indicated that in most cases the experience had had some beneficial effect. About half the students felt that their teamwork and interpersonal skills had been enhanced substantially.

The following notable comments were made in summarizing the study abroad experience in two to three sentences:

“Going to South Africa was an awesome experience I will keep with me all of my life. I had a wonderful time learning about the country and its people first hand. I also feel that I may have helped to introduce technology that will help improve their agricultural productivity in the future.”

“Overall, I feel that my study abroad experience was very worthwhile and rewarding. The chance to learn and interact with another culture, different from my own, was very fulfilling.”

“The South African experience was absolutely amazing! From an educational standpoint, I not only learned about sugar cane harvesting, but I also learned how to better work with people who I have no knowledge about with regards to their background and history. From a cultural standpoint, I realized how very fortunate I am to live in the United States and realized how many things I take for granted.”

“Working on projects dealing with a subject I knew nothing about six months ago and then being able to explain in detail to someone here is amazing. Also, I’ve always wanted to go on a safari, and now I can say that I have.”

The following statement provided in a reflective paper by one of the students underlines the potential influence this type of study abroad experience can have:

“Since returning from the trip, it has amazed me how relevant everything I learned there has become. Several of the classes I am taking are on international development planning, and we discuss issues like implementing appropriate technologies, the effects of endemic diseases, and the role of gender and race every day. Having this experience has increased my level of appreciation of many of these issues. Also, the opportunity to travel in the “global South” made me more comfortable with the idea of pursuing an occupation that would send me to similar locations. All of this has strengthened my resolve to pursue a career in international development. The experiences this trip gave me were invaluable; such a chance to travel and collaborate on meaningful research is an opportunity I recommend no one pass up.”

CONCLUSIONS

The approach of using a collaborative engineering capstone design project as a means of interacting with students in a different country proved to be very effective. Students felt that they learnt more from working on a project than they would have from a short course as a study abroad experience. The projects resulted in the U.S. students being exposed to very different technological needs in South Africa, but they realized that they were able to contribute to the solution of engineering problems through their own engineering ability and experience gained in the U.S. The format of the South African visit with the combination of time spent on projects and on excursions was successful in allowing students to experience the culture and environment in that country as well as understanding the appropriate technological needs for engineering solutions.

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