Our Second International Senior Design Project

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Abstract

In 2005, the Department of Civil Engineering at Rose-Hulman Institute of Technology decided to incorporate an international component into its 18 year old capstone senior design program. The advantages of international experiences for engineering students are well documented:

- Students have the opportunity to partner with local or international organizations
- Students get exposed to international design codes and standards
- Students get to experience the global working environment

These are just a few of the benefits associated with international projects. However getting involved in foreign projects is not without its problems:

- Students face challenges associated with distance
- Students have to deal with the different cultural and educational environments
- Access to pertinent codes and engineering data is often difficult

In the department's first international project, some of these major problems were encountered and the lessons learned were documented. Using these lessons learned, we decided to undertake a second international senior design project. This paper discusses how recommendations and experiences gained from our first international project were used to our advantage. Specifically, the paper addresses the following issues:

- Partnership with the Rose-Hulman Engineers Without Borders (EWB-RHIT)
- Collaboration with overseas academic institution
- Support provided by an engineer in the problem-source country

Additionally, the paper presents a survey of the student team experiences as well as the client's comments. These comments are compared with similar surveys from our first experience to ascertain if there has been any improvement in the areas of obtaining relevant engineering data, client communication, etc. The paper finally highlights the advantages of this project, the pros and cons of working with the EWB chapter and our experience gained in working with an overseas academic institution.

Introduction

Each summer, fifteen to twenty corporate or governmental sponsors submit proposals for design projects to the Civil Engineering (CE) Department at Rose-Hulman Institute of Technology (RHIT). In August each student ranks the projects, and assignments are made to maximize student preferences. The design team includes four to five seniors, a faculty coach, the client, and the course instructor. There is no charge for the design projects other than direct costs.

These year-long client-based projects have been the senior design capstone model at Rose-Hulman since 1988.

The learning objectives for client-based, senior design projects include: problem-based learning (of the civil engineering design process), communication proficiency, team-work skills, and project management orientation. The year-long experience contains many key elements and deliverables to achieve these learning objectives. The design process experience is cultivated through problem identification, development and assessment of alternative solutions, data collection, engineering design, and cost estimation. Team-work and project management skills are developed through rotating group assignments. Written communication skills come from the three deliverables required of each group: the proposal, progress report, and final report. Faculty assessment of these written reports is demanding and thorough. Oral communication skills are enhanced through four major presentations: the proposal and progress presentations to the senior class and faculty, final presentations to the client and presentations at a professional venue.

Two years ago, members of the civil engineering faculty thought it would be beneficial for Rose-Hulman students to venture into the international arena. The dialog began when one of the faculty participated in a mission's trip to Trinidad during the summer of 2005. Conversations with the local in charge of the project resulted in a senior design project for Rose-Hulman students. The end result was a design report for a missionary complex complete with an orphanage, a medical facility, a home for battered women, and a soup kitchen[1].

There are many good reasons to expose engineering students to international projects. For example, the explosion of knowledge precipitated by the Internet and the resulting global economy will make engineering services increasingly dependent on an international talent pool. This is very apparent to the National Academy of Engineering as stated in its report on the engineer of 2020[5]. Global competition from India and China is an inescapable conclusion of Thomas Friedman in his book entitled "The World is Flat"[2]. Engineers ignore these economic dynamics at their own peril; embracing change and competition is likely to produce satisfactory results. A new technological workforce will emerge in the 21st century according to author and futurist David Heenan[4] and we need to prepare for it.

Our first international senior design project produced many challenges. The lessons learned encompassed all phases of the project as summarized by Hanson et al[3]. Examples of the primary lessons are listed below in their appropriate categories:

- Purpose (International projects should align clearly with program outcomes.)
- Project Acquisition (Personal relationships with perspective clients is invaluable.)
- Project Planning (Build a budget; site visits are just as critical for international projects.)
- Site Visit (Itemize and prioritize the objectives of the site visit.)
- Design (Information acquisition and factors of safety are important design considerations.)

We obtained our second international project through the student chapter of Engineers Without Borders at Rose-Hulman (EWB-RHIT). The project involved the design of an agricultural training facility. The Obodan Sustainable Development Center (OSUDEC), located in Accra, Ghana will provide participatory learning experiences to promote rural development. The OSUDEC facilities will consist of a computer training center, conference hall, caretaker house, hostel, poultry building, office space, and executive chalets. In addition, the center will need power (from the nearby grid), water (groundwater source), a fruit orchard, a vegetable garden, an irrigation pond, and a children's playground[6]. Key tasks include the development of floor plans and the site design along with the structural and foundation design of the center's buildings.

Project Setup and Initiation

(Anticipated Challenges - dealing with these challenges at an early stage in the process)

Capstone projects in the RHIT Department of Civil Engineering require advance preparation by the course instructor and by likely project mentors to assure the work scope is consistent with the learning objectives. Sometimes, preparation also requires advance acquisition of resources the design team will need to be successful. In the case of an international design project, the instructor and mentor must consider the possibility that the student team may not be able to visit the project site and whether data necessary to complete a preliminary design remotely can be acquired or even exists. As a minimum, the design team should have the following relevant data:

- Information about previous and current land use, including current photos of the site
- Region-specific geologic and soil mapping information
- Site and regional topographic data
- Pertinent codes and related engineering data
- Information on local construction and design practices

The search for some of this information, if not all, is a significant feature of the international project experience, so students should be expected to conduct that search. Even so, the instructor and mentor must be confident the data can be acquired before offering the project to the students.

In addition to the above preliminary data, the specific soil conditions at the site can have a significant impact on the project for the design of foundations and wastewater systems. Remote, tentative foundation design can be a big improvement over conservative "rules of thumb" design and a significant contribution to the learning experience if regional and site-specific data are available. The design of a wastewater management system is even more highly dependent on the site-specific soils. For this design, ground water conditions are needed along with shallow soil characteristics to estimate hydraulic conductivity. Tentative ground water conditions can likely be determined through interview and local observations by the client, but shallow hydraulic conductivity requires empirical correlation with at least index properties such as grain size analyses and soil plasticity.

Site-specific soil data are not likely to be available through literature searches or by query with local practitioners. Thus, some provisions must be made to acquire samples from the site for at least index testing to permit soil classification that can then be combined with regional soil data to permit preliminary design. Sampling and testing of soils can be achieved by (1) client sampling followed by shipping the soils overseas, (2) client sampling and in-country testing by a local lab, or (3) soil sampling by a project team member during a site visit followed by local testing or transport of samples by the team member. Note that there are federal regulations limiting the transport of soil into the United States. For the previously referenced Trinidad project, a team member traveled to the site over Thanksgiving break, and conducted local soil sampling and testing. The key is for the instructor and mentor to perform advance planning and perhaps even have the testing conducted before the start of the capstone project so that lack of local soil data does not impair the project.

Partnership with Engineers Without Borders (EWB)

To address the problem of obtaining site-specific data, the CE department partnered with EWB-RHIT. EWB-RHIT was established in the fall of 2004. Since its inception the chapter has partnered with disadvantaged communities over to improve the quality of life through implementation of environmentally and economically sustainable engineering projects. Currently, EWB-USA is involved in 80 projects in 35 countries around the world. To start a project, a community in need of engineering assistance applies through EWB-USA for aid. EWB-USA then evaluates the community's request for assistance by determining the feasibility of using college engineering students to solve the problem. Once this is done, college chapters, like EWB-RHIT, send in applications to volunteer to fulfill the needs of the community.

In 2004, Dr. Anthony Akunzule (the 2006 client) made EWB-USA cognizant of some of the major problems in his community, Obodan, Ghana. In response to his request, the EWB-RHIT chapter visited Obodan in summer 2006 to construct a poultry building. Prior to this visit, the CE department was contacted by the client about a potential senior design project of an agricultural training facility. Fortunately, the poultry building was part of this agricultural training facility. Aware of some of the problems encountered in our first international design project, especially in obtaining the relevant engineering data, we decided to partner with EWB-RHIT. This partnership solved many of the problems encountered in our first experience with international projects. While in Ghana, EWB-RHIT was tasked to obtain the following site-specific soil data as well as pertinent design codes: previous land use, design codes, rainfall data, common building materials, local construction techniques and practices in Ghana and some site photographs. Most importantly, the group provided soil samples from specific locations of the site and these were sent to an academic institution in Ghana where laboratory testing was performed. This was extremely important because of the difficulty in bringing soil samples from another country to the United States. Through this collaboration, most of the engineering data was obtained prior to the student team working on the project.

Collaboration with Kwame Nkrumah University of Science & Technology (KNUST), Ghana

As noted previously, site-specific soil data is crucial to a useful design by the student team. For the OSUDEC project, a team from EWB-RHIT planned to visit the project site the summer before the scheduled capstone design in the RHIT CE department. The instructor, mentor, and geotechnical faculty member in the department thus met with the EWB-RHIT leadership to plan for acquisition of local site data, including soil samples for testing. After extended discussion and investigation into issues with the transport of samples into the U.S., the instructor, mentor and EWB leadership concluded local soil testing should be investigated. As a native of Ghana, the project mentor took leadership on this task. Specifically, the project mentor arranged for soil index testing with a colleague at Kwame Nkrumah University of Science & Technology, Ghana, (KNUST) located approximately 270 km north-west from the project site. The colleague, Dr. Samuel Kofi Ahiamadi who is a co-author of this paper, had expertise in geotechnical engineering and volunteered to facilitate index testing in accordance with American Society for Testing and Materials (ASTM) standards.

The RHIT geotechnical faculty member subsequently coached the EWB leadership about soil sampling, including decision-making during sample acquisition, observation of soil consistency for qualitative strength assessment, and sampling protocol to preserve natural water content. Arrangements were made by the RHIT project mentor for transport of the samples to KNUST after sampling, thus facilitating acquisition and testing of site-specific soils before the CE capstone team had even arrived on campus for fall classes. The collaboration by Dr. Ahiamadi was instrumental to the project, plus the RHIT geotechnical faculty member found the interaction with Dr. Ahiamadi professionally enriching.

The RHIT CE capstone project leadership believe that future projects will find it similarly challenging to transport soil samples to the U.S., but stress that site-specific soil data is crucial for successful design. Consequently, future project planning will consider local soil testing first. Development of a protocol for non-engineers to conduct sampling, make on-site observations, and secure samples for local shipping is under way by the RHIT geotechnical faculty member.

Survey Results

Student perceptions and attitudes are an important part of the capstone design experience. Therefore, questionnaires were conducted with the seniors in 2005 and 2006 during weeks 7 and 14 of the 30 week project. Table 1 presents the results of the first survey. Overall satisfaction of students with their project selection was high, 4.0 to 4.2 out of 5, but the students on the international projects were even more pleased with their choice, 4.5 to 5.0. Table 2 presents the results of the second survey. Questions 1 through 5 focused on what motivates students in their selection of projects. Consistently and overwhelmingly, the most important aspect to students is the subdiscipline(s) of civil engineering that the project emphasizes. One concern of the faculty was that an international project would be more work for the student team compared with domestic projects. The responses to Questions 6 and 7 show that on average, all students feel they work slightly harder on their project compared to the other groups. Therefore, there is probably no difference in time spent by teams on an international project compared with teams on a domestic project.

Table 1. Results of surveys conducted during week 7 of the capstone design course during the 2005-2006 and 2006-2007 academic years.

Question : I am … pleased with the project to which I was assigned.		1: abs. not	2: not	3: somewhat	4: very	5: extremely	Average
Members of International Proj Team	2005	0	0	0	2	2	4.5
	2006	0	0	0	0	5	5.0
Members of All Other Teams	2005	0	0	7	13	7	4.0
	2006	0	0	8	22	15	4.2

Table 2. Results of surveys conducted during week 14 of the capstone design course during the 2005-2006 and 2006-2007 academic years.

Questions	Year	1: Not a factor	2: Small factor	3: Some factor	4: Important factor	5: Most important factor	Average
1. Indicate how much the international aspect of a potential senior design project would affect your choice of a senior design project	2005	4	9	9	8	0	2.7
	2006	13	9	15	10	0	2.5
2. Indicate how much the humanitarian/ charity aspect of a potential senior design project would affect your choice of a senior design project	2005	5	2	10	11	2	3.1
	2006	6	3	16	19	3	3.2
3. Indicate how much the potential benefit of the project to the client would affect your choice of a senior design project	2005*	-	-	-	-	-	-
	2006	2	3	25	11	6	3.3
4. Indicate how much the civil engineering specialties aspect of a potential senior design project would affect your choice of a senior design	2005	0	0	4	6	20	4.5
	2006	1	1	3	19	23	4.3
		1: Abs. not	2: Prob. not	3. Possibly	4. Probably	5: Absolutely	Average
5. Rate your desire to work on an international senior design project if one was available in your preferred area of civil engineering	2005	0	6	14	7	3	3.2
	2006	0	9	19	10	9	3.4
		1: Much less	2: Less	3. About same	4. More	5: Much more	Average
6. Indicate how much work your project requires compared to the international project [domestic project team members]	2005	0	2	16	7	1	3.3
	2006	0	1	31	8	2	3.3
7. Indicate how much work your project requires compared to the other projects [international team members]	2005	0	0	3	1	0	3.3
	2006	0	0	3	1	1	3.6

* Question not asked in 2005 survey.

When seniors in week 14 of the 2006-2007 academic year were asked to complete the statement "My biggest concern about working on a senior design project for an international client is…", five students indicated "communication" and four indicated "obtaining data". When asked to complete the statement "The biggest advantage about working on a senior design project for an international client is…", the responses focused on broadening their experiences.

Important Considerations for Further Improvement

Based on our second experience with international design projects, a number of key observations were made by the authors that will require consideration:

- There is the need to improve the medium for communication. For the next international design project the following communication channels will be explored; videoconference, teleconference via a phone line and web conference.
- To reduce the burden of gathering codes and making new arrangements for in-country soil testing, we recommend creating a long-term relationship with an organization in the region. Currently, the RHIT CE department is in the process of establishing a Memorandum of Understanding (MOU) with KNUST to achieve this objective.

Conclusions

In order to provide students with some international experience with regards to the global working environment and how to deal with the different cultural and educational environments, the OSUDEC project brought together student teams from the CE Department and EWB-RHIT, a professor, a client, and a local engineer from the problem-source country. Some lessons learned from this experience are:

- The project provided the students the opportunity to consider economic, social and societal impact, application of appropriate technology, and the limitations of the problem-source country while applying engineering skills.
- The students learned creative problem solving and cross-cultural communication.
- Collaboration between the student team, EWB-RHIT, a local engineer, and KNUST was very successful. EWB-USA is involved in a lot of projects all around the world and can be used as an avenue to obtain necessary information.

Overall, international design projects provide students with valuable experience in communication, design, and organizational skills. Additionally, such projects expose some of the challenges that can be encountered in dealing with an international client in a different cultural and educational setting.

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