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Meeting Engineering Program Objectives through Service Learning Opportunities in Developing Countries

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Abstract: The civil engineering profession, in an adaptive reaction to emerging roles for civil engineers, is recognizing the need for new engineers to possess a more robust skill set than just the typical design background. This paper describes the efforts of Clemson Engineers for Developing Countries (CEDC) to fulfill the more nontraditional and often unaddressed "learning outcomes" noted by ASCE's Civil Engineering Body of Knowledge for the 21st Century as important prerequisites for licensure. The learning outcomes are addressed through ongoing international service learning projects in Cange, Haiti. The paper focuses on the following four outcomes and their fulfillment methods: leadership, globalization, teamwork, and communications. The student led organization has allowed students to set up their own fundraising mechanisms, to seek out members to join design review boards, and to develop their own project objectives. This level of student autonomy is noted as key to ensuring that students achieve competency in these four areas.

Key words: ASCE BOK2, leadership, service learning, communication, teamwork.

1. Introduction

Engineering professional societies and their related accreditation organizations are currently placing a strong and continuous emphasis on broadening, and in some cases expanding, undergraduate and graduate engineering programs. Within the civil engineering profession such program guidelines were published by the American Society of Civil Engineers in 2008 as the Second Edition of the Civil Engineering Body of Knowledge for the 21st Century (BOK2). Contained therein is a recommendation that future professional engineering registration require either an MS degree or a 30 semester hour credit equivalent beyond the traditional BS degree. Also contained within BOK2 are 24 specific recommended "outcomes" of engineering education and experience that should serve as a prerequisite for licensure.

This paper suggests an effective means of exposing engineering students at both the undergraduate and the graduate level to four of the more "non-traditional" program outcomes listed and described in BOK2: leadership, globalization, teamwork, and communications. Recent experiences of the authors in establishing the Clemson University student organization Clemson Engineers for Developing Countries is reviewed, and lessons learned from three student site visits to Cange, Haiti are used to support the recommendations put forth in this paper.

2. Service Learning in Engineering

Service-learning is an education enhancing process intended to aid in student development and learning by engaging students in activities to address human and community needs [1]. Service-learning has been used for decades as a pedagogical tool, but until recently, engineering programs have been slow to incorporate service-learning into their curricula. Service-learning is recognized as a "valuable pedagogical tool" that has a powerful impact on young people and their development [2, 3]. Service learning gives young engineers an opportunity to see how their work directly affects the lives of others.

Traditional engineering curricula focus on design, analysis and implementation skills related to the

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specific engineering field of study. However, many professional and accreditation organizations including the American Society of Civil Engineers (ASCE) and the Accreditation Board for Engineering and Technology (ABET) acknowledge a shift in the business environment that demands engineering graduates who are better trained in interpersonal skills such as teamwork, communication, leadership, and globalization.

Research has shown that service learning facilitates development of leadership skills, self-esteem, teamwork, communication skills, and acceptance of cultural diversity [4-7]. The reciprocal relationship that forms between the students and community nurtures personal growth and a deeper sense of social responsibility among students while empowering communities as they become more self-sufficient [8].

Service learning participation forces the student to utilize skills from the classroom in a practical, real-world application. This experiential learning helps students develop skills that may not be addressed in other undergraduate courses. Experiential learning reinforces students' education and creates enthusiasm for learning [7, 9]. Further, when incorporating a component outside the bounds of the typical university setting, experiential learning can help connect students with practicing engineers and professionals. These connections facilitate business opportunities and mentoring for students along with sharing of knowledge between industry and academia [10].

Service learning projects outside of the U.S. can be used to encourage a more global perspective in engineering students, and recent trends, including the rapid growth of Engineers without Borders, show that many engineering service-learning groups choose to work with international projects [11, 12]. The global perspective can help students gain a deeper awareness of global issues, such as water availability, poverty, and mass unemployment, by seeing these problems firsthand and talking to community members facing these challenges. While visiting the site of an international based service project immerses students in another culture, students do not necessarily have to travel to benefit from interaction with a foreign community. Service-learning courses can help students become culturally aware through reading assignments and direct communication with students who have visited the community.

3. Clemson Engineers for Developing Countries

The Clemson University student organization Clemson Engineers for Developing Countries (CEDC) has recently completed efforts related to the design of a water filtration, purification and distribution system for the rural village of Cange, Haiti. Six CEDC students traveled to Cange in June 2009, expending a week of effort to obtain the field data required to execute their designs. These design efforts, and those related to similar infrastructure improvements in Cange including prefabricated housing alternatives, were addressed in a one semester hour credit class. Twenty students were enrolled in the combined undergraduate/graduate course during the Spring Semester 2010. To encourage cross-disciplinary collaboration, course enrollment is open to any undergraduate or graduate student at Clemson University regardless of major. The student projects in Cange are being executed in coordination with the Episcopal Diocese of Upper South Carolina, and other groups who have maintained a long time presence in Cange.

The recent devastating earthquake in Haiti placed an added urgent emphasis on the student design projects. The medical facility in Cange, one of the best in the country, is experiencing an overwhelming influx of refugees. Missionary, medical, and other personnel currently located in Cange urged the CEDC student project teams to expedite their water system designs and be available to oversee system installation in Cange as soon as Haiti travel became practical. Thus, a second site visit for the purpose of distributing final system design documents and interacting with local

engineering professionals and residents was executed in March 2010. Additional information pertaining to the ongoing CEDC student projects may be obtained from the student organization web site: www.clemsonengineers.com.

4. ASCE BOK2 Recommended Program Outcomes

4.1 ASCE Body of Knowledge for the 21st Century

The ASCE Body of Knowledge for the 21st Century expects civil engineering students to gain knowledge, comprehension, and application of 24 outcome areas in a BS degree curriculum. The BOK2 publication acknowledges that for many of the outcomes, participation in activities outside the classroom are effective means of fulfilling, or partially fulfilling, the outcome requirements.

However, for a number of outcomes, BOK2 makes a strong statement that more needs to be accomplished in teaching the outcomes in the classroom. With respect to the leadership outcome, for example, BOK2 states, “Leadership can be taught and learned … the formal education process has the potential to make a significant impact on teaching leadership principles and developing leadership attributes.” The key to BOK2 implementation appears to be, therefore, structuring a careful balance between what is learned within the classroom, and what can be applied through student activities outside the classroom.

The four recommended BOK2 program outcomes addressed in this paper are briefly discussed below with outcome implementation recommendations cited. The extent to which student involvement with service learning activities in developing countries addresses these outcomes is addressed in the following section of the paper.

4.2 Leadership

BOK2 defines leadership as “developing and engaging others in a common vision, clearly planning and organizing resources, developing and maintaining trust, sharing perspectives, inspiring creativity, heightening motivation, and being sensitive to competing needs”. ASCE stresses the application of leadership principles within small homogeneous groups and university sponsored organizations.

4.3 Globalization

Global issues that can serve as a learning framework cited in BOK2 include “the international scale of such extreme and long-term environmental events as natural disasters, global climate change, and their impacts on the natural, built, and social environments”. Global professionalism is also cited, stressing the challenge of practicing ethically in a global environment. Industry interaction is mentioned as one of many ways to generate global awareness within an academic program.

4.4 Teamwork

BOK2 cites the importance of teamwork and states specifically the need for “understanding team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, and time management and being able to foster and integrate diversity of perspectives, knowledge, and experiences”. Students are encouraged to seek out activities within student government and civic and service organizations.

4.5 Communication

BOK2 particularly stresses the need for young engineers to acquire the skills necessary to communicate with non-technical audiences. Students are encouraged to “seek out tasks and functions that involve ever more challenging communications.”

5. Addressing BOK2 Program Outcomes through CEDC Initiatives

5.1 Leadership

Student members of CEDC have structured the

organization such that a team leader role is assumed by the student during their second semester of involvement with a project. This initial semester allows team members to become oriented with a project. Team leadership requires the student to have a firm grasp of the design opportunities within their specialization and to organize and lead four to five team members to a common goal. Student leaders facilitate brainstorming sessions to determine multiple solutions to a given problem. Students perform a feasibility study for each solution, and based on the results, the student leader chooses a direction for the team to pursue.

5.2 Globalization

As a result of the January 2010 earthquake in Haiti, the CEDC student teams faced numerous challenges that are unique to working in an international environment. Coordination with international organizations was required to ensure the safety of the team traveling to Cange. Building materials and supplies required for even the most basic reconstruction efforts were not readily available. CEDC tries to maximize the use of local labor and materials in order to support the community's economic activity. However, the local labor force is often is not sufficiently trained to interpret design documents or execute complex construction operations. The economic and social benefits of using labor intensive materials versus materials with low labor costs but a higher material cost is a constant consideration. Facility design documents must be crafted to ensure that all construction can be accomplished with hand tools because heavy construction equipment is not available.

Students also faced challenges unique to working in another country and culture. For instance, no formal building codes exist on a large scale within Haiti. Students had to consider the ethics of this situation and their solution was to execute CEDC designs in compliance with U.S. code requirements for both seismic and wind events. Another cultural challenge was the reluctance of Cange residents to provide design feedback related to the community water stations. Students determined that the community members were hesitant because they thought that expressing dislike for the ergonomics of the designs would be an insult to CEDC. To avoid requiring the community members to express negative thoughts, the CEDC team drafted three designs, and modified the questioning by asking which aspects the community favored most. As CEDC continues working with the community of Cange, the group has become increasingly aware of cultural differences and continues to work to address these differences.

5.3 Teamwork

As a part of CEDC membership status, students are expected to work in teams to accomplish complex design tasks. Student teams are broken into specializations based on the current tasks. These teams work not only interdisciplinary (within their specialization), but they also must closely interact with others in larger intradisciplinary teams. For example, teamwork is required between a field data team, a pump design team and a structural design team.

5.4 Communication

Quality communication includes both understanding of what others are attempting to communicate, as well as expressing ideas to others in a concise manner. CEDC communication activities include presentations to professional organizations and to undergraduate classes, interviews with local media outlets, and face-to-face solicitation of donations from nontechnical audiences. Students must adapt their presentation styles to appropriately address each of these unique audiences.

CEDC teams also interact with a design review board, composed of local professional engineers. Design teams prepare formal progress reports to both

the design review board, as well as to client representatives in Haiti. The design documents prepared by the design teams must be sufficiently clear to convey design intent to construction crews who are often receiving their instructions through a third party translator. To help address this issue, once design drawings are completed and reviewed, supplementary manuals and other technical documentation is typically prepared. This documentation often takes the form of step-by-step instructions with photo insertions.

In the classroom, post-trip reports and post-semester reports are used to maintain continuity between semesters of the one-credit class. These reports document as many details as possible. Design documents and their methods of development are described in depth, similar to what would be executed in a typical civil engineering capstone design class.

6. Recommendations

6.1 Creating a University Sponsored Student Organization

In early 2009, the paper authors initiated contact with a group of Clemson University students to brainstorm ways in which the students could best participate in activities outside the classroom that would satisfy the students' desire to help in the developing world as well as serve as "differentiators" on an employment resume. The discussions soon focused on international service work in general, and creating an autonomous organization serving developing countries in particular. Although the University has a successful chapter of Engineers without Borders, the students were of the strong opinion that creating their own organization would better enhance student interest and participation. Clemson University recognized Clemson Engineers for Developing Countries as a University student organization in January 2010. It has been observed that indeed, permitting the students themselves to develop their own objectives, select their own peer reviewers, and make their own fund raising decisions has greatly enhanced their leadership, teamwork, and communications skills. The CEDC faculty advisor is of the strong opinion that student groups such as CEDC should be given the maximum amount of autonomy possible under whatever constraining policies may exist within an academic institution.

6.2 Funding the Student Organization Activities

Requiring the students to finance their own international travel has created numerous opportunities for the group to make fund raising presentations to non-technical audiences, thus greatly enhancing teamwork and communications skills. The recent earthquake in Haiti, and the fact that the students had been working in Cange pre-earthquake, most likely increased their ability to raise funds from church groups, civic organizations, and industry sponsors. Major corporate entities are currently being contacted to solicit long-term financial support for CEDC.

6.3 Media Relations

The student group has been interviewed and filmed on numerous occasions by University and statewide press media. Selecting engineering projects with a high degree of public interest has proven to be an excellent means for the students to practice and perfect their communications skills. Selected media press releases and video clips are available on the CEDC web site, www.clemsonengineers.com.

6.4 Interaction with the Engineering Profession

Engineers without Borders and other well established student organizations have formal built in mechanisms for industry interaction and peer design review. However, the CEDC students were forced to seek out their own industry partners. The project in Cange, Haiti was identified initially through contact with the Episcopal Diocese of Upper South Carolina. Some professional engineers had been supporting

previous work in Cange. The CEDC students expanded these contacts by essentially establishing their own group of peer review advisors. A major utility company volunteered a senior project manager to serve as an ongoing technical advisor to the group. One particularly effective informal oversight mechanism has been Clemson University faculty members. Students have benefited from establishing closer outside the classroom interactions with faculty members from multiple departments. The faculty members also seem to benefit from these rewarding interactions.

6.5 Unique Challenges and Benefits of Working in a Developing Country

It is an understatement to say that executing engineering design work in a developing country such as Haiti requires some comprehension of the local demographics, government, religion, history and culture in general. The students had unique opportunities to participate in religious services and festival celebrations during their visits. Their design alternatives for community fountains and prefabricated housing required carefully prepared interactions with the local population as well as others who have spent considerable time working in the country.

7. Conclusion

The American Society of Civil Engineers has issued a strong challenge to the profession to broaden academic curricula and place more emphasis on such topics as leadership, globalization, teamwork, and communications. To address this challenge at Clemson University, the student organization Clemson Engineers for Developing Countries was formed and a number of international design and in-country field exercises are ongoing. The activities of CEDC have been well received and supported by Clemson University administration, local practicing professionals, and the Clemson community at large. CEDC efforts are accomplishing not only the goals of ASCE, but the goals of service learning programs in general as reported in academic literature. The fact that CEDC is focusing its efforts in a developing country, and the fact that the students have been given total autonomy in managing the student organization, has perhaps enhanced the goals that have been established for the organization.

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