Service Learning from Start to Finish: Building a First year Playground Design in South Africa

Natalie Van Tyne, James Wong, Kay Godel-Gengenbach, and Kathryne Van Tyne
nvantyne@mines.edu, jwong@mines.edu, kgengenb@mines.edu, kvantyne@uchicago.edu

***Abstract* - The "humanitarian engineering" programs at a public engineering-oriented institution provide its graduates with a variety of readily applicable career skills, including the ability to work effectively in a global community. Our project involved the design and on-site construction of a playground at a school for disabled students in South Africa, involving a first year design team and a joint first- and third-year construction team. The project's major goals were aiding in the development of increased student mobility, ease of construction and maintenance, ease of student access, low material and labor cost, safety in use, and the creation of a sequence of play units that would work together seamlessly. Constraints included a one-week time frame to build the equipment on site, a highly compacted bare soil surface, limited access to power tools, and a $2,000 budget. Local acceptance is essential to viability, which was realized as students recognized the difference between actual and perceived needs, incorporated local materials and ideas to foster ownership, collaborated continually with school staff and sponsors, and demonstrated flexibility in both scheduling and implementation to its greatest advantage.**

Index Terms – cornerstone design, humanitarian, international, service learning

INTRODUCTION

The first year engineering design course at a public university in the western United States encompasses learning objectives that include a guided design methodology based on open-ended problem solving, creative and critical thinking skills, decision analysis, oral, written and graphical communications skills, and effective teamwork [1]. This one-semester, three credit course incorporates a design project to address a current, real-world problem, often sponsored by non-government organizations, local business owners or local governments. Our first year design project was a playground for disabled students in South Africa (aged 6-35 years). Whereas the clients for the design stage were third-year students in the institution's technical-humanities honors program, the clients for the construction of the playground were the teacher and principal of God's Will Disabled School, which was aided, in part, by a group of four South African tour guides who had adopted a growing travel industry practice known as "responsible tourism" or "voluntourism" [2]-[3]. Our institution was contacted by one of these guides through our alumni living in South Africa.

The first year students worked with a group of third-year students from an honors program in order to develop and subsequently implement their design project in the field. In addition to achieving the learning objectives for their respective courses, both groups also gained improvements in their critical thinking, communication, and teamwork skills, as well as a sense of adaptability to changing technological and global circumstances [4], including those influenced by the effect of one's culture on their perception of reality.

Engineers have a responsibility to find solutions for issues related to design and implementation encountered in the field. Therefore, engineering students must learn how to deal with uncertainties with respect to the client, the environment and the resources available. This project, in particular, helped our students develop a shared cognitive understanding of the risks associated with their decisions as the project developed.

The third yearthird-year students were part of an honors program that focused on the relationships among local policymakers, the local community, the environment and potential engineering projects. These students were completing a unit in international studies containing one or more community service projects, that would allow them to understand the intricacies of these relationships in the field. The decision was made to involve the first year design students in this project to enable them to develop a wider perspective as they learned to incorporate our engineering design methodology to meet a need for viable designs with limited specifications and numerous unknowns.

The resulting playground design was selected through a semester's end competition among nearly 100 design teams; the winning team was invited to accompany the third-year students to South Africa for the construction of the playground during July 2011. It was anticipated that the design team would collaborate with the community and the construction teams if modifications to the original design were necessary.

EDUCATIONAL BENEFITS OF SERVICE LEARNING

The term "service learning" has been used to describe the educational benefits that students derive from participating in an academic course that involves the production of a device, method or process to benefit a community. While the outcome of a community service project clearly benefits

its recipients, it can also promote the enhancement of students' writing, critical thinking and research skills [5]. Having a project developed by a community group in the context of the community's physical and social environment helps students to appreciate the reality of the design process outside of the classroom. In certain contexts, it has also been shown to lead to increased subject matter comprehension, higher grade point average and greater tolerance for diversity [6]. For example, humanitarian engineering projects and programs have a potentially valuable and meaningful role in applying knowledge-based resources to underserved communities.

Finally, the incorporation of service learning into an engineering curriculum can enhance an institution's fulfillment of ABET outcomes, especially (c) ability to design a system, component or process, (d) ability to function on multidisciplinary teams, (e) ability to identify, formulate and solve engineering problems, and (g) ability to communicate effectively [7] -[8].

PROJECT BACKGROUND AND PURPOSE

All 500 students in the first year design course pursued the same project, which was chosen by the design program faculty from several available projects. The impetus to choose this particular project, as well as this particular disabled school, originated in the mission of the institution's humanitarian engineering programs. These courses and sequences provide graduates with a variety of readily-applicable career skills, including the ability to work effectively in a global community. This ability widens the scope of fulfillment of the professional responsibility that engineers and engineering educational institutions have to provide service to society [6]-[7].

The client for the project was God's Will Disabled School, established in 2006 by its current principal, who sought to teach basic life skills to physically and mentally disabled children who were not welcome at the public schools. These are primarily children and young adults, for whom formal education and social services were not available, and who were ignored or discarded by their families as a burden [2]-[9]. Moreover,as an emerging nation with a history of discrimination, South Africa has many priorities to address. The reality is that many South Africans with disabilities, particularly in rural areas, cannot enjoy the social, political and economic rights being introduced throughout the country [9]. It has been estimated that as many as 99% of those disabled were excluded from the labor market because of illiteracy and a lack of other work-related basic skills [9].

The school's principal and teacher envisioned that at least some of the disabled children in their community had the capability to be able to participate in their society and even earn a living. To do so, they would need to learn to solve problems, make decisions, and recognize where they can be useful, through play as well as in the classroom. Stimulating both the mind and the body was identified as critical to success. Since the school was built on a fenced lot containing approximately 0.25 acres (10,900 sq. ft.), with only two small classroom buildings, a variety of both large and small outdoor play units could be arranged just far enough apart to stimulate less-mobile students to attempt to walk from one brightly colored unit to another, and become aware of colors, shapes and numbers.

EVOLUTION OF THE PLAYGROUND DESIGN

The project's design stage challenged the students' imagination and creativity to provide a design for a safe, affordable and recreative playground for students who might never have such an experience otherwise [9]-[10]. The first year design course consists of 11 sections of 50 students each, with five students per design team.

Each design evolved through the application of a guided design methodology with four stages distributed over a 15-week semester: project initiation, project development, subsystem analysis and design completion [1]. When the course subject matter leads directly to a real world experience in the form of a project with a well-defined end use, these stages of design become more tangible to students [6], as they realize that the success of the outcome is strongly influenced by the quality of their output at each stage of design.

Our collective emphasis on open-ended problem solving through design often causes first year students to become anxious about the fact that there is not one right answer for their problem [6]. The issues associated with community needs, in particular, may lead to a conflict between the need for a solution within one semester's time, with the reality that the best solution may not be attainable within that time, given the resources available from the community and the design course. Students can be encouraged to further develop skills in critical thinking [6] when they recognize that even a solution that is not fully optimized has enabled them to learn about the design process.

Although project designs require a certain amount of technical rigor, creativity is still a major component. The creative process, when applied to engineering problems [11], corresponds to the four stages of our design methodology: problem finding (project initiation), divergent thinking and constraint satisfaction (project development), convergent thinking (subsystem analysis) and problem solving (design completion). Each stage of this methodology is given approximately equal emphasis in the first year design course, as it has been demonstrated that students need time to reflect on their results at each stage to enhance their creative skills, as well as gain practice in critical thinking [6] -[11].

Design specifications, constraints and assumptions are shown in Table 1 as follows.

TABLE 1
DESIGN SPECIFICATIONS, CONSTRAINTS AND ASSUMPTIONS

Specifications	Constraints	Assumptions
Ease of construction	Four days to construct; all dimensions in metric units	Construction will be completed within four days
Ease of maintenance	Limit the majority of structural materials available to lumber and rubber tires	School personnel would (a) assist with construction;(b) be able to repair units, as necessary, and (c) build similar play units at other locations
Durable under conditions of use	Construction taking place during the winter	Daily weather is temperate enough to permit outdoor construction
Inexpensive to build and maintain	$2,000 budget; limited funds to ship tools and supplies to South Africa	Design cost estimates would not exceed budget; donation of used tires and some tools
Safe and easy to access for students with undiagnosed physical and mental disabilities	No blind students	Teachers available to assist students with limited mobility to access the units
Suitable and sufficient mental stimulation (e.g., sensory, creativity, etc.)	Do not overload each play unit with multiple or conflicting stimuli	Play units for very young able-bodied children will be usable by disabled students
Encourages increase in physical mobility and cognitive awareness, where possible	Consider the limited abilities among disabled students.	Play units that work together seamlessly

The best overall design contained nine separate play units, painted in bright primary colors and arranged in a circle to make supervision easier. The play units consisted of a climbing and sliding ramp, see-saw, picnic table with chalk-drawing surface, music station, double swing set, obstacle course, tire fort, sunshade covering and tetherball court.

PROJECT RESULTS: THE REALITY OF CONSTRUCTION

The first year design and third-year international studies course assignments, written surveys and journals, and photographs provided data for assessment. For example, the design team members participated in a survey to record their expectations about the site conditions and what they actually found, as shown in Table 2. Assessment of the design course assignments also revealed that, given the specifications to use lumber and old tires as much as possible, the design teams were able to provide a wide variety of play units, resulting in additional opportunities for physical and mental stimulation. This was important in consideration of the South African students' largely undiagnosed disabilities.

TABLE 2
DESIGN TEAM MEMBERS' EXPECTATIONS VS. ACTUAL CONDITIONS

Site Condition	Expectation	Reality
Site terrain	Remote, packed dirt lot next to wildlife preserve	Lot was fenced, adjacent to cultivated fields and houses
Weather	Cold temperatures and frequent rain	Mostly sunny days, steady breeze, occasional rain, very cold nights
Work pace	Same pace as in United States; one week to build	Much slower in nearly all respects; four days to build
Transportation	Paved roads, all travelers in vehicles	Non-maintained dirt roads, many hitchhikers
Work team dynamics	Play units to be built as designed	Certain units built as designed, others changed due to site conditions and team leaders' preferences
Proximity to supply sources	Expected to be relatively nearby	Several hours' duration to reach nearest hardware/lumber stores and back, as well as conduct business
Construction materials	Pre-cut lumber to standard U.S. sizes	Lumber was cut differently, and often required custom cutting
Utilities	Limited availability of electrical power and outlets; limited water supply	No power outages or cutbacks during construction; insufficient number of electrical outlets; water supply contained in a nearby 1000-liter outdoor tank. No indoor plumbing
Tool usage	Use of both power and hand tools brought from the US	Power tools burned out quickly; incompatible with power supply and materials to be cut or drilled

All of the playground equipment was built during a vacation in the school's term. However, the school principal arranged for a large number of the disabled students to visit during the construction, so that the teams could meet them and observe what they could and could not do, and so that the disabled students could see what was being built for them. After the equipment was finished, a number of able-bodied children of the school staff successfully tested the equipment and enjoyed playing with the various units, indicating that the chosen play units would fulfill their objective to provide opportunities for cognitive stimulation and both physical and mental development through play, such as gross and fine motor skills, visual and auditory stimulation, eye-hand coordination and increased mobility.

The original assumption that the playground would be built within one week was fulfilled – but the total duration of "one week" was four days rather than five or seven. In addition, rain for most of one day slowed the pace of construction and forced many activities to take place indoors, where space was limited. Throughout the building process, whether on sunny or rainy workdays, the design teams shared tasks where possible: when one team was either caught up or waiting for materials, it helped another team build the next stage of their unit.

Given the site conditions, time and material constraints, and construction team dynamics, six of the original nine units were built. The tire fort, sunshade covering and tetherball court were replaced with a wooden "wonder wagon", a "talking tube" and a wooden block matching game. These replacements were selected by the third-year students from "runner-up" first year playground designs.

DISCUSSION

The double swing set contained two single swings and a two-person "boat" swing. The single swing seats had been carved from tires (a local invention found by the third-year students during their travels); the boat swing consisted of a wooden platform, two wooden sides and two half-tire sides that were bolted together. All of the units were painted in bright, primary colors for easy recognition through color contrast. The "wonder wagon" was so named because it contained fold-down sides for easy access, with the flag of South Africa painted on the entire interior surface. White plastic water pipe comprised the "talking tube", with sprayer heads on either end to simulate microphones. On-site creativity and adapatability were evident, wherein designs were not only adapted to existing constraints, but incorporated hitherto unidentified creative or otherwise value-added features. Students learn about effective decision making through the recognition that local problems can be solved using local technologies, as opposed to the ethnocentric position that they always have the best ideas.

A collection of metal pipes in graduated lengths and a drum head provided sound-making activity at the music station. The wooden block matching game consisted of three rows of square blocks, each block painted with a simple geometric shape on two faces, and with each row of blocks mounted on a horizontal rod.

The students also learned quickly that the cultural patterning of time and expectations of efficiency differed greatly between themselves and the South Africans. This difference has been identified by Wang [12], who described the students' view as influenced by a monochromatic time-centered culture, where time is perceived as something manageable, in which they "slice time into discrete units…allocated for specific events" [12]. Now they were operating in a society where time is viewed as continuous and therefore is not schedule-dependent. One example of this perspective is the amount of time it required to purchase the necessary lengths of lumber at the lumber yard. This required six hours and a great deal of waiting, which the students remarked was very different from similar experiences they had had within the U.S. The major cultural difference leading to this delay was that the process for purchasing materials was not entirely "self-service" but involved checking at several levels to be sure that the product matched the invoice before any materials could be cut. This was accommodated by dividing an order among several students, so that each step could be conducted for several smaller orders in parallel.

A serious oversight was the failure to recognize that South Africa operated on 220v/50Hz power. Therefore, power tools brought from the U.S. could not be used. This was corrected by purchasing locally available power tools and extension cords, which were donated to the school for use in future projects.

The climbing and sliding ramp proved to be the most complex item to construct. As a result, the design and construction teams held many discussions concerning safety features and methods of construction. The two teams learned to negotiate differences in opinion and to compromise in the interest of the unit. The result was a highly popular piece of playground equipment that could be used safely by the disabled students.

Through these examples, and many others, the school sponsors, clients, third-year students and first year students gained an appreciation of each others' roles and found ways to cooperate when adaptations needed to be made. Everyone in the construction effort also gained respect for the commitment, skills and overall good will of the school and community members.

CONCLUSIONS AND RECOMMENDATIONS

A number of lessons learned from this experience may be helpful to instructors and programs who plan to implement international service-oriented design projects and/or service learning experiences for their students, particularly when different college levels are involved (e.g., first year design team, third-year implementation team):

- Choose a project that the local community identifies as important.
- Articulate the difference between actual and perceived needs, as sustainable value lies in the fulfillment of actual needs. Prepare to adapt a design layout to features that may have been changed once site information is made available.
- Use local ideas and materials wherever possible, to foster a greater sense of ownership by recipients.
- Accept site conditions and local interests as integral to the success of the project by fostering cultural

integration and sharing knowledge and experiences. There is no such thing as "too much research" into these areas – begin as early as possible to learn about and understand the dynamics of the local culture.

- For an inter-class project, encourage and facilitate effective communication among students in different college levels during the design phase to build mutual trust and understanding. On site, identify and adjust to points of disagreement among individuals to aid the production process.
- Learn basic phrases in the clients' native language and use them appropriately to show respect and build a collaborative relationship among clients and students.
- Demonstrate the importance of future maintenance and security to assure the long-term productivity of the project. Utilize flexibility in both scheduling and implementation to its greatest advantage. In a developing country, it may take a longer amount of time to access supply sources and procure materials. If at a hold point during one aspect of construction, find another way to add value to the project during the free time.

Engineering, as a profession, is intended to make life better for people, and service learning experiences enable students to focus their developing engineering skills on an outcome which will benefit a community as well as themselves. An international service learning experience provides students with the additional opportunity to develop the ability to work effectively in a culture that differs from their own. As students gain confidence from international experiences, they add value to their engineering or science degree.

REFERENCES

[1] Robert D. Knecht, *A Guide for an Engineering Design Process.* Plymouth, MA: Hayden-McNeil Publishing, 2010.

[2] Sunny Skies Tours, "Responsible Tourism." http://www.sunnyskiestours.co.za/pages/tour-packages/responsible-tourism.php. Accessed October 3, 2011.

[3] Dr. Ken Dorman, "Volunteer Vacations." Globe Aware, http://www.globeaware.org/volunteer-vacations. Accessed May 8, 2012.

[4] Colorado School of Mines, "The McBride Honors Program in Public Affairs." http://mcbride.mines.edu. Accessed October 3, 2011.

[5] S. Jiusto and D. DiBiasio, "Experiential Learning Environments: Do They Prepare Our Students to be Self-Directed, Life-Long Learners?" *Journal of Engineering Education*, Vol. 98, No. 3, pp. 195-204, Jul. 2009.

[6] Linda Barrington and John Duffy, "Maximizing the Benefits of Service-Learning in Engineering." in *Proc. ASEE Annual Conf. and Expo., AC 2010-2149, 2010.*

[7] ABET, "Criteria for Accrediting Engineering Programs, 2012-2013." http://www.abet.org/engineering-criteria-2012-2013/. Accessed May 15, 2012.

[8] Dan G. Dimitriu. and Jerry O'Connor, "A Service Learning Project for a Freshman Engineering Course." In *Proc. ASEE Annual Conf. and Expo, AC 2011-100, 2009.*

[9] "Prevalence of Disability in South Africa." Chapter One: Situation Analysis in" Integrated National Disability Strategy (White Paper)." Office of the President, Independent Living Institute, http://www.independentliving.org/docs5/SANatlDisStrat.html. Accessed September 14, 2011.

[10] Shelley Barry, "Changing Attitudes: An Overview of Awareness Raising about Disability in South Africa." *Disability World*, No. 9, July-August 2001, 4 pp. http://www.disabilityworld.org/09-10_02/arts/southafrica.shtml. Accessed September 14, 2011.

[11] Christine Charyton and John A. Merrell, "Assessing General Creativity and Creative Engineering Design in First Year Engineering Students." *Journal of Engineering Education*, Vol. 95, No. 2, pp. 145-156, Apr. 2006.

[12] Gang Wang, *Exploring Cross-Cultural Differences in Engineering Decision Making.* Ph.D. dissertation, Department of Industrial Engineering, Wayne State University, Detroit, MI, 2008. UMI # 3315598, ProQuest LLC.

AUTHOR INFORMATION

Natalie Van Tyne, Teaching Associate Professor and Director, Design EPICS Program, Colorado School of Mines, nvantyne@mines.edu

James Wong, Adjunct Instructor, Design EPICS Program, Colorado School of Mines, jwong@mines.edu

Kay Godel-Gengenbach, Director, International Programs, Colorado School of Mines, kgengenb@mines.edu

Kathryne Van Tyne, Doctoral Candidate**,** Department of Psychology, University of Chicago, kvantyne@uchicago.edu