Learning Outcomes of an International Service Learning Project in Civil Engineering

Ann E. Jeffers[1], Paul A. Beata[1], and Beverly Strassmann[2]

[1]Department of Civil and Environmental Engineering • [2]Department of Anthropology
University of Michigan • Ann Arbor, MI USA • Email: jffrs@umich.edu

CONTEXT FOR LEARNING

A Bridges to Prosperity student chapter designed and constructed a suspended pedestrian bridge in central Bolivia in 2013. In May 2013, a team of five university students traveled to the site for a period of four weeks to oversee a major portion of the construction. The students assumed the role as the lead engineers for the project.

RESEARCH QUESTIONS

- To what degree did the project advance the students' mastery of technical concepts?
- How did complexities (e.g., linguistics, local construction practices, diverse social and cultural environment) related to the site affect students' perceptions of engineering design and construction, particularly within a global and social context?
- How did the experience affect the students' confidence in tackling unpredictable and ill-posed engineering problems?
- How did the project affect the students' abilities to function in multidisciplinary teams?
- What communication skills were strengthened as a result of the project?

METHOD

We asked the students to keep reflective journals over the course of their travel to Bolivia. Writing prompts were provided to elicit responses that would answer the research questions. Four out of the five students who participated in the project completed and submitted their reflective journals (n = 4). We analyzed the writing prompts within a phenomenological framework, allowing common themes to be identified from the students' responses.

MEASURED LEARNING OUTCOMES

Using thematic analysis, the learning outcomes were grouped into three major themes.

Technical skills: Leadership/project management skills, quality control, safety, engineering tolerances, sense of scale, keeping to a schedule, decision-making skills, adapting to site conditions, understanding design philosophy and factors of safety, reading construction drawings, excavation/foundation construction, mixing/pouring concrete, building rebar cages, constructing a rock wall, using power tools, Abney levels, and safety harnesses

Global competency and cross-cultural communication skills: Global perspective regarding civil infrastructure, understanding of Bolivian culture, appreciation of and tolerance for life without modern conveniences, cross-cultural communication skills

Teamwork and interpersonal communication skills: Conflict resolution, interdependence

EVIDENCE OF LEARNING OUTCOMES

Overcoming Cultural and Linguistic Barriers

The juxtaposition of resources and lifestyles between Bolivia and the U.S. provided a rich opportunity for cultivating global competency in the context of engineering. The students worked alongside members of the community and had to resolve differences in work habits, such as the shortened work day and the regular breaks taken by the community members to chew coca leaves. The project also involved a complex chain of communication. As one student commented, "I feel like we both end up nodding about things [when] we don't really understand what we are communicating."

EVIDENCE OF LEARNING OUTCOMES (CONTINUED)

Handling Unexpected Conditions in the Field

When the students arrived on site, the anchor holes were placed 5m from the design location. One student remarked, "On day one we were struck with panic!" Another student elaborated on the team's course of action:

> We asked [a Bridges to Prosperity staff member] what we should do about it and her response was "you're the engineers; you can decide what to do." So, we ran a few calculations and decided that we needed the excavation to be where we originally intended it to be to achieve an acceptable margin of safety. So we had the community fill in the hole and dig a new hole 5 meters away (excavation for the anchor cage).

The anchor holes needed to be 4m deep, but the students were only able to excavate 2m by hand. The students performed calculations in the field to verify the safety of a modified design with 2m deep anchor holes. Thus, the students successfully adapted the design to the site conditions.

Regarding the experience of adapting the design to the field conditions, one student commented,

> There is so much of the bridge building process that you can't prepare for in the classroom, so you just get out there and do the best you can. I think I learned that 90% of what we did we just learned on the fly from [the mason], [the Bridges to Prosperity staff], and even each other. Each bridge is different and each site has its own challenges, so the only thing to do is to be constantly thinking of what the task at hand is and if there is any way to improve it. The work we did required about 30% classroom knowledge and 70% just common sense and physics laws. Each are important and it was a good mix.

Working Together as a Team

Prior to travel, the students developed a shared set of goals to be accomplished during the trip, created a detailed construction schedule, designated task leaders for each construction task, and discussed and planned for various scenarios that might be encountered in the field. Interdependence was high due to the complex and high-stakes nature of the project. For example, tasks related to quality control required team members to check the work of others. Challenging construction tasks provided significant opportunities for group-level creativity (e.g., using buckets to lift dirt when excavating a great depths). One student described the functioning of the team as follows:

> We were constantly offering ideas we thought would make this process more efficient. Some ideas were accepted by the group as feasible, others not so much. That's how the group worked, offer new ideas of how to do every task from lifting dirt out with buckets to jumping on cross beams to weight them down, and then some would be accepted, others not. Nothing was personal, but we were given large challenges and so any idea on how to make something easier/more efficiently should be heard.

IMPLICATIONS FOR ENGINEERING EDUCATION

Our findings support the notions that

- International experiences strengthen global competency and communication
- Real-world engineering projects improve mastery of technical skills as well as interpersonal communication skills
- Service learning instills a greater understanding of the social context of engineering work.

The extent of learning was aided by the fact that the students assumed the primary responsibility for the bridge and were allowed to make mistakes in the field with, of course, the supervision of a trained engineer.

Acknowledgment

This work was funded by the University of Michigan Center for Research on Learning and Teaching through an Investigating Student Learning grant.