A Novel Approach to Promote Experiential Learning in a Construction Skills Workshop

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There exists a need to provide broad training for students who embark on development projects, such as those sponsored by Engineers Without Borders. While students need construction skills, it is equally important to prepare them to work with people of different cultures and to provide them with means to prevent and manage illness and injuries when they are hours to days from medical services. This paper describes a novel approach to this problem. Essential Skills for Sustainable Development (ESSD) is an experiential workshop that integrates cultural context and medicine into skills training sessions. A pilot project in 2009 resulted in a positive response from participants who subsequently traveled abroad. The results of qualitative and quantitative assessment of this program will inform the improvement of the preparation and delivery of the ESSD for 2010.

Key Words: Experiential Learning, Engineers Without Borders, Transdisciplinary Education, Cultural Integration, Travelers' Health

Introduction

College students in engineering and construction management are exposed to theory that is needed to solve technical problems, but they often have no experience in the practical skills necessary for implementation. The assumption has been that graduates will gain the experience they need once they start in their profession – and that the role of the university is best limited to providing knowledge. However, graduates without practical experience are at a distinct disadvantage in the professional world, and students interested in participating in development projects need to know how to apply what they are learning.

Constructivist learning theory tells us that people learn through experience, that cognitive conflict stimulates learning and that knowledge evolves through social negotiation (Savery & Duffy, 1996). Furthermore, "[k]nowledge results from the combination of grasping and transforming experience" (Kolb, 1984, p. 41). Experiential learning, in which students work together to solve problems using tools in specific, complex and changing situations, provides an opportunity for students to learn and apply theory while gaining practical skills.

Engineers Without Borders-USA (EWB) is one example of a program that involves students in development projects in remote and rural areas in the US and abroad. The ultimate goals of EWB projects are: to show students that engineering problems are not always well defined and may require working with people who have different perspectives; teach students to interact with different cultures; to teach students to work with limited tools; and to provide students with direct hands on experience (Amadei & Sandekian, 2008). However, we have found that without prior experience with project management and construction trades, students involved in these projects are vulnerable to failure. Furthermore, we have seen that failure to engage successfully in cross-cultural communication has resulted in undesirable outcomes in other projects.

In an effort to better prepare students at Northern Arizona University (NAU) for EWB projects, engineering advisors proposed a mandatory workshop to provide hands-on skills and safety training. Anthropology and physician

advisors who were also involved with EWB pointed out that executing a construction project in a remote developing community poses challenges beyond the physical building project itself: cross-cultural communication and health problems can trump the best-laid construction planning. In this paper, we describe the outcome of this discussion: a transdisciplinary, contextual and experiential approach to a construction skills workshop.

Methodology

EWB Students were elated at their successful implementation of a project in Ghana in 2008. Hindsight revealed that they were unprepared technically and culturally for the project, and that their return home without significant illness and injury had more to do with luck than with planning.

In 2007, some of the students had attended a regional conference that included short workshops providing skills training. This proved extremely useful on the implementation in 2008, however, the weekend conference could not provide all of the construction skills that the students needed and it did not address cultural and safety issues.

Inspired by these workshops and the challenges of the implementation, faculty from the departments of anthropology, civil engineering, construction management and the EWB chapter travel medicine advisor conceived of a transdisciplinary, experiential course to prepare students interested in development work. Essential Skills for Sustainable Development (ESSD) was developed to provide students with practical engineering tools and problem-solving skills accompanied by basic training to prevent illness and injury in the field, and with an introduction to cultural perspectives to enhance community partnerships in the design and safe implementation of desirable, effective and sustainable development projects at home and abroad.

Nicholas Ashford, in trying to address the challenges of educating engineering students for sustainable development (2004, p.244) distinguishes among inter-disciplinary, multi-disciplinary and trans-disciplinary programs. He asserts that inter-disciplinarity implies the intentional creation of a new discipline from the blending of two established disciplines –biochemistry is a prime example, as is radiation oncology.

A defining characteristic of university education, multidisciplinarity is manifested by the requirement that students study a constellation of subjects outside their declared major. There is little or no coordination among these topics or between individual topics and a student's major, and many students, erroneously viewing these departures as irrelevant, fail to apply themselves to "freshman enrichment" or "liberal studies" courses.

Transdisciplinary education "is non-hierarchical and dynamic, acknowledging that areas of current understanding are constantly expanding, changing and developing" (Winberg, 2006, p.164). It "transcends the narrow focus of one or more disciplines and is not constrained to adopt pre-existing models for problem definition or solution" (Ashford, 2004, p.244). The special challenge of transdisciplinary education is that the goal is not to turn university students or faculty into generalists: "A genuinely transdisciplinary approach, which includes discipline based knowledge, should endeavor for an understanding of appropriate disciplinarity." What is needed is "a contextualized form of knowledge production" (Winberg, 2006, p.169) in which the perspectives of multiple stakeholders and academic disciplines are brought to bear on dynamic problems, and in which produced knowledge is permitted to be contingent and negotiable in its real-world application.

ESSD was piloted as a five day workshop in May of 2009, immediately after the end of the spring semester and prior to the departure of students for Africa. In the spirit of transdisciplinary education, it presented topics on project management, safety, surveying, system design and construction, covering solar and hydraulic systems and wood, masonry and concrete structures – all within the context of a simulated culture integrating a rich history, traditions, cuisine, dress, characters and norms. Actors provided students with cross cultural, experiential learning situations replicating real life. Travel health topics and emergency scenarios were woven into the "story", creating another layer of experiential and didactic learning.

The progression of the course mimicked the EWB project cycle, which typically encompasses several months. Compressing this into five days resulted in the following schedule: The first day was divided among workshop logistics, project pre-planning at the 'home base', and an "assessment trip" during which the participants were greeted formally by actors posing as 'natives' with speeches and a feast. Day two brought the students back to the

'home base' to finalize overall project plans using the data collected at the site. Days three through five consisted of returning to the site to implement the project plan followed by a wrap-up and course evaluation.

Each engineering module was presented as a brief lecture on theory, safety, tools and practice followed by several hours of hands-on construction according to the project plan that was developed on the second day of the course. Throughout their time at the field site, students addressed problems in the anthropology of development, negotiated cross cultural disagreements, and learned healthy behaviors, safety, and emergency first aid. A detailed course schedule is shown in Table 1.

Table 1

ESSD Workshop Schedule

Time	Day 1	Day 2	Day 3	Day 4	Day 5
7:30 AM	Introduction	Breakfast			Breakfast
8:00 AM		Project Management Module	Breakfast	Breakfast	Medical Illness
8:30 AM			Medical: Managing trauma in remote locations	Hydraulics (classroom)	Comprehensive Exam
9:00 AM	Contact 'natives' Cultural Relativism and Ethnocentricity			(water source issue arises)	
9:30 AM					
10:00 AM					
10:30 AM	Survey and Mapping (classroom)				Solar (classroom)
11:00 AM		Concrete Design (classroom)	Break	Culture: Process	
11:30 AM			Safety	Hydraulic (practical)	
12:00 PM	Travel to site	Travel to site			
12:30 PM	Welcome Feast	Return Feast	Lunch and Cultural Conflict	Lunch and environmental safety	Lunch Food Culture Shock talk
1:00 PM	Survey and Mapping (practical)	Site Safety			
1:30 PM		Concrete (practical)	Wood (classroom)	Hydraulic (practical continued)	Solar (practical)
2:00 PM					
2:30 PM		(cultural conflict: inappropriate material for concrete mix)	Wood (practical)		
3:00 PM				Medical: Serious injury management	Wind Power (classroom)
3:30 PM			(medical emergency: broken arm)		
4:00 PM	Travel back 'home'				Wind Power (practical)
4:30 PM	Survey and Mapping: Post processing	Medical: Allergies, Insect borne diseases		Globalization discussion	
5:00 PM					Dinner Wrap-up and Feedback
5:30 PM		Dinner	Medical:		

6:00 PM 6:30 PM	Medical: Food illness	Emergencies in remote locations	Dinner
7:00 PM	Dinner	Dinner	

The goals and objectives for ESSD included quantifiable knowledge and skill sets as well as attitudinal and affective outcomes. These included:

- Engineering: gain familiarity with and skills in performing project management, surveying and mapping, site safety, concrete, masonry and wood construction, hydrology, photovoltaics and wind power design,
- Anthropology: become exposed to cross cultural sensitivity, realize appreciation of unfamiliar customs and traditions, understand issues of development, practice with conflict resolution and teamwork,
- Travel and emergency medicine: knowledge of and methods for the prevention of diarrhea and insect bites, knowledge of basic anatomy, practice with medical documentation, management of sick travelers in the field, evacuation plans, emergency trauma response.

The curriculum design included situations in which participants would encounter unanticipated problems, the intent of which was to cause them to think on their feet and work outside of their comfort zones. Participants had to reformulate their plans to address not only the technical aspect of the task at hand, but also some sort of external influence. The following examples illustrate this injection of external cultural conflict into the project implementation:

1) During the classroom portion of the hydraulics module, the participants use the data collected in the survey module to design a pumping and pipeline system that satisfies certain technical constraints. As the students implement the most efficient solution, a number of hidden conditions emerge: the chosen pipeline route crosses sacred land; the local leader pressures students to re-align pipeline across her land (covertly to gain control of it); materials provided are not what was ordered
2) During the concrete construction module, a local offers to help mix concrete and proceeds to insist that local (unsuitable) soil should be used in the concrete mix "to make it more sticky"
3) During the masonry construction module, participants learn after completing half of the structure that sharp right-angles in buildings are taboo in the local culture

Additionally, the curriculum called for "surprise" medical scenarios, including gastroenteritis and a mass casualty resulting from an automobile accident. These events acted as "pop quizzes" in which the students could exercise and strengthen their new skills in lifelike situations.

This non-credit pilot project was the first of its kind at the university and was attended by undergraduate and graduate students. About half the students were in engineering majors while the rest represented departments of advertising, anthropology, biology, Native American studies and physics,

Results

Although ESSD was created on very short notice in order to prepare students for a return to Ghana, several qualitative and quantitative modalities were devised to assess the efficacy of the workshop. These included the results of pre-and post- tests composed of identical multiple choice problems covering the general course content, daily surveys of student opinion about course content, method and instructors, a summative written survey, and semi-structured individual ethnographic interviews in which students and faculty reflected on the course three to six months later.

Table 2 summarizes the results of these tests. Students made good gains in knowledge throughout the course; medicine, concrete and masonry demonstrated the largest gains partly because students knew the least about these subjects before the course began.

Table 2

Mean scores on multiple choice pre and post tests (n=13)

Subject	PreTest	PostTest	Gain
Travel Health and First Aid	30%	67%	37%
Surveying and Mapping	46%	88%	42%
Cultural Anthropology	50%	84%	34%
Development Anthropology	66%	84%	18%
Concrete Slab	32%	62%	30%
Masonry Construction	12%	44%	32%
Site Safety	(n/a)	52%	(n/a)
Wood Construction	(n/a)	72%	(n/a)
Pumps and Pipes	40%	48%	8%

The daily and summative surveys assessed student self-efficacy as a proxy for satisfactory teaching of objectives. Unfortunately, due to a shortage of staff, not all the daily assessments were collected. Table 3 contains the results of surveys that cover approximately 30% of the major objectives. Students rated their confidence to be able to perform the objectives on a ten point Likert Scale in which a score of 1 indicated strong disagreement and 10 strong positive agreement.

Table 3

Mean results of students scoring achievement of objectives

OBJECTIVE	SURVEY QUESTION	MEAN SCORE/ (out of 10)
Students will gain confidence in teamwork	I am more comfortable working as a member of a team than I was before ESSD	9.9
Students will prevent diarrhea	I will choose safe food to prevent diarrhea when in the field	8.5
Students will avoid mosquito bites.	I will prevent insect bites while working in the field	9.7
Students will correctly document illness and injury in the field	I feel confident that I can take vital signs and a patient history.	8.1
Students will feel capable of managing trauma in the field	I feel confident that I will be able to respond appropriately to an injury in the field	8.0*
Students will know how to use GPS for mapping	I am confident that I can use a GPS to locate features on a map	8.7
Students will be able to organize project planning	I feel confident that I will be able to plan a project effectively	8.0*
Students will mix and pour a concrete slab correctly	I am confident that I can mix concrete to pour a slab.	9.5
Students will mix mortar and lay block	I am confident that I can mix mortar and lay block correctly.	9.3*
Students will frame in a wood building	I can effectively assist in wood construction.	9.0*
Students will understand and apply principles of site safety.	I feel confident that I will recognize and prevent unnecessary risk on site.	8.7*

Note: * indicates n ≥3

Experiential problem solving, or skills testing in anthropology, emergency medicine and engineering demonstrated to the faculty's satisfaction that student teams had gained competence in each of these areas; although a useful form of grading these problems had not been established before the final exam. Selected responses are provided below.

At the end of the course students completed a summative survey including short answer questions eliciting opinions on trans-disciplinary and experiential learning and the design of the workshop.

On transdisciplinary learning:
"It's how all college should be. Learning without the context of synthesizing multiple disciplines is detrimental… it encourages the sort of 'in-the-box' thinking which ensures mediocrity in any field." – Non-engineering senior.
"I think learning to work with other disciplines at the college level is essential. Not only does it give insight into how the rest of your careers will work, it opens your eyes to some other majors/fields of study you may not have considered given only the opportunity to read about them." – Engineering freshman.

On the cultural laboratory:
"I believe human behavior and reactions are far too complex to be accurately portrayed in a reading or a lecture. I think there should be more interaction with the [natives] in future classes. Also, having an actual [native] to interact with created a chance for open ended learning about the culture and simulated a real life environment." – Engineering freshman,
"The 'real life' interaction with a foreign culture really served as a mirror and helped me see myself, my actions, my responses in another light." – Non-engineering sophomore.
"I felt the simulated culture was not all that useful. I would rather have spent more time learning construction, hydrology, and medical skills that could make me more useful in a team. I think the only way to deal with other cultures is to visit them: it's really something that can't be simulated." – Engineering freshman,.

On experiential learning:
"The classroom learning is necessary to have some background… but without putting that knowledge into a physical use it becomes worthless." – Engineering freshman
"It creates team work, camaraderie, and a more comfortable setting," – Engineering sophomore

Semi-structured interviews with instructors revealed that they were surprised by the time commitment required to develop a meaningful technical module in the cultural context of the workshop. However, all the instructors interviewed remarked that they liked what they saw, and one said, "I'm ready to take it on the road!"

At the end of summer break, semi-structured interviews with six of the students revealed themes of increased self-efficacy in the application of construction skills and enhanced understanding of issues in development and cultural anthropology; that the course was useful to students who went to Ghana and to those who stayed in the United States, and a continued enthusiasm for the educational model. Students responded to probes with recommendations that will be implemented in ESSD for 2010.

A student who traveled to Ghana remarked, "everything we learned in the course we had to apply." An advanced engineering student who had missed the course because he went to Ghana early was evacuated shortly after the arrival of the rest of the team. The evacuation plan was activated and the remaining students, none of whom were engineers, assumed the management of the project. The students oversaw the construction of a masonry nurses' quarters, mounted and wired photovoltaics, repaired pumps and wells and reinforced the institutional relationship between EWB-NAU and the community, now in its fourth year.

A student who did not travel to Ghana remarked that because of the course, he changed his view of development from one in which "we'd come up with a concept and idea that we'd thought was obviously needed… then you'd go overseas, you'd do what you'd planned and then you'd leave. But after the course it became very clear… that the communities had to be involved and it had to be sustainable to where the community could take care of it after we left."

One of the cardinal goals for preparing students to participate in development projects was to increase students' comfort with and competence in teamwork. One student who traveled to Ghana spontaneously offered that "I was enormously more comfortable with the team I was going with after the class than I was before the class."

There was universal enthusiasm for the transdisciplinary approach, as one of the four students who traveled to Ghana commented: "Because you know, it is incredibly important that you're going to make a project work, that you understand the cultural, the environmental, the physical, the design aspects… It's at the crossroads of multiple disciplines that everything gets done… I honestly think that interdisciplinary education should be the focus of the university, especially in this day and age where things change so fast."

Discussion

Essential Skills for Sustainable Development represents a novel approach to transdisciplinary and experiential education. Faculty from the departments of anthropology and engineering worked together with a medical advisor to integrate their educational perspectives and to generate a whole that was greater than the sum of its parts. This created an experiential learning context that was more than simply "hands-on" – it presented the kind of variability, slipperiness, and challenge of real life, along with the rewards of human interaction.

Response to the pilot project by facilitators, instructors and participants was generally positive. The development of the workshop occurred over a relatively short time, resulting in a slightly rushed implementation of some of the modules. This, in turn, put pressure on the instructors to deliver novel workshop modules with minimal preparation. It also resulted in a cultural experience that was less than optimal. This was definitely noticed by the participants, as it is apparent from the surveys and interviews that most did not feel very culturally immersed. Nevertheless, there was ultimately a conclusion that the cultural components were worthwhile, even if they fell short of expectations.

Participants did indeed learn construction skills, and at least a few of them were able to utilize these skills on site in Africa and at home immediately after the workshop. The participants placed a premium on the hands-on work and felt the need to complete all projects that were started, even if it meant extending the time of the workshop. They also acknowledged the potential of team building inherent in an extended workshop.

The workshop provided an environment in which participants not only learned useful skills; they also learned to acknowledge the importance of context in the design and implementation of engineering and development projects. Students were challenged to move past the basic levels of learning in which facts and concepts are recalled, recognized and comprehended and into the higher levels of application, analysis and synthesis.

Engineering does not take place in a vacuum. Engineers need to be able to apply theory and practice in the human environment – an environment that changes and challenges the ability to adapt on many levels. ESSD demonstrates that experiential education can address more than hands-on construction skills – that it can be used to teach not only the "how", but the "why" and "why not" of engineering. Far from being "only" practically useful, experiential education is a powerful tool to teach the apprehension, analysis and application of abstract concepts.

Future Plans/ Recommendations

ESSD has received funding and is on the NAU International Education course schedule for the summer of 2010. Based on the feedback from participants and facilitators, we plan to expand this workshop into an 8-day event (starting and finishing with half days) and integrate camping to allow for more team-building and reflection time. We have arranged to use a field site in the National Forest about 30 minutes from campus for this purpose. We intend to improve the quality and quantity of the simulated cultural experience by increasing the number of 'natives' and enlisting theater students or previous workshop participants to play these roles. We identified the need to expand introduction and pre-planning portions of the workshop from ½ day to 1 ½ days, while still leaving five days in the field for implementation. A few of the modules have been identified for significant improvement, while the others will be polished to better fit their timeframes. We will integrate institutional evacuation planning and trip preparedness emergency protocols with the assistance of NAU's Wilderness Medicine Program. The students will be assessed on their ability to solve a construction problem, resolve a cross cultural problem, and to manage an "illness" and to describe how to prevent others from contracting it. In order to better evaluate the effectiveness of the workshop, more structured instructor/facilitator debriefing will be implemented. We will propose requiring

university EWB members to participate in this workshop one year prior to travel (with refresher just before departure).

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