AC 2008-1937: READING BETWEEN THE LINES: EVALUATING SELF-ASSESSMENTS OF SKILLS ACQUIRED DURING AN INTERNATIONAL SERVICE-LEARNING PROJECT

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Abstract

Students and faculty nationwide are proclaiming the educational benefits associated with participation in international service-learning projects. According to recent studies, this form of experiential education allows students to develop leadership, communication, team-building, and critical thinking skills, while instilling a sense of civic responsibility. Involved faculty members declare service-learning to be a "valuable pedagogical tool"[1] that is synergistic and complementary to abstract theories taught in the classroom. By engineering solutions to practical problems with real-world constraints, students construct the necessary scaffolding to achieve a deeper understanding of classroom concepts. While the academic advantages are recognizable and numerous, they do not comprise students' motivation for being involved. The truly unique and engaging quality of a service-learning project is the potential for each eye-opening experience to engender personal growth within the student. The challenge herein lies in the validation of this transition.

This paper presents an evaluation of the educational benefits of service-learning projects by focusing on one case study. The most recent endeavor of the Tufts University Engineers Without Borders (EWB) Chapter involved a Green Building Initiative in Ecuador. During the summer of 2007, six students accompanied by a professor embarked on a month-long project in Hacienda Picalqui and El Cristal, Ecuador. During the project, students evaluated their own skill sets by filling out Pre-Travel, Post Travel, and Post-Post Travel surveys and reflected daily on events, health and progress. Comparisons of the Pre and Post-Travel surveys verify substantial advancement in leadership, teamwork, communication and problem solving skills; however, due to the debatable reliability of self-assessments, proving how and when transitions occur is imperative. The verification of students' self-assessments is hidden within the text of their daily surveys and reflections. By mapping the events of the trip to the ups and downs of each person's experience, skill development as well as personal growth can be verified.

Introduction

Previous research and literature has indicated that service-learning as a pedagogy stands alone in the category of experiential education because it allows students to practice engineering design and apply technology while "addressing human and community needs" [2]. Consequently, this symbiotic development engenders "broader appreciation of education and self" [3, 4]. The hypothesis presented is that students who become engaged in service-learning projects enrich their education by enhancing their engineering skill sets; developing new problem-solving techniques; and strengthening leadership abilities as well as teamwork skills. This research further hypothesizes that service-learning participants experience personal growth over the course of the project; rather than looking for what a career in engineering can do for them, students glimpse their potential global and societal impact as engineers. By integrating the theories of cognitive psychologists, this paper aims to elucidate on why and how the students on the EWB Ecuador Project were able to learn and develop during the trip as a result of specific

occurrences. Furthermore, the results of this study aim to justify service-learning as a component of undergraduate engineering curricula because it addresses requirements set forth by Engineering Criteria (EC) 2000, specifically Criterion 3, established by the Accreditation Board for Engineering and Technology (ABET) [5]. Thus, the motive driving institutionalization of service learning is twofold: (1) the experience produces highly capable engineers, and (2) the program gains recognition for effectively satisfying accreditation requirements.

Background

One of the most frequently used definition of service-learning was coined by Barbara Jaccoby, who described it as "a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development. Reflection and reciprocity are key concepts of service-learning,"[6]. The interdependent elements of experience, reciprocity, and reflection are tightly entwined, inseparable, and essential to the developmental process. The experience must involve reciprocity, which "determines the purpose, nature and process of social and educational exchange between learners and students,"[7], whereas reflection is essential in connecting the "experience and the intention, the experience and the learning,"[8]. The following summarizes the work of four well known theorists in evidencing the educational significance of service-learning and explaining why reciprocity and reflection are necessary for learning to ensue.

Developmental Theories

Several psychologists have posited that experiential learning represents a paradigm shift in higher education because it heightens the role that students can assume as constructors of knowledge. The roots of experiential learning can be traced back to John Dewey, a cognitive psychologist who pioneered the study of experiential learning in the early 1900s. Dewey argued that knowledge is an "always active attempts to respond to one's situation in the world"[10]. A person will have new experiences as a result of living, and will continue to develop as a result of experience, hence engaging in lifelong learning. In Dewey's terms, experience is in essence "the material out of which human life is built" [11].

Furthermore, Dewey recognized that reflection on experience is crucial to reinforce new knowledge. He suggested that reflection orients one in experience: the acquisition of knowledge must be continually linked to concrete situations and the challenges they present. Learning in actual life contexts requires the student to be fully enthralled, physically and emotionally. In contrast, learning in the conventional classroom prevents the student from drawing meaning and connecting a meaning to abstract information. "Students who learn concepts through directly realizing their useful application know them better and more genuinely than those who have simply memorized abstract theories and facts,"[12]. By creating solutions to overcome real-world problems with limiting constraints, students construct the necessary scaffolding to achieve a deeper understanding of classroom concepts. Dewey argued for "education of, by and for experience,"[13]. This threefold concept implies that with experience, the student's capacity to understand (education of) the world is augmented; students continue to learn by experiencing new situations; and students should employ what they have learned in dealing with future

situations. This last aspect of the concept is sometimes referred to as "continuity," a principle that describes one's ability to apply previously learned theories to solve unanticipated problems[14].

Continuity is particularly important as it relates to engineering education. The National Academy of Engineering's (NAE) recent report, The Engineer of 2020[15], suggests a necessary paradigm shift in engineering education, redirecting the focus to better prepare engineers for the anticipated challenges of the future; globalization, sustainability, complexity, and adaptability[16]. Incorporation of international service-learning projects into an engineering curriculum provides a feasible mechanism of accomplishing this goal. As a progressive form of experiential education, service-learning is based on Dewey's model insofar as service-learning projects will inevitably trigger new conflicts in real-world situations, forcing students to struggle in a cloud of unfamiliarity before discovering a solution: an indispensable skill for future engineers.

Piaget's Work

Although founded on many of Dewey's original theories, Jean Piaget later spawned many of his own theories of cognitive development. As one author summarizes, "Simply stated, Piaget's theory describes how intelligence is shaped by experience. Intelligence is not an innate internal characteristic of the individual, but arises as a product of the interaction between the person and his or her environment," [9]. According to Piaget, intelligence evolves through a series of four qualitatively distinct stages; the students described in this research are in either the concrete operational or formal operational stage. Development occurs when a person is confronted by conflict; as previously stated, it is the struggle that gives rise to understanding. Piaget theorized that transitioning to the next developmental stage involves completion of three active processes: assimilation, accommodation, and equilibration, during which the "mind transforms, and is transformed by, incoming information"[17]. The transitional process is activated by an unfamiliar problem or new experience that conflicts with a one's existing knowledge. Duckworth states, according to Piaget, it is "…one's own effort to resolve conflict that takes him or her to another level" [18]. An individual first attempts to assimilate the new information into his of her mental framework and then adjusts his or her way of thinking to accommodate it. The final process of equilibration "refers to the overall interaction between existing ways of thinking and new experience"[17].

Thus, according to Piaget, experiencing conflict is prerequisite for development.
Piaget's functional stages are representative of differing ego functions in response to different "crises," and are often reliant on psychological accounts, rather than on logical or moral philosophical ones[19]. Piaget characterizes egocentric thought as a person's inability to perceive or relate to others in a situation[20]. As development occurs, there is shift in perspective; the person "decenters" and is able to move from subjectivity to objectivity. For Piaget, the social context offers possibilities of varying perspectives, which in turn, presents the essential co-operative experience that is necessary in leading one out of egocentricism. As it will be illustrated in the following case study, this concept of shifting perspectives is directly applicable to the EWB students who participated in the service-learning project.

Kohlberg's Work

One of the most common objections to cognitive-developmental theory, especially Piagetian theory, is that it ignores the social-emotional side of a person. This notion stems from the fact that Piaget was ostensibly more interested in concentrating on cognitive development than moral development. Lawrence Kohlberg, although a proponent of Piaget's cognitive development theory, believed that there are parallel structures or stages in the domains of physical reasoning and of social and moral reasoning[21]. Kohlberg later developed a theory of moral development based on the work of Piaget and Dewey. He posited that there are three levels of moral reasoning, each comprising two stages, with each stage representing increasingly more complex and more abstract moral reasoning. Similar to Piaget's inter-stage cognitive transition, Kohlberg believed that a person must face a situation that poses problems or contradictions to his or her current moral structure that will cause a state of dissatisfaction and moral conflict, but will ultimately lead to a higher level of moral reasoning and ability. Kohlberg's theories can be directly mapped onto service-learning outcomes. Moral dilemmas are likely to arise from students' involvement in service-learning, especially on a project that takes place in a third world country. As the EWB case study shows, through the internal struggle, reflection, and guidance, many students resolve the conflicts and thereby advance to a level of more complex moral reasoning.

Kolb's Work

David Kolb recognized the impact of experience on learning, and by collecting and systematizing the crucial components, derived the "Experiential Learning Theory of Development"[9]. His goal was not to pose experiential learning as a third alternative to behavioral and cognitive learning theories, but rather to suggest experiential learning theory as "a holistic integrative perspective on learning that combines experience, perception, cognition, and behavior". He further describes learning as "…the process whereby knowledge is created through the transformation of experience"[9].

Kolb's learning cycle describes how experience translates into concepts that are used as guides towards new experiences. As Jaccoby point out, there are three prevalent implications of Kolb's model that are central to service-learning[6]. First, the course must be structured with continual opportunities and challenges to enable to students to move "completely and frequently" through the learning cycle. Second, Kolb's model underscores how central and important reflection is to the learning cycle, and third, reflection must "follow direct and concrete experience and precede abstract conceptualization and generalization"[6]. Kolb further identified strategies to increasing retention of knowledge in students. According to his theory, learning must begin with motivation, upon which theory, application, and analysis are founded. As one researcher acknowledges, "Once motivation is evident for most students, learning will flow" [22]. Engineers Without Borders and many other service programs are completely voluntary; the motivation to help others and to learn is inherently instilled within those who join.

Case Study

The following case study based on a Tufts University Engineers Without Borders project will correlate significant events that occurred during a service-learning trip with cognitive

development theories, thereby providing explanation as to why service-learning is more powerful and sustainable type of education.

Tufts University EWB's most recent endeavor involved a Green Building Initiative in Ecuador. During the summer of 2007, six students accompanied by a faculty advisor embarked on a month-long project in Hacienda Picalqui (Tabacundo) and El Cristal, Ecuador. The project included developing and building a water collection and filtration system for a residence at the hacienda and performing health surveys and a water sampling plan for the town of Cristal. Over the course of the project, students evaluated their own skill sets by filling out Pre-Travel, Post-Travel, and Post-Post-Travel surveys and reflected daily project progress and events, as well as health and emotional wellbeing. [Note; To-date, only the Pre-Travel and Post-Travel surveys have been administered.] The Pre- and Post-Travel surveys asked the students to rate certain abilities on a scale of 0 to 30. In additions, each student filled out a daily survey and reflected on each day's events. The students' reflections represent "active response(s) to the challenges in (their) environment(s)" [24]. The daily reflection allowed students to recognize and integrate their learning, while providing an outlet for them to release stress, discomfort and dissonance.

Survey Results

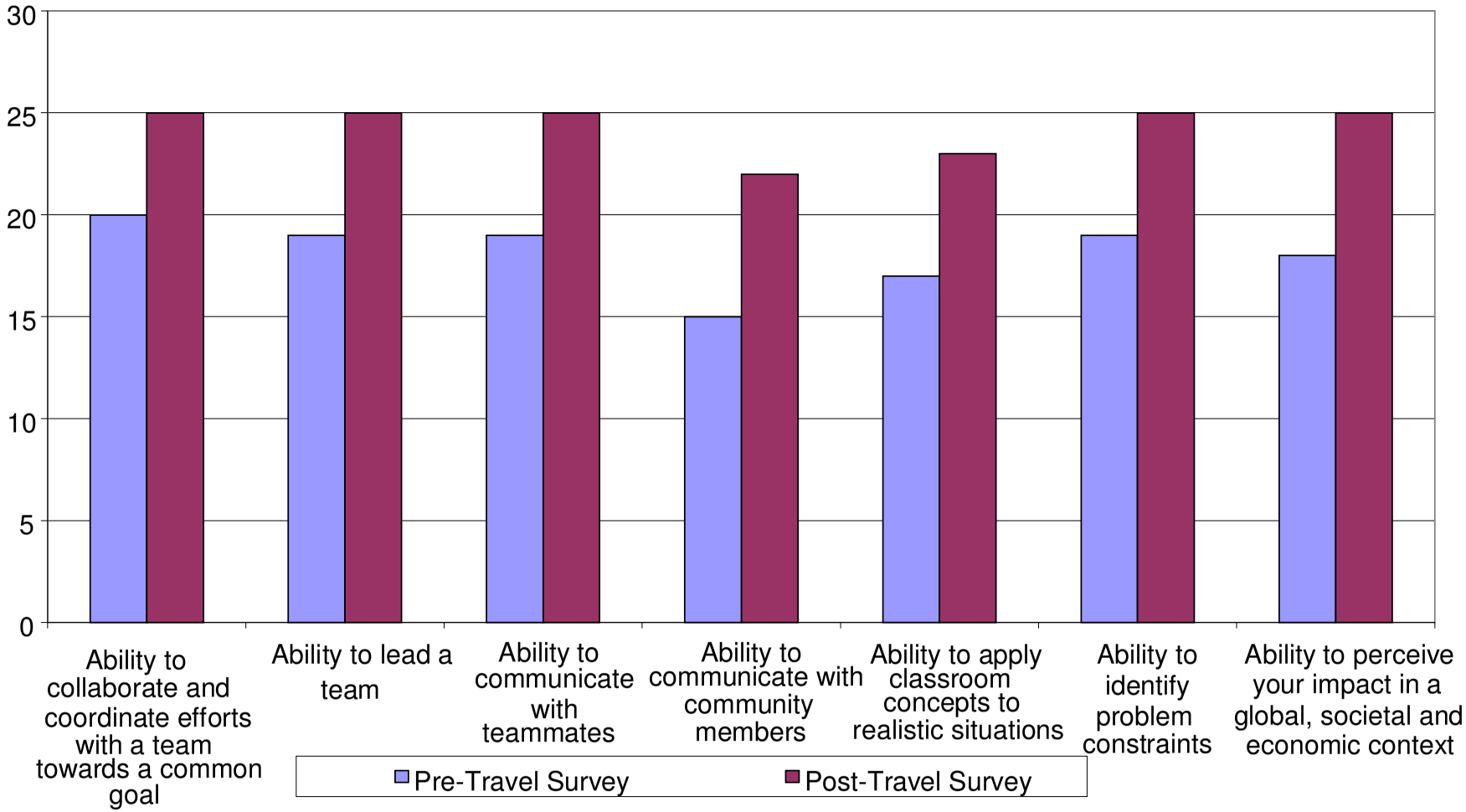
As shown in Figure 1, comparisons of the Pre- and Post-Travel surveys indicate substantial self-reported advancement in leadership, teamwork, communication and problem solving skills for each team member.

Sole use of self-assessments to prove how and when transitions occur is debatable[23]. Therefore, the Pre- and Post-Travel self-assessments are verified within the collective text of their daily surveys and reflections. In examining the "hills and valleys" of each person's experience as well as the group's experience as a whole, skill development as well as personal growth are identifiable. In examining the scores of the group as whole, it is interesting to see that there is a period during which all of the scores were lowest. By investigating their reflections during those days, the challenges they were facing became evident (see below).

When the daily questionnaires and reflections are examined on an individual basis, it becomes apparent that each person was attempting to cope with his or her own internal conflicts. Since the difficulties among students were different, it is likely that their minds and bodies were trying to endure the toll this project was taking on them. The constant stress of being in an unfamiliar country, verbally communicating with the community (for some) was very difficult if not impossible, and attempting to engineer and teach the communities members about a filtering system was physically and emotionally draining.

In overcoming these conflicts, participants learned about leadership and teamwork, bonded with community members, gained confidence in applying engineering technology, and even began to perceive the positive impact they were capable of having on others. As Kolhberg posited, "…bumps are part of a healthy social-moral curriculum. The experience of conflict is therefore an important spur for social and moral development" [20]. A few examples of these individual transitions are elaborated below.

Figure 1 : Pre- and Post-Travel Self-Assessment Survey Results



Reflections Example 1 – Project Purpose

In the very beginning of the project, Participant 1, the group leader, faced a disrupting moral dilemma. She began to question what EWB's real purpose was for being there, and expressed reluctance in leading a group on the project, as shown the following.

> *"I'm very glad my concerns are now on everyone else's shoulders- too bad it is this late. I've been dreading this trip and no one would understand- I'm the only one worrying. It will ease once we get there and I'm not the only one worrying. Why are students sent to help the problems of grown adults? Do we really think that little of them?"*

Participant 1's stress was assuaged when the group talked to the community members and figured out that the project needed to be changed. As the next excerpt shows, she was able to overcome a stressful social situation, and lead the group onto the next challenge. Hope was restored, and she was able to continue on with the journey, physically, mentally, and socially.

> *"Project is changing a lot- as expected. Beginning to feel more comfortable about potential success. Seeing (NGO correspondent) and nothing exploding was great. I thought there had been some huge miscommunication and we weren't wanted. Getting to El Cristal will be even better."*

Participant 1's transition is corroborated by Kohlberg's theory, "A moral law, like a law in physics, is not something to swear by and stick to at all hazards: it is a formula for the way to respond when specified conditions present themselves."[10]

Reflections Example 2 – Change in Project

The entire team was forced to overcome a problem when they realized, after arriving in Ecuador, that the project would have to change because the community's needs had changed. This situation presented a conflict which required the group to collaboratively generate a new design for a different problem, and build it with limited resources. The group's motivation remained strong, allowing them to persevere as a team. Demonstrating Dewey's principle of "continuity" and entering Kolb's cycle of experiential learning, the students were able to devise a new water filtration system for the community. Overcoming this obstacle strongly affected Participant 3, who was responsible for construction execution and assuring correctness and quality. She doubted herself when questioned by others, as shown in the following excerpt.

> *"Today was very frustrating. The wire mesh was not specified before we went out and I was told we had two sized although they looked the same gauge to me. Once out in the field I repeated the sizes we needed and everyone kept saying that can't be right. Although, I was positive in my numbers from the start. I began to get confused and let them make me question myself, which made me lose confidence in my answer. The problem was that I was dealing with older engineers, so I assumed they knew more than I did, but in actuality, they weren't there for our*

filter building day so they didn't know. I have learned that I have to stick by my answer if I believe it's correct."

By discussing her issues with others and clarifying the work, she not only finished the filter construction, she gained an entirely new confidence in her engineering ability and learned about what she could improve upon when leading a group.

"I thought today went really well. I felt more confident because all the confusion was cleared up... I need to be more organized and fully ready to answer questions when I lead a task. Also, we all need to check each other's work."

From an academic standpoint, the student's were able to implement abstract engineering theories to create a device that would benefit the community. As Kolb states, this is crucial for future engineers[9]: "The science-based professions, and especially engineering, require highly developed capacity for working with abstract conceptualizations in the work utilization of advanced technology for solving real-world problems." The students adapted to unforeseen circumstances in creatively engineering a water filtration system for the community. Furthermore, working together towards a common goal for a less fortunate group of people, the students began to "decenter" themselves, from a Piagetian perspective, by shifting the problem from subjective to objective, thus deterring egocentricism. According to Kohlberg, the students were able to succeed together as they developed cognitively, morally and socially. As he explains, "The moral curriculum and academic curriculum are two sides of the same coin. When students work together in a co-operative mode, their enthusiasm for learning and academic performance significantly increases."[21] Since behavior and reasoning exist in a dynamic, interactive relationship, pro-social behavior leads to opportunities to take the role or perspective of others, which in turn leads to advances in social-moral reasoning.

Conclusion

The ultimate goal of this study is to demonstrate how service-learning fulfills Engineering Criteria 2000 (EC 2000) established by Accreditation Board of Engineering and Technology (ABET) effectively and efficiently, while adding a unique dimension to engineering education. ABET EC 2000 set forth the following requirements for engineering universities:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

In reviewing this case study, it is evident that this experience of service-learning undoubtedly stimulated development in a variety of ways among the participants. Comparison of the Pre- and Post-Travel self-assessment surveys indicates that the following abilities were strengthened:

- Ability to collaborate and coordinate efforts with a team towards a common goal
- Ability to lead a team
- Ability to communicate with teammates
- Ability to communicate with community members
- Ability to apply classroom concepts to realistic situations
- Ability to identify problem constraints
- Ability to perceive impact in a global, societal, and economic context.

These self-assessments are verified via the student's daily reflections. Thus, it appears that many of the ABET requirements were met in completing the task of designing and building the water filtration system. The students demonstrated recognition of their professional and ethical responsibilities. They applied mathematics and engineering knowledge in designing the filtration system and performed tests to confirm functionality. The collaborative effort of this multi-disciplinary team required constant communication among team members as well as with community members to verify that the product would meet the community's desired needs. At project's end, the students began to realize their impact as engineers in a global and societal context. As one participant reflected,

> "*I am sad to leave Cristal. I really like my family and all the other people we have met here, and they really appreciate the work we've done for them."*

As presented by Jaccoby[6], "People cannot be told how to be responsible, knowledgeable citizens. They must be involved in the process." Jaccoby believes it is the element of reciprocity that "elevates (service-learning) to a level of philosophy, an expression of values- service to others, community development and empowerment" that engenders a transition in perspective[6]. Examination of the EWB Ecuador case study indicates that students who are engaged in service-learning develop a greater complexity in their thinking; on cognitive, social, and moral levels. While the service aspect of the experience elevates the students' sense of social responsibility, the reflective component fosters students' learning and development. Integrating service with learning catalyzes developmental mechanisms that promote human growth on all levels, thereby triggering developmental transitions that may be impeded by a classroom setting. From an educational standpoint, the outcomes of the experience can be easily mapped onto the ABET Criteria and prepare students for overcoming unanticipated challenges, which is an indispensable curriculum component according to the NAE. Therefore, this research strengthens the argument for implementation of service-learning courses into the engineering curriculum as an option for students. To attain the desired results, the students must be motivated to participate themselves; as Kolb's model of Experiential Learning theorizes, motivation is needed to spark the cycle of learning.

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