AC 2011-2353: A PARTICIPATORY INVESTIGATION OF LEARNING IN INTERNATIONAL SERVICE PROJECTS

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A Participatory Investigation of Learning in International Service Projects: The Process and Content of Learning

Abstract

Current efforts to improve engineering education focus on various solutions, such as more holistic curricula, incorporating more practical experiences, or stronger emphases on what is good for community and society. While these outcomes are highly valued, the means to achieving them are not well understood. This study examined the learning experiences of engineering students engaged in international service projects, specifically what and how students learned from their experiences in these projects. Key foci of the study drew upon theories and models of experiential and social learning, identity, and intercultural competence. The students were participants in the local Engineers Without Borders chapter at the University of Illinois. The findings highlight what students reported learning related to: (a) the need to invest time and effort, (b) interacting with community and team members, (c) implementing projects, and (d) their individual development. These findings articulate the benefits to students of international service experiences and provide ideas for instructional methods that might foster this learning in other students.

Introduction

For some time there have been calls for improving the methods and content of engineering education. These calls stem from concerns that the typical engineering curricula are not providing students with experiences that enable them to acquire the competencies and professionalism required by the profession in the global 21st century.\(^1,2\) To address these concerns, some educators advocate for a more holistic curriculum and more practical experiences that can enhance student engagement and better prepare them for professional practice.\(^1\) Others propose increasing the social interaction and development of students via collaborative, integrative learning experiences that allow them to develop a deeper understanding of engineering and enhance their practical skills.\(^3\) There is also a growing emphasis on globalizing engineering education with the intent of fostering greater global competency in students.\(^4,5,6,7,8\)

From our experience working with students in the program Engineers Without Borders and other service-learning experiences we gleaned anecdotal evidence that many of these students had transformative experiences that significantly changed their views of the world and their place in it as engineers. Initial findings indicated that students became empowered and impassioned by their experiences, and developed a more holistic, realistic understanding of engineering as practiced beyond the academy. It appeared that these experiences provided the kinds of holistic, practical, globally oriented learning experiences that are the goals of curricular reform.

To better understand these experiences and how they affect students, we proposed that a deeper, participatory investigation of what and how students learn through international service projects could yield ideas and synergies that lead to a meaningful enhancement of the engineering curriculum. In this paper we report on the initial findings of our investigation into student learning in international service projects through the Engineers Without Borders chapter at the University of Illinois.
First, we provide some background on the various calls for engineering education reform, followed by a review of relevant learning theories, intercultural competency development and the concept of formulating a professional identity. Second, we describe the design of and methods employed in the study. Third, we present the initial findings of the study highlighting what students are learning from these experiences and how they are learning them. Finally, we draw initial conclusions and possible recommendations for incorporating pedagogical methods into domestic classrooms that show promise in developing broader, more holistic perspectives and competencies reported by students having international experiences.

Background: Challenges and Opportunities in Engineering Education

Various recommendations across the educational landscape, including the Engineer of 2020, focus on preparing students for the complex and global challenges of the 21st century—often meaning that engineering students need to become more self-directed, globally competent, and socially aware—in other words, more holistic engineers. Although these outcomes are highly valued, the means to achieving them are not well understood, and the barriers to initiate curriculum changes that support these outcomes are formidable.

The College Learning for the New Global Century, a report published through the Association of American Colleges and Universities’ LEAP (Liberal Education and America’s Promise) initiative recommends four essential learning outcomes for college students to prepare for twenty-first-century challenges: 9
1) Knowledge of human cultures and the physical and natural world,
2) Intellectual and practical skills,
3) Personal and social responsibility, and
4) Integrative learning

[This] vision for student learning places strong emphasis on global and intercultural learning, technological sophistication, collaborative problem solving, transferable skills, and real-world applications—both civic and job-related. In all these emphases, LEAP repositions liberal education, no longer as just an option for the fortunate few, but rather as the most practical and powerful preparation for ‘success’ in all its meanings: economic, societal, civic, and personal.

These themes resonate with current movements to prepare engineers for the 21st century. The “Engineer of 2020” recommends that students develop strong technical skills, and more socially oriented knowledge, skills, and dispositions that enable them to solve problems effectively. Redish and Smith 10 include intercultural competence, i.e., “working effectively in diverse and multicultural environments” and “work effectively in the global engineering profession” in their framework for future engineers (p. 296). Duderstadt 2 calls for engineers with liberal arts and entrepreneurial perspectives, and “perhaps more important than anything... a new spirit of adventure, in which risk-taking and innovation are seen as an integral part of engineering practice, and where bold solutions are sought to the major challenges facing our world” (p. 64).
The terms skills, competencies, and characteristics of individuals related to ability and performance are often used interchangeably in the literature. The use of these terms ranges from narrow definitions of skill sets to broad definitions of competency models. In their study of the skills needed by the engineering graduate of the future, Spinks, Silburn, and Birchall \(^{11}\) summarized the literature on the concept of skills concluding that the term has evolved from a relatively narrow definition of practiced activity (doing something) to include other related concepts of knowledge, capabilities, competencies, abilities, attitudes, dispositions, and other attributes of the individual. This discussion is beyond the scope of this paper and the authors recognize that learning and competence is multifaceted and inclusive of cognitive, affective, as well as other individual and interpersonal characteristics. For this paper, the use of the terms skills, competencies, knowledge, and abilities tend to follow the sources of the lists and refer to the characteristics of well educated, holistic, and capable engineers.

Our framework for understanding and exploring the characteristics of a competent engineer is the National Academy of Engineering’s “essential characteristics of the Engineer of 2020” summarized in Table 1.

Table 1: *Essential characteristics of the Engineer of 2020* \(^{12}\)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
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<tbody>
<tr>
<td>Strong analytic skills</td>
<td>The use of science, mathematics, and domains of discovery for a particular challenge and for a practical purpose.</td>
</tr>
<tr>
<td>Practical ingenuity</td>
<td>Skill in planning, combining, and adapting.</td>
</tr>
<tr>
<td>Creativity</td>
<td>A use of invention, innovation, and thinking outside the box.</td>
</tr>
<tr>
<td>Communication</td>
<td>Effective use of language to achieve engineering objectives with and through multiple stakeholders.</td>
</tr>
<tr>
<td>Business &amp; management</td>
<td>Connecting engineering to technological, economic, and social factors in decisions and policy making.</td>
</tr>
<tr>
<td>Leadership</td>
<td>Providing professional direction in various ways, including contributing to management and policy decisions.</td>
</tr>
<tr>
<td>Ethics &amp; professionalism</td>
<td>Making effective and wise choices that take economic, social, and environmental factors into consideration.</td>
</tr>
<tr>
<td>Dynamism-agility-resilience-flexibility</td>
<td>The elusive quality that results in quick and resourceful problem solving.</td>
</tr>
<tr>
<td>Lifelong learners</td>
<td>A commitment to taking on new professional directions and challenges.</td>
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</table>

Through in-depth interviews with industry experts, Spinks, Silburn, and Birchall \(^{11}\) collected data that summarized the skills needed by engineering graduates in the future into three categories: technical, personal, and business. Additionally, they identified three roles required of successful engineers of the future:
The role of a specialist having technical expertise

The role of an integrator having the expertise to operate and manage across boundaries of technical and organizational functions

The role of change agent having the expertise to lead change in uncertain organizational, industrial, and societal environments.

Although the technical domain of engineering is well documented in education programs, the application of technical skills outside of education is less well understood. Similarly, the application of personal and business (organizational) skills is less emphasized in engineering education. This study focuses on how and what skills students learned related to applying technical knowledge, leading and managing projects, developing intercultural competence, and developing a professional identity. In addition, we have included more detail from the literature on experiential learning, intercultural competence, communicative competence and the development of professional identity.

According to Farr, leadership development in industry can best be described as ad hoc with “on the job training” being the primary mechanism. Engineers at all levels must be adept at market forces and business realities, developing large scale systems, and working with people from other disciplines and cultures. Industry leaders are calling upon educators to provide a holistic education applying systems thinking and strong interpersonal skills.

**Experiential learning**

Many researchers have viewed learning as inseparable from experience. One of the pioneers who acknowledged the importance of experience in learning is Dewey. He viewed experience as the central concept in his system of ideas about effective teaching. In his system, experience is a starting point of an educational process and it is never the result. The central challenge of an education based on experience is to select the kind of activities that live fruitfully and creatively in subsequent experience. This requires educators be aware of how the context of learning affects what is learned and what surroundings are conducive to having experiences that lead to learning and growth.

Kolb is a leading theorist in experiential learning. He believes that learning is created through transformation of experience. For him, learning is not a mere transmission of content but an interaction between content and experience. His model of experiential learning cycle is based on Lewin's problem-solving model of action research and drawing and Dewey's concept as well as Piaget. This cycle consists of four steps that delineate how learners transform an experience into abstract knowledge, which is applicable to future decision-making or problem-solving situations. Those steps are concrete experience, observation and reflection, formation of abstract concepts and generalization, and testing implications of new concepts in new situations. Kolb also suggested specific learning and teaching strategies to be used to facilitate each stage of experiential learning.
Table 2. Kolb's Model of Experiential Learning with Suggested Learning Strategies.

<table>
<thead>
<tr>
<th>Kolb's Stage of Experiential Learning</th>
<th>Example Learning/Teaching Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Experience</td>
<td>Simulation, Case Study, Field trip, Real Experience, Demonstrations</td>
</tr>
<tr>
<td>Observe and Reflect</td>
<td>Discussion, Small Groups, Buzz Groups, Designated Observers</td>
</tr>
<tr>
<td>Abstract Conceptualization</td>
<td>Sharing Content</td>
</tr>
<tr>
<td>Active Experimentation</td>
<td>Laboratory Experiences, On-the-Job Experience, Internships, Practice sessions</td>
</tr>
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</table>

Kolb went a step further and argued that learning is different for each individual. As learning is such a complex process, there are opportunities for individual differences and preferences to emerge. A preferred mode of learning describes the individual's orientation toward gathering and processing information during learning, and corresponds with the four steps in the experiential learning cycle. Kolb argued that an individual's learning style often combines two modes of learning, each of which emphasize some learning abilities and deemphasize others. This lends a possibility that the learning outcome of engineering students will be affected by each individual's preferred modes of learning, or their learning style.

Boud, Cohen, and Walker 16 viewed learner's active engagement to an experience as prerequisite for experiential learning. They took a different position in explaining individual differences in learning, emphasizing interpretation as a source of difference for learning among individual learners.

Subjectivity plays a role in one's making sense of an experience, which in turn leads to different interpretations of an experience. When different learners engage in the same event, the individual's interpretation of the event will vary and each person will construct it differently. This view adds to major influences on how learners construct their experience. Those factors include: (a) the personal foundation of experience, (b) the cumulative effect of learner's personal and cultural history, 17 (c) the learners' predisposition in learning (equivalent to learning style), and (d) assumptions about the purpose of learning. 18

Overall, higher education has increased the opportunities for experiential learning as a formal component of college and university curricula. Faculty view experiential learning as a valuable addition to traditional instruction and a way to make learning relevant to students. As such, the literature on experiential learning in higher education is expanding across the range of disciplines from the social sciences to the arts and humanities. 19 Experiential learning techniques are being used in the professional and technical disciplines including education and the health careers and social work to provide students with the competencies necessary to pursue successful careers upon graduation. 20
Intercultural Competence

Among the many theories and definitions of intercultural competence, a model by Deardorff\textsuperscript{21} stands out as relevant. Its underlying purpose is to develop “globally-ready” (western) students for and through international learning experiences (p. 32). Developing global or intercultural attitudes in students includes fostering respect (valuing other cultures), openness (withholding judgment), and curiosity and discovery (tolerating ambiguity). Intercultural knowledge and comprehension involve cultural self-awareness, deep cultural knowledge, and sociolinguistic awareness. Intercultural skills involve reflection: listening, observing, analyzing, evaluating, interpreting, and relating\textsuperscript{21} (p. 36). Development of these attitudes, knowledge, and skills in students results in internal and external outcomes that support a more interculturally competent individual. Internal outcomes include an informed frame of reference shift (as evidenced by adaptability, flexibility, an ethnorelative view, and empathy). External (observable) outcomes include effective and appropriate communication and behavior in an intercultural situation\textsuperscript{21} (p. 36).

Of particular interest in this context of this study is how students come to understand how cultural factors (customs, values, etc.) impact engineering decisions and practices. Downey et al.\textsuperscript{4} emphasized the importance of understanding the cultural variations that affect how engineering problems are defined and addressed.

Communicative competence

At a basic level, professional competence in speaking, listening, reading, and writing is essential in any engineering context. Numerous campuses and organizations offer courses, seminars, and online resources (e.g. ASME, http://professionalpractice.asme.org/home.cfm) to help engineers learn to communicate effectively with their clients and their colleagues. Sheppard et al.\textsuperscript{1} emphasized the importance of engineers learning how to explain technical material in to non-technical audiences.

Riemer\textsuperscript{7} considers the importance of communication skills in intercultural contexts. He uses Hofstede’s\textsuperscript{22} work on dimensions of culture to suggest that engineers need to be aware of culturally based styles of language use – that the ways engineers use and interpret language functions, such as expressing opinions, allocating tasks, or negotiating a design, are dependent on cultural dimensions such as degree of power distance, individualism v. collectivism, and a short-term v. long-term orientation to task completion.

When engineers are speaking in a second language, the language choices they make are critical. Successful use of language in intercultural contexts entails accuracy (in terms of, for example, grammar and vocabulary use), as well as sociolinguistic appropriateness, discourse fluency (an ability to participate in extended discoursal endeavors), and strategic management, or an ability to recognize communication mis-steps and make repairs when necessary.\textsuperscript{23} Table 3 summarizes the competencies targeted for analysis in these areas.
### Table 3. Elements of Cultural and Communicative Competence

<table>
<thead>
<tr>
<th>1. Intercultural competence</th>
<th>Knowledge</th>
<th>Skills</th>
<th>Attitudes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural self-awareness</td>
<td>Reflective skills:</td>
<td>Respect</td>
<td></td>
</tr>
<tr>
<td>Deep cultural knowledge</td>
<td>Listening, observing, evaluating, analyzing, interpreting, and relating</td>
<td>Openness</td>
<td></td>
</tr>
<tr>
<td>Sociolinguistic awareness</td>
<td></td>
<td>Curiosity and discovery</td>
<td></td>
</tr>
</tbody>
</table>

### 2. Communication skills for engineering

- Formal presentations
- Problem solving with colleagues
- Communicating with community partners
- Effective listening
- Appropriate use of technical/non-technical language

### 3. Second-language communication skills

- Linguistic accuracy
- Sociolinguistic appropriateness
- Discourse fluency
- Strategic management

### Professional Identity

An additional focus in the current engineering education community is the development of students’ professional identity. A professional identity (a category of social identity) is personally, contextually and socially derived, and is one lens through which individuals view their jobs, responsibilities, organizations, and roles in life. Essentially, individuals define who they are partly based on their memberships and interactions in social groups. Social identity forms as a process of self-categorization. Through this process of categorization, individuals evaluate their readiness and fit to a group and assess the group’s openness to their membership. In adopting the identity of a group, the individual’s personal identity recedes to the background and identity as a member of the group takes over, including adopting the norms, beliefs, and values of the group. In the case of engineering students, the process of adopting the identity of an engineer is under development and thus affected by students’ experiences (curricular and co-curricular, formal and informal) and their perceptions of those experiences.

Social identity can be defined as institutional, normative, and discourse practices that are associated with individual identity. Alvesson stated that social identity most often indicates that the individual takes on certain values, norms, and ideas based on identification with a specific group. Nystrom suggested these institutional and normative values and ideas help to develop professional identity: which is a blending of ones professional and personal lives.
Research has shown the importance of multicultural awareness and professional identity development within engineering fields, especially when considering the expanding global arena. There is an array of speculations concerning what professional identity development includes: self-labeling as a professional, integration of skills and attitudes as a professional, and or a perception of context in a professional community. Integration seems to culminate when envisioning oneself as part of the professional community. Gibson explains with integration of personal attributes and professional training, the individual contextualizes the new identity in a professional community in which the “self as professional” is tested via feedback from peers.

According to Gibson, there are two phases of professional identity development. Phase one can be identified when new professionals rely on external authority figures and experts for conceptual learning, experiential learning, and external evaluation. This phase is usually during undergraduate and early graduate academic standing. Phase two of development can be recognized when new professionals encounter authorities in their profession and experience feedback on professional skills acquired during formal education. Gibson suggests with this feedback, new professionals move toward an internal locus of evaluation as they examine, process, and internalize external evaluations. In the final phase, learners are able to self evaluate, integrating experience with theory to merge personal and professional identities. Professional identity is solidified when the locus of evaluation becomes internal.

Future professionals “sense of being” is the core awareness that can be transformed into knowledge as it becomes meaningful in different situations. These claims intimately link social and professional identity and suggest they uniformly impact the formation of the other. For engineering students who have already formed much of their social identities through multiple avenues of life are often lacking an important part of development: professional identity. When entering higher education students not only become aware of a specific body of knowledge and skills, they are also exposed to different communities of practice, with particular sets of traditions, activities, and boundaries. These communities affect how the graduates become prepared for and identify with their future work.

**Theoretical Frameworks for Investigating Student Learning**

The guiding framework for this study drew upon previous theoretical work on experiential learning—specifically the process by which students have concrete experiences and proceed to reflect, conceptualize, and experiment about these experiences. Their reflection and conceptualization fostered greater intercultural competence and a stronger sense of identity as engineers. Additional guidance came from research on social identity, intercultural competencies, and service learning. This study pulls these various strands of theory and practice together to develop a richer understanding of learning in international contexts and how it might enhance the engineering curriculum.

**Research Design**

Our research questions are the following:

1. How do experiences in international service contexts influence engineering students’ learning (knowledge, skills, attitudes) and practice?
2. How do experiences in EWB international service contexts affect engineering students’ professional identity?
3. How can students use reflection to translate their experiences to suggestions for curricular and co-curricular change?

In order to answer these questions we have adopted a participatory action research model. Participatory action research is a methodology for knowledge production that is based on participants’ roles in setting the agenda, involvement in data collection, analysis, and interpretation, and control over the use of outcomes. Greenwood, Whyte, and Harkavy 37 add that key features of participatory action research include collaboration between the researcher and members of the organization across the research process to study and transform the organization, incorporation of local knowledge of members of the organization, eclecticism and diversity in research approach, and linking scientific understanding to social action. This design enables students to better understand their own learning and practices in international engineering service projects—toward an effort of improving those practices and the broader curriculum.

From the beginning, informal and formal meetings with EWB students and the research team have shaped the focus and data collection methods in this study. Initially, students’ stories about the impact of EWB on their lives inspired the main research questions. Later, EWB student leaders dialogued about prompts and procedures for reflective journal writing and reflective dialogs during their on-site work. Student leaders brought ideas for recording their experiences (e.g., video recording, blogging) and unpacking their learning (e.g., post-trip interviews and debriefings). The participants also joined with the research team and faculty members to dialogue about learning outcomes from international service experiences. Together, they explored the question: How can the lessons learned from students in international engineering projects translate into the development of meaningful learning opportunities in curricular and co-curricular engineering programs?

Further meetings with EWB students and faculty to review the findings are planned to encourage instructional development and curricular enhancements that capitalize on this learning. This collaborative approach empowers students to engage in reflection and action that can lead to greater self-understanding and to significant curricular changes that matter to them.

This paper focuses on the findings related to the nature of student learning in international service-learning contexts. Through interviews, meetings, discussions, and journals, students provided rich narratives about their experiences, including changes in their knowledge, skills and attitudes about themselves as engineers and as people.

Findings

The following findings begin to answer the first research question: How do experiences in international service contexts influence engineering students’ learning (knowledge, skills, attitudes) and practice? These findings indicate the processes of learning experienced by students in these experiences, as well as the content of what they were learning from these experiences. There is a high level of overlap between how students are learning and what they are learning, and we have approached the analysis from this integrated perspective (process and
content). In reality, process and content are intimately intertwined and difficult to separate when looking at the statements gathered from students reflecting and describing their experiences. Still it is useful to consider both aspects of learning because what someone learns is usually the outcome of an experience they encountered. The first section of the findings that follow focus on the learning-related processes students encountered during their international projects. The second section focuses more on the types of knowledge and skills (content) they reported learning from their experiences.

**Initial analysis of student learning processes**

There were four major themes representing the learning processes reported by students: (a) investing time and effort, (b) interacting with community and team members, (c) project implementation process, and (d) individual development (Table 4).

Table 4: The categories and processes of student learning.

<table>
<thead>
<tr>
<th>Thematic categories</th>
<th>Learning process codes</th>
</tr>
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</table>
| Investing time and effort            | - Adapting to new perspectives, customs, environments  
- Takes time to learn, time to adjust  
- Learning by trial and error  
- Shortage of time to collect data  
- Need more time to implement project  
- Rehearsing presentations  
- Spent more time in meetings than anticipated  
- Second time on site was less stressful |
| Interacting with community and team  | - Learning from community and villagers  
- Getting to know the village, local people, kids  
- Struggled to integrate village processes with project  
- Negotiating during presentations  
- Tendency for older/experienced students to do most work  
- Working with a mentor was beneficial  
- Need charismatic leader to inspire and motivate  
- Experienced students share knowledge with younger students |
| Project implementation process       | - Recruiting interested people  
- Settled in and got bearings  
- Dividing into teams, groups form around students’ interests  
- Collecting data, beginning research  
- Realizing the difficulty of project and that failure is possible |
| Individual development               | - Individual differences in adjustment time and quality  
- Learning to integrate social and technical aspects of project  
- Need to learn new things fast  
- Learning new perspectives on how to do things  
- Transformative experience  
- Need to break out of comfort zone  
- This changed the direction of my career  
- Brought about a cultural change in belief |
The first process was the realization by students of the need to spend time learning and understanding the situation they encountered in the field. There was the feeling that this sometimes surprised students who might have expected that things would be more efficient and less time consuming. For example, “Brad,” a team member on the Nigeria project from the beginning, has spent a great deal of time on site. The following excerpt from his commentary reflects a maturity of intercultural knowledge and attitudes, and highlights an internal shift in his cultural self-awareness and his respect and openness to other cultures. It also reflects a personal understanding of the challenges of EWB work. Brad described what he learned as follows:

The fact that you have to spend some time in the community to get an idea of how to do things properly, I think is obvious to me now. Communities are different enough from one another, that there is no blanket approach. You need to talk about things in terms of community participation and community management. You have to spend some time in a community to find out what works, and it may not look quite like what EWB tells you it would look like.

He also expressed some skepticism about the EWB model:

A lot of my experience has told me that our involvement in this way isn’t necessarily what the developing world needs. I tend to lean toward the conclusion that our projects can usually be good for the community involved, but that this model, in the grand scheme of things, will probably be irrelevant to international development.

Another category of learning processes related to the need to intimately and thoughtfully interact with both the local community members and with each other on the team. This was closely related to the need to invest time and students came to realize the importance of developing relationships, trust, and camaraderie with their “partners” in the field—whether they be fellow students or people in the village.

A related process of this interaction with the community was trying to understand the local ‘way of doing things.’ This often required a deliberate effort to better understand the villagers’ perspectives and values. These particulars had a strong influence on the level of support local community members provided and on the extent of collaborativeness students experienced on the project. This dynamic was probably accentuated because the students were in this situation for a short time (two to four weeks) and felt pressure to accomplish something within that time.

You need to talk about things in terms of community participation and community management.

A big part of it, much more than I expected, was talking to a village, establishing trust with them. What happens on these projects is rumors spread very quickly. Foreigners walking into a village saying you’ll do something big. So, what I found interesting, right away we had a big village meeting.

Related to this was the process of interacting with their team members. Students reported their observations that their colleagues demonstrated different levels of adaptability to the situation
and different levels of leadership and dependability in the situation. Personalities and group dynamics were an important component of the experience for students. Leadership was related to experience in the way that students with more experience in the international setting or on the project did most of the work. Mentoring was an important factor in the learning, and something that was not always available. There appeared to be a recognition and deference to the more experienced students that promoted a valuable sharing of knowledge within the team.

Usually -- especially in design, I think older people who have taken a course tend to do a disproportion of the work, you know, even if you get involved, you might not get to do much of the work if you’re younger.

Another important learning process reported by students related to project implementation. This process was closely related to typical project management processes with a few interesting nuances that fostered student learning beyond the typical project learning in the classroom. These nuances related more closely to the social factors of project management, such as recognizing interested and dependable people that can get things done. Other experiences were more typical in the sense of getting one’s bearings in the situation, dividing into teams to accomplish specific tasks, and actually undertaking the work. These experiences are not that different from other project management experiences. However, one interesting comment from students recounted their surprise at the unexpected difficulty of beginning these tasks. This is related to the learning about the amount of time and effort needed as described earlier. Yet some students expressed some surprise at realizing that their efforts might fail, or that they were not very good at implementing projects. These were important insights for students that they acquired from having worked through the process in the community.

There were things we could have done that most of them involved one of us staying any longer to make it work better. So, that’s part of the reason I came was because I think it’s necessary for someone from the implementing team to stay longer. But more, it’s just I wanted to leave something finished for once.

They are too similar to the ways that so many other projects have failed. We talk. We know the vocabulary of community management, participatory practices. But we weren’t very good at putting it together.

Another important category of experiences related to the learning processes focused on individual development. As expected, this category seemed most profound for the first time students. Much of the learning arose from actual hands-on activity. Students learned by doing. They also developed an appreciation of the need to integrate social and technical aspects of the project, which also contributed to a greater appreciation of cultural differences. As they developed a greater appreciation for differences, some reported having something of a transformative experience. These experiences brought about cultural changes in beliefs, new perspectives, and even a career change. Overall, students indicated a broadening of their view of the world and how things worked. For most that we talked to, this was an experience not to be missed—no matter how difficult. A community partner (who sponsored the project and housed the EWB students) had similar reflections about these students’ development:
In another environment, you see new perspectives of how to do things. The transformation I’ve seen in the students that visited here, it is sort of an eye-opener. Some were coming here without knowing exactly what to expect. In the environment, first of all, is the cultural shock, you know? There are things you see as normal, things you see as abnormal. And when you come to a new environment, it’s the other way around. These ones are normal, and these ones are abnormal. And for me, I think the greatest contribution … of these programs is that students see the other side of every issue. I think it’s making a better engineer of these students.

Our analysis of what students learned (content) provided additional insights into their learning (see Table 5). Most of this learning is closely related to the processes described above. For example, when students reported their surprise at the amount of time and effort required to implement a project, this also indicated something they learned about the complexity and difficulty of implementing projects.

Table 5: The categories and content of student learning.

<table>
<thead>
<tr>
<th>Thematic categories</th>
<th>Learning content codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural appreciation</td>
<td>− Need to understand local differences, community practices</td>
</tr>
<tr>
<td></td>
<td>− Villagers have certain understandings</td>
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<tr>
<td></td>
<td>− Noticed differences among communities—no common approach</td>
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<tr>
<td></td>
<td>− Learning the local social system, hierarchy, class system</td>
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<tr>
<td></td>
<td>− Realizing the importance of language and communication</td>
</tr>
<tr>
<td></td>
<td>− Noticing similarities across cultures</td>
</tr>
<tr>
<td></td>
<td>− Balancing universal principles and local elements</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>− Learned to identify others that are dependable</td>
</tr>
<tr>
<td></td>
<td>− Not everyone learns the same or the same things</td>
</tr>
<tr>
<td></td>
<td>− Recognizing that some people cling to stereotypes</td>
</tr>
<tr>
<td></td>
<td>− Noticing similarities among different people</td>
</tr>
<tr>
<td></td>
<td>− Learning how different leaders emerge</td>
</tr>
<tr>
<td>Self discovery</td>
<td>− Learning what an engineer is, new perspectives of profession</td>
</tr>
<tr>
<td></td>
<td>− EWB developed creative skills</td>
</tr>
<tr>
<td></td>
<td>− Learning to be less naïve about other cultures</td>
</tr>
<tr>
<td></td>
<td>− Recognizing low level of implementation skills</td>
</tr>
<tr>
<td></td>
<td>− Realizing importance of confidence for making good assumptions</td>
</tr>
<tr>
<td></td>
<td>− Experience, maturity is important to understanding projects</td>
</tr>
<tr>
<td></td>
<td>− Wondering how much intuition is valuable</td>
</tr>
<tr>
<td></td>
<td>− Learned how complex situations are</td>
</tr>
<tr>
<td></td>
<td>− Learned to be more comfortable taking action</td>
</tr>
<tr>
<td></td>
<td>− Learned to be more critical and challenge status quo</td>
</tr>
<tr>
<td></td>
<td>− Increased motivation to learn more</td>
</tr>
<tr>
<td></td>
<td>− Developed a broader view of problems/solutions</td>
</tr>
<tr>
<td>Project implementation process</td>
<td>− Small groups are more productive</td>
</tr>
<tr>
<td></td>
<td>− Realizing need to act without all data available</td>
</tr>
<tr>
<td></td>
<td>− Making tradeoffs in finding the solution</td>
</tr>
<tr>
<td></td>
<td>− Learned how much effort is required to do simple things</td>
</tr>
<tr>
<td></td>
<td>− Learned from previous projects</td>
</tr>
<tr>
<td></td>
<td>− Community support appears after implementation</td>
</tr>
</tbody>
</table>
From their interactions with community members, students learned the necessity of attending to cultural and local situations, as well as to personal preferences in the village. This included the development of a greater appreciation by students of differences in communities and the value of not holding to one common approach for all situations. While they perceived previously unexpected similarities between people from other cultures, they also perceived the need to attend to idiosyncratic details in a particular community or group within a community. This knowledge was one of the valuable outcomes of their intercultural experiences and carried over into their technical understandings in the way that they came to appreciate that even though they believed in some universal principles related to their project work they had to learn to temper their beliefs to conform to local particularities. More specifically, this type of experience also enhanced their interpersonal experiences and skills. A key outcome of this was again a greater appreciation for differences in the attributes of different people. As well, they learned to appreciate differences in the community and differences in their team members. One aspect of this enrichment in understanding of other cultures was described as becoming less naïve about other cultures.

This is a complex society with good and bad. There are parts of the culture that I don’t like. And I think unless you’re willing to admit that to yourself, you’re not going to see the culture for what it really is. It’s a complex culture. It’s a real culture. It’s really relevant to these people. It’s what they use to get by.

Another area of important learning related to students’ self-discovery and self-development. Students reported significant changes and expansion in their perspectives of engineering and their identities as engineers. Students described their greater sense of confidence and enhanced professional skills. And an important development mentioned by many was a greater motivation to learn more about the world and their work. They talked about the importance of having a broader view of problems and solutions, wondering about the need to rely on intuition more than they expected, and about developing their creative and entrepreneurial skills.

Finally, students talked about some of the insights they gained related to implementing projects. Major discoveries were related to learning to make tradeoffs in finding solutions and realizing the need to make decisions and take action without all the data they previously thought was necessary. This loosening of the problem solving process they learned prior to their work on these projects seemed to be an important discovery by students. They described the adjustments in their perspectives they enacted as they pushed themselves “out of their comfort zones” in the process of doing their work.

I was a little uncomfortable at first, didn’t know what to expect. But in the end, you come out a lot better. You know? It’s better to experience it than to not even though it might be outside your comfort zone. So, for me, it wasn’t anything I ever learned in my courses, even since then, since I have EE courses.

In summary, students reported tremendous changes in their perceptions, expectations, and development from their experiences in these intercultural projects. Many achieved a deeper
learning about the context in which engineering was practiced and a deeper understanding of their abilities and roles in this work.

**Discussion and Conclusions**

Our goal for this study was two-fold: first to better understand what and how students learned from their international experiences and second, to develop ways of fostering some of these outcomes in campus-based curricula. Regarding what and how students learn from their international experiences shows the practical benefits for students of implementing “real projects.” They come face-to-face with community and physical constraints. They experience the time and effort required to negotiate with community members and among themselves. They see important differences in the way people react to their work and in the ways they adapt to situations. These experiences make an impression that is hard to replicate in a traditional classroom setting.

The emerging process and content themes in our data analysis indicate that international engineering service experiences provide rich contexts for student learning. We believe that a deeper understanding of this learning can be translated into curricular and co-curricular practices more broadly that develop the attributes of the “Engineer of 2020” that prepare students for engineering practice in today’s global society. Examining how these attributes develop in international service contexts can provide authentic source material to create curricular, instructional and faculty development resources that can be used to infuse the curriculum with content, activities, and assignments that are designed to achieve learning objectives related to these attributes. This authentic source material includes stories, observations, and reflections about what kinds of experiences students have that contribute to their learning and professional identity development and how those experiences inform their professional practice, examples of how students interpret their experiences and use them to make engineering decisions, and exemplars of how they develop intercultural competence in a variety of international settings.

As we continue to collect and analyze data with the student participants about their learning, we are beginning to involve them in the process of reflecting on and translating the outcomes of their experiential learning into curricular materials. There is a great deal to be learned about how research findings on student learning can best be translated into curricular change. An analysis of the NSF’s Engineering Education Coalitions indicates that “traditional means of disseminating research results (e.g., conference papers, journal articles) are insufficient to catalyze systemic reform” 38 (p. 94) due to institutional and cultural barriers. According to Sheppard, et al., “Engineering faculty are key stewards of the engineering profession. It is their job to fan the creative fire, feed technological curiosity, and foster the social responsibility of the next generation of men and women engineers” 1 (p. 208). Although faculty members are often viewed as catalysts, we have scant information about how to engage them in curricular reform 39 (p. 339). The student participants in EWB are uniquely situated as experts in their own learning, and this provides an opportunity for exploring how co-curricular and curricular endeavors might connect, which could ultimately amplify student learning and development outcomes during college. 40
The second phase of our study involves a new approach to engaging faculty by connecting them to students in a collaborative working group to develop materials and resources based on the EWB experiences. These materials can be used both in and outside of the engineering classroom. Engaging students in participatory action research to better understand their own learning and practices in international engineering service projects—toward an effort of improving those practices and the broader curriculum—is an innovative approach to engineering education. Involving the students in the process of exploring the themes or issues that they face in their EWB work is likely to “…embed their solution in the context, making it more appropriate and more likely to be implementable than that developed by external researchers acting as ‘experts’” (p. 563).  

Potential outcomes resulting from the participatory action research might include recommendations for K-12 outreach, workshops for students to package their experiences for the job market, cross-cultural reflection modules, curricular and co-curricular activities and reflection strategies, and service-learning course design workshops for faculty.

Bibliography