Experiential Learning: Lessons Learned from Global Higher Education Programs for Cleaner Production in Latin America

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Abstract

Environmental education is linked to both business and engineering in a multinational partnership called *Pathways to Cleaner Production in the Americas.* In this partnership, faculty from seven Latin American universities are collaborating on the development of curriculum, and practicum/internship experiences that will equip engineering, environmental science and business students with the technical knowledge, skills and expertise required for the promotion of cleaner production in micro, small, and medium enterprises (MSMEs) in each country. The anticipated outcome is to generate a workforce equipped with new knowledge, skills and attitudes toward sustainability through cleaner production, and capable of facilitating and implementing sustainable industrial development. The partner universities modified or developed new courses, conducted workshops for capacity building of faculty and businesses in their communities, and incorporated experiential learning in practicums and internships.

This paper focuses on the following research questions generated for determining the impact of the experiential learning:

- What technical competencies do the students gain from the courses/practicum/internship?
- What social responsibility competencies do the students gain?
- What workplace competencies do the students gain?

A student survey was developed and administered to 72 students from six participating countries. The results reflect gains in knowledge, skills, and attitudes toward cleaner production; the challenges of the experience in the context of working with a business; teamwork, communication and problem-solving work skills; and the changes in perceptions of cleaner production, social responsibility, and their role in a work setting.

The survey results for the question regarding what was learned from teamwork indicate that the students perceived that they gained skills in multiple areas attributable to their experience in the practicum or internship when working as a team. Particularly strong across all participants were responses indicating increased skills in collaboration, communication, commitment to the project tasks and work ethics. Students indicated that the experiential learning changed their perceptions of teamwork and the value of working with others. The students also overwhelmingly reported that the biggest challenge of teamwork is miscommunication. The second most common response was lack of similar backgrounds within an interdisciplinary field such as sustainability in cleaner production. It is clear that students successfully gained technical skills from the course work but the experiential learning provided the context for gaining and applying social skills needed for working with others in the workplace.

Keywords: *Experiential Learning, Cleaner Production, Sustainable Development, Education, Practicum, Internship, Global Partnership*

INTRODUCTION AND PROJECT GOALS

Environmental education is linked to both business and engineering practice in a multinational partnership called *Pathways to Cleaner Production in the Americas.* In this partnership, faculty from seven Latin American universities are collaborating on the development of curriculum, and practicum/internship experiences that will equip engineering, environmental science and business students with the technical knowledge, skills and expertise required for the promotion of cleaner production in micro, small and medium enterprises (MSMEs) in each country. The anticipated outcome is to generate a workforce capable of facilitating and implementing sustainable industrial development.

The *Pathways to Cleaner Production in the Americas* partnership, funded by the U.S. Department of State under the *Pathways to Prosperity in the Americas* initiative, through Higher Education for Development (HED), is in its final year of a three-year project. As former Secretary of State Hillary Clinton remarked on the sustainable business practices and the cooperation of countries participating in the *Pathways to Prosperity* initiative, "We are working to help small and medium-sized enterprises decrease the amount of water, energy, and raw materials they need to protect natural resources, shrink carbon emissions, and save costs (http://pathways-caminos.org/en/Home.html)." This project, *Pathways to Cleaner Production in the Americas,* constitutes one of the pillars of the *Pathways to Prosperity* and is focused on promoting the implementation of cleaner production practices and facilitating sustainable manufacturing and industrial development and economic growth in Latin America. Its multinational approach to integrate business, engineering, and environmental education represents a collective response to the need for technically innovative skills training in industry across the Americas. Illinois Institute of Technology (IIT) in partnership with the New York Institute of Technology (NYIT), is the lead in establishing the cross hemispheric academic network, which includes Insitituto Tecnológico de Costa Rica, Instituto Tecnológico de Santo Domingo of the Dominican Republic, Universidad Centroamericana "José Simeón Cañas" of El Salvador, and Universidad San Ignacio de Loyola of Peru, **Universidad Rafael Landivar in Guatemala, Universidad Nacional Autónoma de Honduras**, and **Universidad Nacional de Ingeniería of Nicaragua.**

There are three major project goals for accomplishing the sustainable industrial development in MSMEs throughout the region. The first goal is to create regional centers of excellence for education, development and implementation of best practices for Cleaner Production (CP) and sustainable development at the universities in collaboration with National Clean Production Centers (NCPC) in each partner country and the World Environment Center (WEC). A second goal is to increase the MSMEs adoption of cleaner production and sustainability practices through increased interaction with academia, especially through experiential learning projects where students work directly with MSMEs. The partners enhanced their academic training and curricula in cleaner production and sustainable industrial development to improve environmental performance and productivity of MSMEs in Pathways countries. Each university held numerous workshops with faculty for capacity-building within their institutions, and with MSMEs in the community to increase their awareness of cleaner production strategies, such as, ways to improve the environment, compliance with government regulations, and cost-savings economic benefits of waste reduction. The third goal is to create a virtual forum for information sharing on sustainable industrial development education and applications among the partner institutions and others in the region. This paper will focus primarily on the second goal involving experiential learning in practicum/internship courses that integrate business, engineering and environmental themes, and that are designed to provide students with authentic experience in a MSMEs in which they can apply their knowledge and skills acquired from the coursework at the university.

BACKGROUND

Experiential learning theory is defined as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (Kolb 1984, p. 41). Kolb derived her theory of experiential learning from educational theorists such as Dewey, Lewin, and Piaget, combining pragmatism, social psychology and cognitive development to form a unique perspective on learning and development (Kolb, 1984).

As we consider experiential learning in a practicum course for sustainable development and cleaner production, we can use the knowledge and skills students have acquired in formal coursework as the starting point for the problem-solving that will take place in a real-world situation. Engineering educators have considered sustainable development (SD) as a "balance between problems and the capacities and capabilities to solve these problems" (Lehmann, Christensen, Du, and Thrane, 2008). They describe expectations for engineers in a global society as not only needing to have technical competencies for problem-solving and producing innovative solutions, but also needing interdisciplinary skills of cooperation, communication, project management and life-long learning skills in today's diverse social, cultural, and global settings. They posit that future engineers will need to interact with other people in other professions to develop solutions and analyze the impact on society; and that new competencies are needed to move engineering education into experiential learning where multiple perspectives from multiple disciplines must be considered for innovative solutions to complex societal problems - such as sustainable development. Lehmann, Christensen, Du, and Thrane (2008) state that "our ability to understand and solve problems is very much linked to our knowledge; and our potential is thus linked to our knowledge of SD, problems, and possible solutions" (p. 285). In order to find solutions that are new and relevant, knowledge from different fields need to integrated and applied in the context of the real-world problems that exist in the field. Problem based learning (PBL) provides a framework for the transfer of knowledge and skills to a complex contextualized situation. In the *Pathways to Cleaner Production in the Americas* internship/practicum experience, that context was MSMEs.

The three main learning principles of PBL are: 1) cognitive learning approach, 2) contents approach, and 3) the social approach (DeGraaff and Kolmos, 2003; Kolmos and DeGraaff, 2007). The cognitive learning approach identifies the problem, places it in context and bases the learning on the learner's experience. The problem or project may involve complex problem-solving strategies requiring situated analyses of multiple and interrelated factors in order to arrive at relevant and viable solutions. The contents approach addresses the interdisciplinary learning and an analytical approach to applying theory to situational problem-solving. The principle regarding the social approach addresses team-based learning. Students learn from each other, share knowledge, and collaborate with each other in their analysis and problem solving.

Lehmann, Christensen, Du, and Thrane, (2008) describe a model developed at Aalborg University in Denmark, known as the Aalborg PBL model (Kolmos, Fink, and Krogh 2006) using a student-centered interdisciplinary approach to problem-based projects focused on SD with companies outside the university. The curriculum in this model was based on the PBL learning principles DeGraaff and Kolmos identified in Table 1.

Table 1. The PBL Learning Principles (Based on DeGraaff & Kolmos, 2003; Kolmos & DeGraff, 2007)

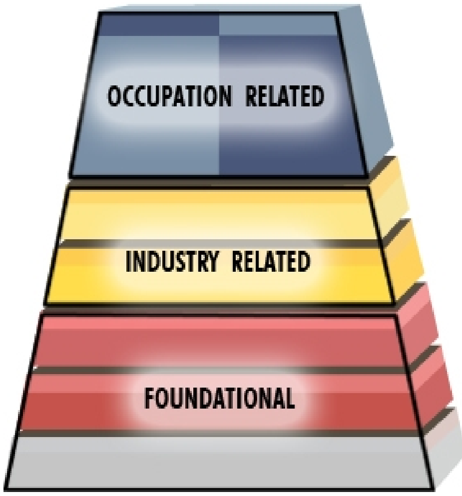
Cognitive Learning	Contents	Collaborative Learning
Problem	Interdisciplinary	Teams
Project	Exemplary	Participant-directed
Experience	Theory practice	
Context		

The program begins with a team of students identifying the problem(s), formulating research questions, discussing methodologies, identifying and analyzing theories that may be relevant to the particular problem. This process allowed the students to have hands-on experience that developed their understanding of the social, cultural, economic and political implications of environmental planning and management. Analyses of the students' project reports suggested that they developed process competencies in addition to gaining technical knowledge and skills. For example, the knowledge and competencies gained in cognitive learning included problem-solving, project management, and contextual analysis. In the principle for contents, students gained subject-matter knowledge, technical skills, cross-disciplinary knowledge, and knowledge management. Collaborative learning competencies were collaboration, communication (oral and written) and project management and planning. The course was designed to address each of these principles. Teams of students were organized to research the problem, review the literature, and discuss the possible solutions for principle of cognitive learning; lectures, readings and supervision were provided to support the contents; and student-directed decision-making for conducting the project and completing the tasks followed the principle of collaborative learning.

Engineering educators at Michigan Technological University have used a similar model called Global Competency –Sustainable Futures Model for curriculum development (Fuchs and Milhelcic, 2007; Milhelcic, Paterson, Phillips, Zhang, et.al. 2008). The program focuses on international development using the Sustainable Futures Model: economic sustainability; environmental sustainability; and societal sustainability. Learning objectives are written using the Global Competency framework (Downey et. al. 2006) which requires students to demonstrate *knowledge*, develop *ability* and show predispositions for viewing engineering through sustainable futures constructs of economic, societal and environmental sustainability. This dimensions of the Sustainable Futures model and Global Competency assessment are reflected as the strategies of curriculum development as assessment in the *Pathways to Cleaner Production in the Americas* project.

Shifting paradigms around SD and the need for the standardization of sustainability competencies by engineering accreditation organizations (i.e. ABET), along with challenges in developing a body of knowledge and teaching materials and methods around sustainability are also discussed in a paper by Zhang et al. (2012). Pearce and Ahn (2010) also argue that desirable skills and competencies for engineering have received prominent recognition not only by accreditation organizations but by professional organizations such as the American Society of Civil Engineers (ASCE) in its Body of Knowledge (BOK 2) for the 21st Century. Among the competencies identified are teamwork, stakeholders management, business and public administration, management of uncertainty and the "ability to communicate and solve problems effectively and professionally with people from other disciplines and cultures; ability to decide and competence to act in ways that favor sustainable development; ability to think holistically and search for integrated solutions; ability to evaluate impacts and manage tradeoffs between technological, ecological, human, and ecological elements." Two clear challenges are to impart thinking that breaks through disciplinary divides and boundaries (Pearce and Ahn, 2010) and to train and empower students and faculty to explore unchartered options outside traditional technical tracks and take on a multiple perspectives approach (Ashford, 2004; Fenner et al., 2005).

Lead researchers for the *Pathways to Cleaner Production in the Americas* considered the Industry Competency Model sponsored by the U.S. Department of Labor, Employment and Training Administration. The interactive website provides a schematic as a pyramid with the first 3 tiers considered Foundational, the next two Industry Related, and the apex sections reserved for Occupation specific competencies.



Occupation Related
- Management Competencies
- Occupation-Specific Requirements
- Occupation-Specific Technical Competencies
- Occupation-Specific Knowledge Competencies

Industry Related
- Industry-Specific Technical Competencies
- Industry-Wide Technical Competencies

Foundational
- Personal Effectiveness
- Academic Competencies

Figure 1. Adapted from CareerOneStop is sponsored by the U.S. Department of Labor, Employment and Training Administration http://www.careeronestop.org/CompetencyModel/.

METHODOLOGY/APPROACH

To achieve the generation of a workforce with new knowledge, skills and attitudes toward sustainability through cleaner production, the partner universities modified or developed new courses, conducted workshops for capacity building of faculty and businesses in their communities, and incorporated experiential learning in practicums and internships. Faculty designed and developed curriculum and administered pre/post student assessments using Bloom's Taxonomy of Learning Objectives (Bloom, 1956) and Webb's Depth of Knowledge (Hess, 2006) for the cognitive analysis of the complexity of learning to determine gains in knowledge as well as achievements and challenges to adequate workforce preparation. Research questions were posed to investigate the validity of curriculum development, courses and practicum for progress toward accomplishing the goals. Specifically, the research questions generated for determining the impact of the experiential learning on the students include:

- What technical competencies do the students gain from the courses/practicum/internship?
- What social responsibility competencies do the students gain?
- What workplace competencies do the students gain?

Curriculum was developed for courses at each partner university, unique to the individual programs and institutional requirements. Most were undergraduate courses, although there were some graduate courses, but the programs varied from environmental science (El Salvador), to chemical engineering (Costa Rica), to industrial engineering (Dominican Republic and Honduras), to mechanical engineering (Nicaragua), to agriculture (Guatemala), and environmental business management (Peru). Faculty modified, adapted and created courses to address the information and strategies students need to address the environmental performance and productivity of MSMEs.

Workshops were designed to provide faculty professional development pertaining to the new curriculum, and were aligned with the project goals included in their courses. Objectives for the workshops were written in active observable terms, e.g. describe, explain, develop, etc. Pre/post assessments were designed and administered to evaluate the knowledge and skills gained from the information provided at the workshops. A Likert scale of 1-5 was used to indicate the extent of agreement with statements of knowledge and abilities pertaining to concepts of sustainable development and cleaner production; e.g. "I can describe…; I can apply…" As expected, the post assessments showed increased knowledge and skills compared with the pre assessments.

The more important and significant measure of impact of the program, and the topic of this paper, lies in the outcomes of the experiential learning resulting from the practicum and internships. The practicum/internship experience was developed as a collaboration with all the partner institutions including IIT, NYIT WEC and NCPC. The practicum was designed for students, individually or in teams, to work on-site at a local MSME in which they could apply their new knowledge and expertise in implementing cleaner production practices. This goal of the practicum was to allow students to provide guidance, technical advice and information essential to MSMEs to improve production capacities and reduce costs related to energy consumption, raw materials, and environmental pollution. WEC was responsible for facilitating the negotiations between the universities and the MSMEs as sites for the students. Students were expected to apply the knowledge gained in the course in a project at a local MSME. Minimum on-site time was 20 hours.

Students prepared project reports that demonstrated their ability to accomplish these objectives. Faculty assigned to facilitate the practicum courses reviewed the reports, and in some cases, required students to make presentations of their findings.

A survey of all student participating in the practicum was administered for further verification of student learning outcomes. Student survey questions were organized to reflect gains in knowledge, skills, and attitudes toward cleaner production; the challenges of the experience in the context of working with a business, and work skills for teamwork, communication and problem-solving; and the changes in perceptions of cleaner production, social responsibility, and their role in a work setting. The survey was designed using Survey Monkey. The faculty project lead at each university distributed the survey link developed unique for the university. Students volunteered to participate.

RESULTS AND DISCUSSION

The findings from the pre/post assessment surveys indicate a significant increase in knowledge, albeit self-report with little to no follow-up to assess application of the increased knowledge. The analysis of student surveys administered at the end of the course or program indicate additional self-reporting evidence of the development of competencies desired in the workplace, including skills, teamwork, communication and problem-solving.

The survey was multiple choice questions with basically two parts: 1) content and technical knowledge and perceptions of the benefits of cleaner production, and 2) practicum/internship experience. The stem for the multiple choice questions for the practicum/internship experience section included:

- What did you learn from the experience of internship/practicum**?**
- What did you learn about the challenges MSMEs encounter when implementing Cleaner Production?
- How did the practicum/internship change your perceptions of Cleaner Production?
- What were the benefits of being part of a team?
- What challenges lie in teamwork?
- How did the team change your perception of teamwork?

A total of 72 students from 6 countries responded to the survey. One university did not respond and another did not have students work in teams. The survey results for the question regarding what was learned from teamwork can be seen in Table 2 which shows that the students perceived that they gained skills in multiple areas attributable to their experience in the practicum or internship working as a team. Particularly strong across all participants are skills in collaboration, communication, commitment to the project tasks and work ethics. These elements reflect similar elements in the Foundational levels of the CareerOneStop Industrial Competency Model shown in Figure 1 and can be aligned to the social approach for the PBL principle of collaborative learning (DeGraaff & Kolmos, 2003; Kolmos & DeGraff, 2007). These social skills are essential in the workplace. The PBL provides the context for the collaborative learning which will be important to the employability of these students.

Table 2. Survey results for benefits of teamwork.

What did you learn about benefits of teamwork?					
Elements of teamwork. Multiple choice selections	Honduras (8)	Guatemala (38)	Costa Rica (3)	El Salvador (17)	Peru (8)
Collaboration	66.7%	59.1%	100.0%	88.2%	50.0%
Communication	50.0%	63.6%	66.7%	58.8%	75.0%
Commitment	83.3%	77.3%	33.3%	88.2%	100.0%
Defend an argument	0.0%	0.0%	0.0%	23.5%	37.5%
Professionalism	50.0%	40.9%	33.3%	82.4%	50.0%
How to give and take criticism	16.7%	54.5%	66.7%	5.9%	62.5%
How to give and accept feedback	16.7%	72.7%	100.0%	5.9%	75.0%
Respect for different perspectives	16.7%	50.0%	66.7%	29.4%	37.5%
The division of labor so that each could contribute	16.7%	45.5%	0.0%	5.9%	50.0%
Work ethics	83.3%	45.5%	33.3%	64.7%	62.5%
Time management	33.3%	59.1%	100.0%	0.0%	62.5%

Similarly, Table 3 shows students' personal perceptions of how the experience changes their perceptions of teamwork and the value of working with others. Again, the social skills indicate workplace skills and dispositions that will be valuable assets for the students in the workforce. It is clear that students successfully gained technical skills from the course work but the experiential learning provided the context for gaining and applying social skills needed for working with others in the workplace.

Table 3. Personal perceptions of teamwork.

How did the team change your perception of teamwork?					
I learned…	Honduras (8)	Guatemala (38)	Costa Rica (3)	El Salvador (17)	Peru (8)
To appreciate the work with	66.7%	50.0%	100.0%	16.7%	87.5%

other					
To respect the opinions of others	100.0%	72.7%	66.7%	50.0%	62.5%
To respect the diversity of knowledge and skills background	50.0%	50.0%	66.7%	66.7%	100.0%
to be responsible for my job	33.3%	36.4%	66.7%	83.3%	37.5%
To communicate better	66.7%	40.9%	66.7%	66.7%	37.5%
To be more professional	50.0%	72.7%	0.0%	83.3%	0.0%
the value of work ethics	50.0%	36.4%	0.0%	83.3%	0.0%
To manage my time better	33.3%	68.2%	0.0%	66.7%	25.0%
I did not change my ideas about teamwork	0.0%	13.6%	0.0%	0.0%	0.0%
I found I did not like teamwork	0.0%	9.1%	66.7%	0.0%	50.0%
I found it difficult to work with others	16.7%	9.1%	0.0%	0.0%	0.0%

The students' reports of the challenges of teamwork encountered in the experiential learning practicum or internship field work in Table 4 overwhelmingly indicate that miscommunication was the biggest barrier. The second most common response was lack of similar backgrounds within an interdisciplinary field such as sustainability in cleaner production, will be a common occurrence in the workplace.

Table 4. Challenging aspects of teamwork.

What were the most challenging aspects of teamwork?

Challenges	Honduras (8)	Guatemala (38)	Costa Rica (3)	El Salvador (17)	Peru (8)
Miscommunication	75.0%	45.5%	66.7%	33.3%	75.0%
Insufficient skills	0.0%	13.6%	0.0%	33.3%	0.0%
Lack of similar backgrounds	50.0%	86.4%	33.3%	50.0%	50.0%
Lack of similar work ethic	12.5%	9.1%	33.3%	0.0%	12.5%

Takes too much time	0.0%	36.4%	0.0%	0.0%	0.0%
Other team members did not do their part	0.0%	13.6%	0.0%	50.0%	0.0%

CONCLUSIONS

The conclusions from this study can be described in lessons learned. Students learned the complexity of technical issues related to decision-making for sustainable development in cleaner production. They also learned the complex dynamics of working with others in team collaboration. The student participants also point to the lessons that communication with others who have different background and perspectives is challenging, and requires time and respect for diversity. On the other hand, faculty learned that the multi-dimensional decision-making perspectives involved in sustainable development are difficult to capture in the curriculum and experiential learning. Lessons also involved faculty, students, consultants and project leaders learning to assist MSMEs in evaluating best practices and decision-making that promotes sustainable development in cleaner production in the context of the legal, economical, resources available, and belief systems at the national level.

In a recent correspondence from a WEC official working with the project, he indicated that many university programs focus on the students' "abilities and skills", rather than on *competencies* for applying abilities and skills in a dynamic problem-based learning (PBL) situation where the 'competence of learning to learn' is of utmost importance superseding basic skills. As described by Lehmann, Christensen, and Thrane (2008), this project, *Pathways to Cleaner Production in the Americas* illustrates their premise that having technical competencies for problem-solving and producing innovative solutions is only one element of the approach, but there is also the need for interdisciplinary skills of cooperation, communication, project management and life-long learning in a multi-nation project involving multiple disciplines and approaches to complex global environmental issues. As technology advances, innovations develop, and systems change, technical solutions and approaches will change, but the need for communication, collaboration, and continuous learning will prevail.

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