Experience-Based Learning: Global Engineering Culture and Society

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Christine Masters is the Assistant Dean for Academic Support and Global Programs and a Teaching Professor in the Engineering Science and Mechanics Department at the Pennsylvania State University. In between raising for great kids with her husband of 31 years, she taught large enrollment statics and strength of materials courses for 12 years and has been leading the Penn State COE student services team for the last 5 years and loves every minute of it!

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I am a visiting assistant professor at Lycoming College. My research interests are 20th-21st centuries Latin American literature and culture; cultural and intellectual history; intersectionality between aesthetics and politics; cultural and historical dynamics of literature and performing arts.
**Work in-progress: Experience-Based Learning in Global Engineering Culture and Society**

**1. Motivation**
In September 2015, more than 190 members of the United Nations (UN) committed to 17 Sustainable Development Goals (SDGs) [1] for bringing equality across the world. Among these goals are poverty reduction, quality education, sustainable cities and communities, and the preservation of Earth’s life-support system. In the Spring of 2017, the leadership at the Pennsylvania State University (Penn State) created an environment to help facilitate collaborations with Universidad Nacional de Ingenieria in Lima, Peru (UNI) by conducting a workshop in Lima, Peru and providing seed funds to foster collaborations in research, teaching, and service between these institutions. In addition to addressing the UN SDGs, these engagement activities seek to create and sustain and international collaboration in a platform known as the fourth age of research [2]. Following these initiatives at Penn State and recognizing the need to prepare our students to make a meaningful contribution to the implementation of the SDGs, we developed a six-week long faculty-led program called: *Global Engineering Culture and Society*. This paper describes the overall vision of the program, and focus on the design, development, implementation, challenges, assessment plans, and what is next for the course: Global Engineering Culture and Society. It provides the rationale for curriculum implementation, and the integration of SDG’s topics into the course material.

**2. Vision of the Program**
This project has significant institutional support, as Penn State and UNI entered into a university-wide strategic partnership agreement. UNI provides local resources, faculty, coordination and local students. At Penn State, the Cross-cultural Engagement and STEM Program has been added as a faculty-led program in its portfolio of approved perennial study abroad programs. The Cross-cultural Engagement and STEM Program represents a joint educational initiative, focusing on cultural immersion, exchange and STEM activities between Penn State and UNI. In this program, up to 30 Penn State students can travel to Lima, Peru from May through the middle of June, annually. Up to 15 students from UNI can also participate in this program as part of the *Global Engineering Culture and Society* course. Students from both institutions will grapple with open-ended projects that stimulate intercultural competence, interaction, and collaboration. In addition to providing undergraduate students with a cross cultural engagement and STEM-related study abroad opportunity, the program also: 1) Expose them to the use of scientific methods in developing a problem statement revolving around identified global challenges; 2) Give them an experience-based understanding of the value of multidisciplinary teams, and; 3) Require them to investigate contemporary issues in a broader global context. From Penn State side, a critical piece of this initiative is the targeting of a diverse student population to include underrepresented and minority participants, as well as those with high-levels of demonstrated financial need. One important aspect built-in the program is providing scholarships to these students. Research has demonstrated that study abroad experiences improve retention and graduation rates, particularly for high-risk populations [3].

**2.1 Program Objectives**
This program intends to create the opportunity for Penn State and UNI students to engage in transformative experiences by critically analyzing the role of engineering and scientific
knowledge in Latin America through cross-cultural experiences in Peru, with these three specific objectives:

1) **Increase Access to Study Abroad in Latin America**
   At Penn State, there are currently no programs that have an emphasis on engineering and science challenges in Latin America. Additionally, students can find engineering education to be “too narrow and lacking the passion of other field [whereby] students learn more by grappling with open-ended problems” [4] but have limited access to these learning opportunities. In the United States, only about 21% of the study abroad population are minority and low-income students [5]. In comparison, we intend to bring our minority student participation rates to over 30%, targeting 10 out of the 30 available slots specifically for minority and low-income students, an increase of approximately 43% over the national average.

2) **Increase Retention and Graduation Rates of Minority Students**
   Student participants in study abroad programs benefit by gaining higher retention and graduation rates as compared to those who do not participate. This benefit has been “observed across a wide variety of variables, including race, gender, major, first-generation status, parental income, SAT score, and grade-point average” [5], and as an intervention for the success of at-risk students [6].

3) **Leadership and Intercultural Competence**
   Study abroad programs provide a unique contribution to college outcomes, such as understanding moral and ethical issues, communication skills, academic performance, and overall satisfaction [7] as well as increasing understanding of “aspects of globalization and the importance of cross-cultural development in relation to the globalization” [8]. Students who participate in study abroad experiences have the opportunity to gain these skills and knowledge which will enhance their leadership potential and their competitiveness in both the national and global market. The program also seeks to strategically increase intercultural competence of the participants [9].

3. **Design of the Courses**
   This 6-week, faculty-led, interdisciplinary program in Peru involves student cohorts comprised of both Penn State and UNI students. The courses are created to help ensure that both participant groups are provided the opportunity to improve their language and cultural competences, as well as scientific knowledge and teaming skills in addressing the UN SDGs. Penn State students will earn 6 credits through taking two courses: *Global Engineering Culture and Society* and *Spanish through Peruvian Culture*. The utilization of local resources as an integral component of the academic experience allows all participants to explore global engineering culture and social issues through multidisciplinary, cross-cultural teams.

3.1 **Course: Global Engineering Culture and Society**
   This course is taught in English, and it is highly beneficial for Peruvian students to develop their English language aptitude. Additionally, it is equally valuable for Penn State students as they meet the cultural and language challenges of the host country. Regarding the need for UNI students to improve their English, according to the EF Education First English Proficiency Index (EF EPI), a global benchmark to measure and track English proficiency in adults over time, Latin America has a low level of English proficiency with Peru in the middle of the pack. The implications of this cannot be understated as, “English is key to a country’s economic development” [10].
The key learning objectives of the course are:

- Develop an appreciation of, and describe how, engineering issues and the SDGs relate to Latin America.
- Demonstrate an understanding of the broad parameters of a technical problem that afflicts society at large with an emphasis on Latin America.
- Determine how to approach a technical problem from transnational and interdisciplinary perspectives.
- Utilize a systems approach to define a technological problem, and illustrate how a systems approach can be employed to devise engineering solutions that benefit specific communities, and humanity at large.
- Produce and interpret information on sustainability goals in order to conduct outreach activities.
- Apply the intercultural knowledge developed in the specific host country in Latin America in communication scenarios connected to its local reality and the United Nations SDGs

3.2 Course Implementation
The course was partitioned in two-week modules to facilitate faculty participation from Peru and the United States. The course delivery began right after the end of the spring semester in the United States. Student population for this course was composed of 90% from STEM fields and about 10% from NON-STEM fields from Penn State while the students from UNI were 100% from STEM fields. The course was composed on average (fluctuations in student participation from the local institution were due to misalignment with the local academic semester) with 25% students from UNI and 75% students from Penn State. Each module was taught by a pair of US-UNI faculty to ensure cultural and pedagogical aspects were fully integrated in each module. The full description of each module of the program between May 6- June 16, 2018 is provided in the Appendix.

4. Challenges
The program is intentionally designed to maximize the potential gains in intercultural development among cross-cultural teams by creating learning opportunities among mixed teams comprised of Penn State and UNI students from across disciplines. But due to the misalignment of academic year in UNI with respect to the academic year of Penn State, it was difficult to keep the same cohort of local students in all academic activities. A solution to this challenge is currently being explored with UNI leadership to create a special requirement in their curriculum to facilitate and encourage participation of their students in the course. It is worth mentioning that participation of mixed students on excursions was in itself a very positive experience for both local and American students in helping them build relationships and encourage them collegiality among all the participants.

This program can accommodate 30 Penn State students and 15 UNI students. At the institutional level, Penn State’s College of Engineering has a strategic goal of 25% participation in education abroad, currently sending 12% of students abroad each year. A major challenge for the participation of underrepresented/minority and high financial need students in the course is the cost of the program. At Penn State, we are actively finding scholarships to enable the
participation of these students. We expect to provide a baseline with the first cohort of students and communicate the outcomes of the program in order to attract corporate sponsors and further institutional buy-in.

In general, the main barriers in increasing student participation at Penn State are visibility, access and curricular integration of the program. These challenges are being addressed through a partnership with academic units, marketing, public relationship, pre-emptively approved credits (integrated with the curricula), low program fees and providing scholarships.

5. Assessment Plans and What is Next?
Currently, Penn State is developing an assessment plan that will begin in April 2019. We will collect data that includes quantitative and qualitative indicators to monitor progress toward meeting the goals of the program. For example, gathering raw numbers and rates of underrepresented and low-income students who participate in the study abroad program and complete their academic program with an academic degree. We expect higher numbers of underrepresented students who participated in this study abroad program will graduate with an academic degree than those counterparts who did not participate. Participants will be asked to provide informed consent to have access to information about their matriculation at Penn State. The increased engagement with the outcomes of retention and graduation will be evaluated by monitoring the number of academic semesters that students complete after participating in the study abroad program, as well as a comparison of the rate of graduation of those who participated in the study abroad program against those who did not participate. A result that indicates a trend in increased academic semester completions and graduation rates will provide data to support the success of the study abroad program.

We will evaluate increased access to intercultural and international experiences [13], particularly those in STEM fields and those who identify with minority, low income, and/or underserved populations by reviewing the demographics of student participants of the study abroad program, such as ethnicity, financial need and major. Leadership development in the form intercultural sensitivity will be evaluated by the comparison of pre- and post-assessments of student participants’ intercultural sensitivity [14]. We plan to examine graduation numbers and rates, by comparing program data against historical data and if possible, a matched control group using analysis of variance. We also plan to study whether completion varies by personal characteristics by using multiple regression analysis.

We intend to offer this program this year focusing on food, water, and energy, and therefore addressing UN SGD 2 Zero Hunger, SDG 6 Clean Water and Sanitation, and SDG 7 Affordable and Clean Energy. We plan to keep one professor from Penn State as an instructor for this year and add the participation of two new professors for the engineering course. A new professor will teach the Spanish course. In UNI, two professors that taught the engineering course last year will teach this year and they will add a new professor to the team.

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Appendix

Contents of Global Engineering Culture and Society Course

Module 1: Weeks 1-2, United Nations SDG-11 Sustainable Cities and Communities, focusing on accessible and sustainable transport systems

The first module addressed the overall vision of the course and smoothly transitioning into UN SDG-11 Sustainable Cities and Communities, targeting smart cities concepts to provide Earth’s life support system.

Specific objectives of this module

Students will learn: (i) engineering issues and the UN sustainability goals related to Peru, (ii) how to approach a technical problem from transnational and interdisciplinary perspectives, and
(iii) how to devise engineering solutions that benefit specific communities. Students will also learn how to learn “just in time” engineering tools like Mblock [11] and Blynk [12] to solve topics under SDG-11 related to the host country.

**Module Contents**
This module addressed the following topics: 1) UN Sustainability Millennium Goals, and Smart Cities Concept (Application to Lima City); 2) Embedded systems overview, components of an embedded system and applications; 3) Introduction to programming using mBlock; 4) Sensors and actuators, acquisition and control; 5) Programming applications, brainstorming on what problem you could tackle in Peru; 6) Internet of Things, 7) Signal acquisition using IoT concept and tools: Blynk; and 8) Project formulation and development.

**Evaluation:** Each topic was aligned with a laboratory assignment, problem identification, group (2-4) oral presentation, and a final project deliverable.

**Module 2: Weeks 3-4, United Nations SDG-4 Quality of Education**
The second module focused on the integration of vectors, geometry, trigonometry, and experimentation for analysis of scientific phenomena and engineering systems, addressing UN SDG-4 Quality of Education.

**Specific objectives of this module**
Students will learn to apply mathematical concepts to determine: (i) forces and stresses in static systems comprising linear elements, (ii) reflection and refraction of light from plane interfaces, and (iii) current in a simple circuit. Students will also learn to take measurements of environmental variables in the field.

**Module Contents**
This module discussed these concepts: 1) Rectilinear geometry and trigonometry, vectors addition and products; 2) Reflection and refraction of light, application for polarizing filters, agriculture, and biology, 3) Atmospheric pressure experiment and intensity of light at high altitudes, 4) Voltage, current, resistance, capacitance, inductance, and transformers, 5) Flashlight circuit, RL and RC circuits, 6) Water purification experiment, 7) Free-body diagram and static equilibrium, 8) Internal forces in simply supported beams and columns; relate to houses and bridges, and 9) 2D truss analysis; Compressive and tensile stresses in a simply loaded beam; Young’s modulus.

**Evaluation:** Every student will write a 500-word reflection for evaluation. Students will also write reports for experiments carried out in class. Students will write reports on a visit to an ancient civilization construction in Peru. They will be required to analyze what they were taught about structures and strengths of materials.

**Module 3: Weeks 5-6, United Nations SDG-11 Sustainable Cities and Communities, focusing on making cities and human settlements inclusive, safe, resilient and sustainable**
The third module focused holistically critiquing design-related strategies that can be used to accelerate the implementation of the targets of UN SDG 11. This module also included hands-on activities of GIS-based simulation tools.
Specific objectives of this module
Students will learn: (i) how to draw case studies from Peru’s disaster context, (ii) to understand the risk and vulnerability in this country including the use of GIS-based tools, (iii) to assess the impact of previous disasters and Peru’s emergency management organization and laws, challenges and successes, and (iv) to analyze Peru’s emergency management system.

Evaluation: Students will write a reaction paper on why are transdisciplinary partnerships critical to successful realization of a sustainable outcome? A final report and presentation based on class hands-on activities and on-site visits to specific sites in Peru.

Module Contents
This module focused on these concepts: 1) Introduction to sustainable and hazard buildings, 2) Cities and communities, 3) Designing mitigation, earthquake simulator, flooding and mudslide resilient structures, 4) Developing a concept for group project choosing from the these options: earthquake, flooding or mudslide resilience, 5) Risk assessment and prediction, 6) Policy regulatory framework: design standards, codes and SDGs, 7) Developing a low fidelity prototype for disaster concept, 8) Sensors, big data and smart cities and resilience, and 9) State of the art review: Disaster warning systems.