

The Role of Multi-Cultural Experiences and Experiential Learning in Engineering Education

Jennifer Tanner¹; Mary Katherine Scott², Jorge Varela³

Abstract: As our world becomes more global, it is increasingly important to expose students to multicultural experiences. However, this can be tough to manage when fitting a variety of technical classes within a degree program. Furthermore, engineering students and advisors generally prefer to streamline their studies and take as few classes as possible. Recent changes at the University of Wyoming (UW), have helped to make short-term study abroad experiences more accessible for engineering majors. This paper presents the results of a vigorous effort to activate a study abroad experience between two partner universities, Autonomous University of Yucatán (UADY) and UW. Funds from an ExxonMobil sponsored “Partners in the Americas” grant were used to prepare and deliver at UW a short-term intensive summer class on masonry for six UADY students, a professor, and their Dean of Engineering. In addition to this course, a fundamental part of this visit was to discuss and collaborate on methods to remove barriers to studying abroad. In addition, students built and tested masonry prisms and reinforced beams. Six months later, “Culture and Engineering of Ancient Mexico,” a short-term faculty-directed study abroad course focused in experiential learning was developed to bring eleven students from UW to the Yucatan Peninsula of Mexico. Pre-departure presentations and meetings at UW were organized to help prepare students for the study abroad experience. The class was very well received. As a result of both courses, bi-lateral mobility has increased between UADY and UW.

¹ Associate Professor, Civil and Architectural Engineering University of Wyoming, tannerj@uwyo.edu.

² Visiting Assistant Professor & SOAR Coordinator, Honors College, University of Wyoming.

³ Professor, Civil Engineering, Autonomous University of the Yucatan, Merida, Mexico.

INTRODUCTION

As our world becomes increasingly global, the role of international skills for engineering becomes even more important. Živković (2014) asserts that “today’s global, competitive and rapidly changing world needs young people who are flexible, active, innovative and creative in problem solving and decision making, who can communicate effectively and work collaboratively.” In an effort to develop young people’s skills, a collaboration was developed between the University of Wyoming (UW) and the Autonomous University of the Yucatan (UADY) located in Merida, Yucatán, Mexico. The project was supported through a grant from Partners in the Americas (PitA), sponsored by ExxonMobil, with a goal of increasing mobility between the United States and Mexico. It capitalized on invigorating an existing professional relationship between authors Tanner and Varela, and Scott’s ongoing field research at archaeological sites in Yucatan.

BACKGROUND

A strategic plan for the University of Wyoming (UW) lists four major goals: (1) driving excellence; (2) inspiring students; (3) impacting communities; and (4) becoming a high-performing university (UW Strategic 2018). The second goal is further explained within the strategic plan to “Inspire students to pursue a productive, engaged and fulfilling life and prepare them to succeed in a sustainable global economy” (UW 2018). The development of this interdisciplinary study abroad course has expanded the horizons of students from both participating universities. Benefits of becoming more globally aware are echoed by the Structural Engineering Institute (SEI) in asserting that:

“The need for new infrastructure in parts of the world that are undeveloped or underdeveloped will emerge as a major opportunity for structural engineers worldwide.

Structural engineers with adequate language and cultural skills, and an understanding of indigenous construction materials and techniques, can look forward to tremendous opportunities in places like Asia, South America, and Africa. (SEI 2013)”

In addition, the SEI further states that “In order to lead the world in structural engineering we must embrace globalization and immerse ourselves in other cultures. Engineers who work on projects in other parts of the world should speak the language and understand the people they serve”.

The international experiences described in the paper used experiential learning techniques to assist students in their learning process. As articulated by Kolb (2019), four facets of experiential learning and descriptions are described below and the cyclic nature is illustrated in Figure 1.

- 1. Concrete Experience** - (a new experience or situation is encountered, or a reinterpretation of existing experience).
- 2. Reflective Observation of the New Experience** - (of particular importance are any inconsistencies between experience and understanding).
- 3. Abstract Conceptualization** (reflection gives rise to a new idea, or a modification of an existing abstract concept. The person has learned from their experience).
- 4. Active Experimentation** (the learner applies their idea(s) to the world around them to see what happens).

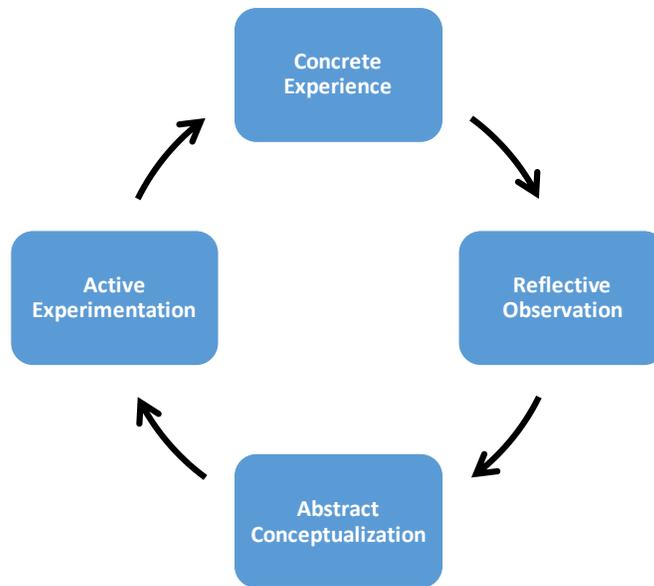


Figure 1: Cyclic nature of experiential learning, Kolb 2019.

SHORT-TERM CLASS ON MASONRY FOR UADY STUDENTS VISITING UW

In June, 2017, a UADY group of six students, one faculty member, and the dean of Civil and Mechanical Engineering visited Laramie, WY. The delegation flew to Denver, Colorado and then traveled to Laramie, with a stop for a picnic lunch at Vedauwoo Park. During this trip, adventurous students climbed up this massive rock formation to observe the geology of the region surrounding Laramie, Wyoming. They lived in the dorms for the week and ate lunches in the student cafeteria allowing them to experience campus life. Every morning for one week, the students participated in a class about designing and constructing masonry. Homework assignments were completed, and grading occurred as a group exercise during class. Students saw their mistakes shortly after making them and observed that others made similar errors. This practice can enhance learning and retention because students have the opportunity to see a better solution to a problem closer to the time that they made the error.

On the afternoon of the first-full day, students mixed grout and filled the cells of a preassembled, masonry beam. Four days later, on the last full day, students participated in

instrumenting, loading, and failing the beam as a laboratory exercise. Companion strength testing was performed on blocks and grout samples. Photos of the students during this visit are illustrated in Figure 2. These demonstrations offered students hands-on experiences that activated their learning, improved comprehension, and helped develop problem-solving skills. As a result of these activities, one of the students returned to Merida and recruited another two UADY students to spend the Spring 2018 semester studying at UW.



Figure 2: Photos of students during construction and after testing the masonry beam.

COURSE OFFERING FOR UW STUDENTS

One of the stipulations of the PitA grant was that UW students participate in a faculty-directed, credit-bearing study abroad experience. A new course was created and described in the UW course catalog as:

“Engineering and Culture of Latin America - A study of ancient engineering problems in Latin America that are applicable to civil engineering. Students will be exposed to cultural aspects that influenced Mayan infrastructure. Prerequisite: ES 2110 or PHYS 1210” (UW 2019).

During the development process, the instructors provided a non-specific description so that a similar class could be adapted and used in other parts of Latin America. The first course offering in January 2018 focused on the geographical region of Merida and the Puuc archaeological zone

consisting of Yucatec-Maya sites dating between the 8th-10th centuries AD.

Class Recruitment and Scholarships

Several informational sessions were organized to talk to students about course content, describe funding opportunities, and recruit participants. Scholarships were offered and assigned based on a course application that consisted of student information and an essay. The essay in particular helped the instructors to identify students with unique personal background or language skills who would be best suited for this course. The instructors followed up with individuals to learn more about their experiences and level of interest in the course. This exchange of information built the student-instructor relationship early on. The application process also served to identify those who had misconceptions about the class content or lacked the writing skills necessary to succeed. Scholarships were awarded and three non-refundable deposits were required at various stages prior to departure. A breakdown of the eleven participants based on engineering sub discipline and gender is summarized in **Error! Reference source not found.** It is interesting that this trip attracted nearly equal male and female students.

Table 1: Class participants based on engineering sub discipline and gender.

Engineering Sub discipline	Participants	Male	Female
Architectural Engineering	1	0	1
Civil Engineering	5	3	2
Chemical Engineering	3	3	0
Electrical Engineering	1	0	1
Energy Systems	1	0	1

Activities and Structure of Events in Mexico

Students and instructors (Tanner and Scott) traveled together from Laramie, Wyoming to Merida, Yucatan in January 2018. In the city of Merida, the group participated in an historical tour of the city and observed the colonial architecture built by the Spanish conquistadors in the early 16th century. Next, the student delegation visited the UADY engineering campus. Students received an overview of their departments from the dean and a tour of their laboratories from faculty members and graduate students. One of the common realizations for the UW students is that both institutions have similar laboratory equipment and capabilities when comparing the undergraduate curriculum at UADY and UW. Another facet to the time spent at UADY was an introduction to Maya history and culture, to help contextualize the engineering feats this stone age culture had achieved in their architectural structures. UADY students and faculty were invited to participate in the program and meals. Students quickly formed friendships and provided insight into student life in both locations.

The second week of the class was spent in Santa Elena, a small community located in the heart of the Puuc archaeological zone. Using this as a home base, the class went on daily excursions to ruins including Uxmal, Kabah, Sayil, Xlapak, and Labná. Additionally, a unique opportunity to visit an archeological site on private land that is not open to the public was presented and the group of students entered a system of caves used for Maya rituals. At this site, students also climbed an unreconstructed temple covered in undergrowth; at the top were impressive vistas overlooking the area. The opportunity for students to compare several reconstructed with one unreconstructed Maya archaeological site helped them understand the difficulty of restoring collapsed structures and consider other aspects of engineering practice including the ethics and politics of preserving cultural heritage sites.

Technical Assignments

A series of technical assignments were designed to promote experiential learning at the Puuc archaeological sites. Before departing for Yucatan, students reviewed structural concepts such as reactions, loads and completing free-body diagrams. Although this content is covered in the prerequisite course (Statics or Physics I), the diverse group of students meant they could have completed this class two or even three years ago, so a refresher was needed.

Once in Yucatan, the group visited all of the archaeological sites open to the public in the Puuc region. Each site had both fully reconstructed as well as unreconstructed temples and platforms, some that could be entered to observe interior constructions. Homework assignments were based on observation of these structures and on-site explanations by Tanner. While on-site, students were asked to sketch a structure and draw free-body diagrams that illustrated the load path from the structure to the foundation. Each assignment built on the results of the previous assignment to help students learn from their mistakes and correctly apply the concepts to the next one.

The first technical assignment included only gravity loads and assumed that the foundation was a simple, or pin, support. As students' knowledge and experience increased, the difficulty increased. For example, the second assignment considered internal moments and moments at the base. Lateral loads from wind were introduced as the final technical concept. An illustration of how specific concepts fit within experiential learning is shown in Figure 3.

The process of visiting several Maya archaeological sites exposed the students to typical 8th century construction methods, allowing them to complete the step of "Concrete Experience". "Reflective Observation" happened during the process of drawing the structure. The process of completing free-body diagrams and recording the load path from the structure down to the

foundation served as “Abstract Conceptualization”. Finally, “Active Experimentation” is achieved by fixing mistakes and completing increasingly difficult assignments that build on the previous. A breakdown of how each experience fits within the four tenants of experiential learning is illustrated in Figure 3. Due to the iterative nature of the assignments, it was important for students to receive feedback quickly. Just as it was with the visiting students from UADY to UW, the UW students received corrections closer to the time that they made the mistake, which made them less likely to repeat that particular mistake in subsequent assignments.

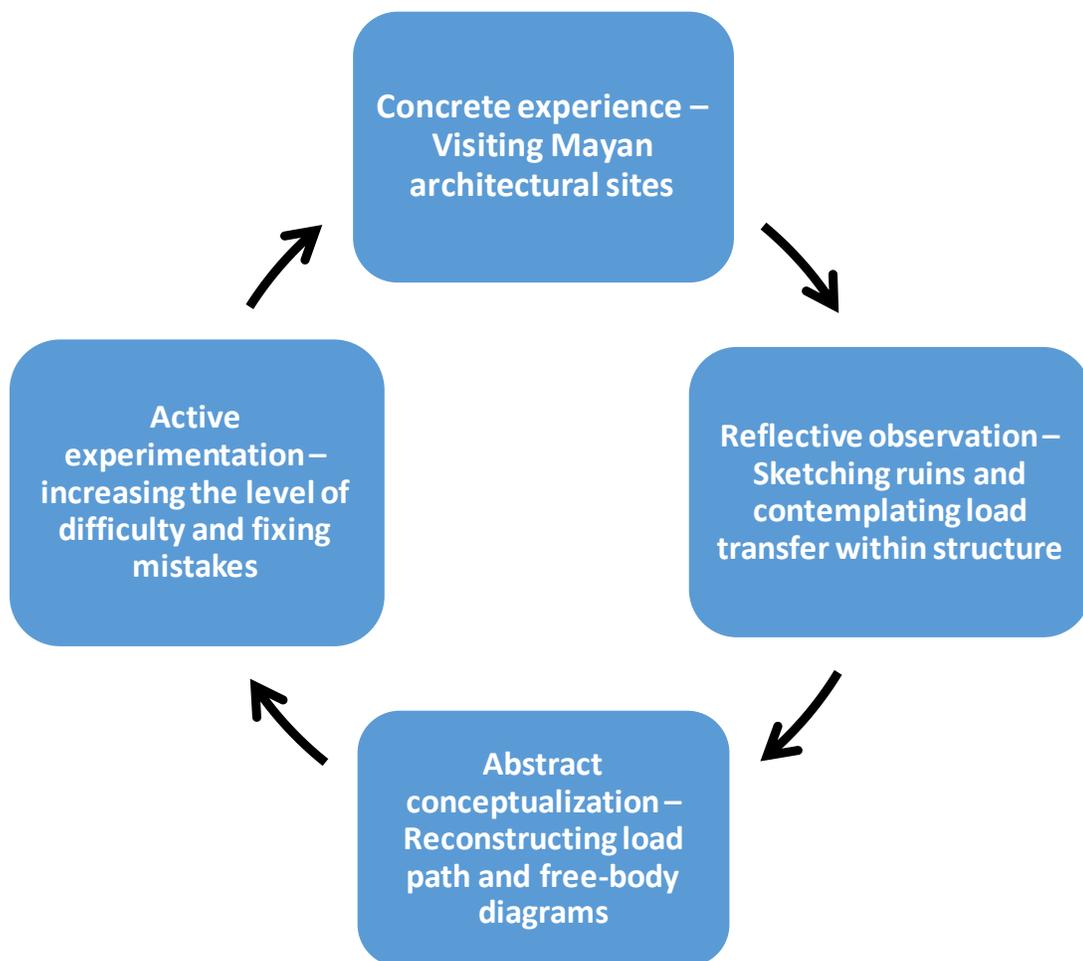


Figure 3: Application of experiential learning in homework assignments.

Cultural Assignments

The integration of the humanities into an engineering science course was critical for students to understand the relationship between architecture and culture in Yucatan. As Harrison and Parks (2016) discuss, “such collaborations lead to more varied and textured learning environments for students entering a uniquely competitive and complex global world”. As such, the UW students learned not only *how* a temple was constructed (from an engineering perspective) with only stone tools, manual labor, and mechanical systems, but also *why* it was placed where it was, oriented to face a particular direction, and *how* it functioned ritually and astronomically. They also took into account the needs –physical, spiritual and otherwise—of the local populations who used these structures daily, and also how these archaeological sites have taken on new meaning in the context of a cultural tourism industry in Yucatan.

During their visits to the different Puuc archaeological sites, students had the opportunity to hear both from of their instructors as well as local historians, guides, and archaeologists about the history, religion, politics, architectural styles, and other areas relating to the pre-Columbian Maya people to the present day. The importance for students developing strong written and oral communication skills within STEM disciplines cannot be overemphasized. Just as pointing out mistakes to students in technical assignments improved learning and retention, similar learning occurs through cultural assignments. Neilsen et al. (2014) note that incorporating reading, writing and other literacy strategies into STEM-based curricula “is a first step in improving student learning and retention in science courses.”

Recognizing this, two writing activities were assigned that addressed a question related to a non-technical, humanities-based theme. To respond to the prompts, students were expected to draw both from on-site lectures, as well as their assigned readings (from their course packets), as

well as personal observations during site visits and of local customs, interactions with Maya people and other experiences. Students also kept a daily travel journal so that they could contemplate their experiences in Yucatan. This gave them the chance to record and critically reflect upon concepts presented in lectures as well as their active learning at the archaeological sites and interactions with local Maya culture. Not surprisingly, these activities also promoted deeper engagement with their surroundings, which made them more conscientious of being accurate in their writings and presentations.

Presentations

As noted above regarding the importance of developing strong writing skills, a series of three presentations were required to help students build their oral communication skills. Prior to departure, each student created an introductory presentation to share their background and why they were participating in the class. At the end of the study abroad portion in Yucatan, small groups of UW students summarized their learning and presented to UADY students and faculty at the Merida UADY campus. Finally, after all assignments were submitted, graded and returned, the same groups presented to other UW students and faculty in Laramie about what they had learned abroad. Each presentation received peer-to-peer feedback and instructor comments. The final presentations showed significant improvement in organization, content and confidence of the presenter(s), likely resulting from constructive comments from both peers and instructors at each stage. It was rewarding to see that even the most nervous students improved their skills through the sequence of presentations. Developing the skills to make successful presentations is essential to training engineers of the future (Direito et al. 2012; Sushila and Bakilapadavu 2017; Živković 2014).

Student Feedback

Course evaluations were conducted and the responses were overwhelmingly positive. Excerpts from the comments are listed below:

- Overall the trip was amazing! I learned a lot about the culture and engineering, and I would highly recommend this class to others if it continues to be offered. All of the
- assignments seemed to go right along with what we had been doing; the only difficult thing was that sometimes our "free time" to do homework got filled up with other
- group activities.
- Hands on learning definitely helped my understanding of load paths, and immersion into the culture of the Yucatán helped me understand what life is like- for every class of person in the Yucatán- better than a textbook could have.
- All of the choices of sites and the order we visited them in was great. (going from smallest to largest) Overall the entire trip was great and I feel like I learned about the
- ancient and modern Maya people and their methods of engineering.
- I really did learn a lot from this course, that may not be engineering related but I learned a lot about people, which I believe is even more important. This has been my favorite class yet and I will be recommending it to my fellow engineering students. Both professors are passionate about the course and know the material thoroughly.
- The study abroad itself was a good way to learn about the culture and engineering aspects of the Maya civilization.

Based on student feedback, a few changes will be implemented. Students will have opportunities to eat evening meals on their own, thus providing an opportunity to test their language skills. An additional pre-trip meeting will be conducted to review the structural engineering concepts of completing a free-body diagram and evaluating load paths within structures. Finally, more free time will be provided to allow the students to spend more time reflecting on their assignments.

MOBILITY BASED ON THIS PROJECT

Our global exchange agreement permits students to move back and forth between Universities without directly paying tuition, provided roughly equal numbers of students travel back and forth. As a result of the masonry short-term class, a group of three students from UADY attended UW during the Spring 2018 semester. Each student completed 12 credit hours that consisted of three undergraduate classes and a graduate masonry course. One of the

undergraduate classes was “Transportation Engineering”, an area of Civil Engineering that is not offered at UADY. Two of the three students returned to UADY to finish their undergraduate degree and the third decided to complete his degree at UW. Because of the international friendships that were made during the classes, several UW students have been visiting Merida during their summer and Spring Break periods.

As anticipated, there is a large demand for students who wish to study at UW. Unfortunately, few engineering students have the language skills necessary to spend a semester abroad studying primarily in Spanish. To resolve this issue, the Global Exchange Program is working to recruit students studying degrees in the humanities, specifically Spanish, to attend UADY and keep the existing program functioning in balance.

CONCLUSIONS

As a result of a grant to promote bi-lateral mobility between the United States and Latin America, a total of 23 students have studied abroad in a formal capacity. A short-term class in masonry and a faculty-led, three-credit engineering science course were developed. Both classes were well received, offered students broader, global perspectives, and impacted them in a myriad of meaningful ways. The interdisciplinary credit-bearing class in Yucatan likewise afforded UW students an opportunity integrate humanities-based perspectives into their STEM-based learning, as well as practice professional communication skills such as writing and delivering effective presentations, areas that are crucial to developing business opportunities for an engineering company.

REFERENCES

- Direito I., Pereira A., Oliveira Duarte M., "Engineering undergraduates' perceptions of soft skills: Relations with self-efficacy and learning styles." *Procedia-Social and Behavioral Sciences* 55 (2012): 843-851.
- Kolb D., <https://www.simplypsychology.org/learning-kolb.html#cycle>, accessed April 2, 2019.
- Harrison R.L., Parks B. "How STEM Can Gain Some STEAM: Crafting Meaningful Collaborations Between STEM Disciplines and Inquiry-Based Writing Programs." In *Writing Program and Writing Center Collaborations*, Myatt A., Gaillet L. (eds). (2017): 117-139. New York: Palgrave Macmillan.
- Nielsen, S., et al. "Embedding Multiple Literacies into STEM Curricula." *College Teaching* 62, no. 4 (2014): 121-128.
- SEI (Structural Engineering Institute), "*A Vision for the Future of Structural Engineering and Structural Engineers: A case for change*" A Board of Governors Task Committee Paper, 2013, pp. 46.
- Sushila S., Bakilapadavu G., "Teaching Soft Skills to Engineering Students: A Case Study of BITS, Pilani." *IUP Journal of Soft Skills* 11, no. 1 (2017): 29.
- UW - A strategic Plan for the University of Wyoming, 2017-2022*, Office of Academic Affairs, University of Wyoming, <http://www.uwyo.edu/strategic-plan/full-plan/>, accessed September 26, 2018.
- UW – Course Offerings*, Office of Registrar, University of Wyoming, http://www.uwyo.edu/registrar/university_catalog/es__.html, accessed April 2, 2019.
- Živković, Slađana. "The importance of oral presentations for university students." *Mediterranean Journal of Social Sciences* 5, no. 19 (2014): 468.