2017 ASEE International Forum:
Columbus , Ohio Jun 28
Paper ID #20759

Wastewater treatment in Myanmar: A multidisciplinary learning experience for engineering and science students from two countries

Dr. Chun Kit Chui, University of Hong Kong

Dr. Chui received the BSc degree in Computing Studies (Information Systems) from the Hong Kong Baptist University in 2004, the M.Phil and Ph.D. degrees in Computer Science from the University of Hong Kong in 2008 and 2010 respectively. He is interested in database and data mining research in Computer Science, as well as pedagogical research in computing education. He aimed to provide high-quality computing education to students in primary, secondary and tertiary levels in Hong Kong. He was selected for the University Outstanding Teaching Award (Individual Award) of the University of Hong Kong in 2015-16, and the Faculty Outstanding Teaching Award (Individual Award) of the Faculty of Engineering in 2012-13. He has also received the Teaching Excellence Award in the Department of Computer Science in 2011-12, 2012-13, 2013-14, 2014-15 and 2015-16.

Dr. Hayden Kwok-Hay So, University of Hong Kong

Hayden K. H. So received the B.S., M.S., and Ph.D. degrees in electrical engineering and computer sciences from University of California, Berkeley, CA in 1998, 2000, and 2007 respectively. He is currently an Associate Professor of in the Department of Electrical and Electronic Engineering at the University of Hong Kong. He received the Croucher Innovation Award in 2013 for his work in power-efficient high-performance heterogeneous computing system. He was also awarded the University Outstanding Teaching Award (Team) in 2012, as well as the Faculty Best Teacher Award in 2011.

Ms. Nyein Thwe Khaing, Dagon University

Ms. Nyein Thwe Khaing (Myanmar) is now a lecturer of English Department, Dagon University, Myanmar. She has been teaching at the university for 12 years. She received a bachelor's degree in English from Dagon University. She completed a master's degree in Arts from Yangon University. She is now doing another master's degree in education at Hong Kong University. She is strongly interested in teaching, doing research related to teaching and learning process and collaborating with other teachers from different academic fields.

Wastewater treatment in Myanmar: A multidisciplinary learning experience for engineering and science students from two countries

The ever changing technology landscape is driving engineering education to become increasingly global, cross-disciplinary, and collaborative in nature everywhere. Besides delivering technical knowledge in classroom, a comprehensive engineering curriculum must also engage students in practical learning experiences that place equal emphasize on professional skills training including teamwork, lifelong learning and social responsibility. These are traits that form the core competencies for not only professional engineers but also entrepreneurs.

Sharing the above vision, a group of engineers and scientists from University of Hong Kong, Hong Kong and Dagon University in Yangon, Myanmar embarked on a cross-country and cross-disciplinary experiential learning project to work on one of the major environmental sustainability issues of the 21st century – wastewater treatment. In this reported pilot programme, 16 engineering students from University of Hong Kong travelled to Myanmar for a weeklong programme where they worked with 40 students from Dagon University to study wastewater quality at Yangon, Myanmar. This project has enriched students' understanding on the importance of water, sanitation, and hygiene as keys to national development. They also experienced first-hand how engineering and science professionals can work together in developing solutions with real-world impact in wastewater treatment. Students from both universities collaborated in teams to design, develop, and deploy an experiment to examine the wastewater condition in Myanmar. Engineering students took the lead on the development of technologies (e.g. implementation of Arduino-based remote data sensing and cloud-based database) to measure and report the biochemical oxygen demand (BOD) in wastewater samples, which is commonly used as an indicator of the degree of organic pollution of wastewater. Science students took the lead on the wastewater sample collections, the experimental design and the reporting of the results beyond the project time frame.

In this paper, we report the design and delivery of the experiential learning project, the teaching and learning activities, the learning outcomes, as well as the evaluation results on the effectiveness of this project on professional skills training such as lifelong-learning skills, teamwork skills and global citizenship.

Introduction

Future engineers should nourish a sense of mission to make a better world with technological innovations. Engineering educators should engage students to explore the world, creating opportunities for them to learn about the needs of the underprivileged, and acquiring practical work experience in developing solutions with real-world impact. Research studies revealed that exposing students to international experiential learning can effectively enhance their professional skills competencies, including lifelong learning [1], teamwork in a multidisciplinary [2, 3] and multicultural [4] setting, and awareness of social responsibility [5, 6] and global issues [7]. These are the learning outcomes that we would like to achieve through this project.

In an effort to provide multidisciplinary and multicultural learning experience for our students, we establish cross-university and cross-country collaborative teaching and learning alliance to connect our students with reputable overseas universities around the world. By engaging students in collaborative learning activities such as field visits, group projects and presentations, they will have a chance to work with partners who are raised and trained in another culture and discipline on the design, implementation, integration and deployment of technology. This mimics the modern global engineering development scenario and defines a new teaching and learning initiative with respect to the professional skill aspects of engineering education in our programme.

The reported pilot project was started in September 2016 initiated by the engineering faculty at the University of Hong Kong in Hong Kong and the science faculty at the Dagon University in Yangon, Myanmar. Teachers from both universities worked together to design an experiential learning programme for students to work on one of the major environmental sustainability issues of the 21st century – wastewater treatment. 56 students participated in this project, including a science team from the Dagon University with 40 students (29 females and 11 males) and an engineering team from the University of Hong Kong with 16 students (6 females and 10 males).

The science team consists of undergraduate students in their first and second year of study in chemistry (10 students), botany (10 students), zoology (10 students), industrial chemistry (5 students) and computer science (5 students). The engineering team consists of undergraduate students at their first, second and third year of study in civil engineering (4 students), biomedical engineering (1 student), computer engineering (1 student), computer science (4 students), mechanical engineering (2 students), electrical engineering (3 students) and environmental engineering (1 student). Students in both universities spent 3 months to prepare for the trip and in January 2017, the engineering team travelled to Myanmar for a weeklong programme where they worked with the science team to study wastewater quality in Yangon, Myanmar.

Pre-trip preparations

Innovation in technology always occurs in response to human need. As a starting point of the project, we engaged our students to research into wastewater related issues of their countries, and to identify the challenges and opportunities their countries are currently facing. Wastewater treatment itself is a broad topic, giving students insights into most aspects of sustainability issues from technological, environmental, political as well as social perspectives. To arouse students' awareness of those issues, students from both universities started with initial explorations and prepared a quality review on the following inter-related topics prior to the trip.

- Water usage and water quality in my country.
- Water pollution, water contaminants and its related impacts in my country.
- Wastewater management policies in my country.
- Wastewater treatment methods, and technologies applied in my country.
- Wastewater monitoring mechanisms and technologies used in my country.

Through information gathering, literature review and field visits, students have enriched their understanding on the importance of water, sanitation, and hygiene as keys to local and national development, providing a starting point for more in-depth knowledge exchange and comparative analysis by students from both countries during the trip.

We also organized pre-trip training program and adopted a three-step practice to nurture innovative, knowledgeable and visionary engineers. First of all, we would like our students to gain inspirations from past breakthroughs. We believe asking "why?" is the first step in becoming an innovator, and the best way to foster an innovative mindset is to learn from major historical breakthroughs in the field. Therefore, we exposed students to important insights that came at various stages of technological development with respect to wastewater treatment and monitoring. We engaged students in learning by providing them with background reading materials and guiding them to critically analyse and discuss the revolutionary ideas that led to the breakthroughs. Secondly, we believe our students have to gain comprehensive and deep understanding of the latest discoveries and challenges in the field. Today's engineering education should equip students with knowledge of cutting-edge technologies such as 3D printing, artificial intelligence, augmented / virtual reality, the Internet of Things, robotics, big data analysis and cloud computing. We provided up-to-date and comprehensive learning materials for students to acquire knowledge of emerging technologies, and encouraged students to think of how engineers could exploit and adopt these new technologies in various sectors of society, including wastewater treatment and monitoring. We believe to create is to connect dots, and emerging technologies are "*lines*" to make those connections happen. Thirdly, engineers have to be visionary. We believe the future belongs to visionary leaders who see possibilities before they become obvious. Therefore we placed interaction with students as a priority, to know their characters and personalities, and developed their aspirations for using technology to create a better world through technological innovation. We prepared students for success by unleashing their unique potential and guiding them to develop their own vision of how technology can help shape a better future, in particular in dealing with the wastewater treatment and monitoring issues.

Students were also required to work in teams to acquire in-depth disciplinary knowledge and to prepare for knowledge exchange workshops for their collaborators. Both universities hosted student-led internal knowledge exchange workshops prior to the trip, in which students pre-ran their designed demonstrations, experiments and hands-on tasks. They also received feedback from their fellow team members for improvement. Multidisciplinary learning thus happened within the engineering team in Hong Kong, and within the science team in Yangon, respectively before the trip. For the engineering team, students gained broader insight on how various engineering disciplines can cooperate to provide a comprehensive solution in the wastewater treatment and monitoring process. Utilizing the engineering synergy, civil, biomedical and environmental engineering students shared their knowledge in measuring biochemical oxygen demand (BOD) in wastewater samples, which is commonly used as an indicator of the degree of organic pollution of wastewater. Electronic and mechanical engineering students introduced hardware technologies to automate the measurement process, which include techniques to calibrate sensing devices, to set up network and wireless communication components, to design and print circuit boards, and to apply electronic soldering to connect wires and electronic components with the printed circuit boards. Computer science and computer engineering students shared their programming knowledge to control the sensing devices, to manage and analyse backend data, and to construct frontend web interface for online reporting and monitoring.

On-site knowledge exchange

Multidisciplinary learning happens across engineering and science when both teams meet up in Yangon, Myanmar. To begin, students first presented their review findings on wastewater-related issues in their countries in an opening session. Then students took part in discussion sessions to compare and contrast the causes of water pollution, the treatment methods, the impact on citizens, the technology levels, as well as the government policies on wastewater issues in both countries. Furthermore, a series of workshops were hosted by the science team, from which the engineering students acquired scientific principles in the wastewater purification process, as well as the scientific methods to test and quantify the abundance of various kinds of organic and inorganic pollutants in wastewater samples. In the end, the engineering team in HKU hosted workshops for science students on the design and constructions of wastewater treatment plants and monitoring systems, the hardware and software technologies involved in measuring and reporting of wastewater conditions, and the design of system architecture, backend database and frontend interface to support large-scale analysis of wastewater data.

Project based learning in a multidisciplinary team

Students also gained first-hand experience on how engineering and science professionals can work together in developing solutions with real-world impact. In this collaborative learning task, students were grouped into 8 teams, with each team consisting of 2 engineers and 4-5 scientists. The project mission was to conduct field visits and to study different types of water pollution around the Yangon city, and ultimately to design a system for reporting the degree of organic pollution of wastewater in the sites.

The construction of the whole system requires collective efforts and contribution of engineering and science. Science students took the lead on the arrangement of site visits and sample collections. They have identified five different sites with the possibility of various types and degrees of water pollution: industrial plants, agricultural plants, underground water wells, freshwater ponds, and sewage drainages around Yangon city. These activities are of immense importance and valuable in particular to the engineering students from Hong Kong, from which they gained some vital skills in fieldwork and got acquainted with the current wastewater problem, solutions and limitations in an authentic setting.

With the wastewater samples collected and stored, students started to build engineering solution to automate the scientific experiment for measuring the degree of organic pollution in the samples. The scientific principle of the experiment is to measure the oxygen consumption due to biological organisms in the wastewater. The sample has to keep in a sealed container fitted with a pressure sensor. Pellets of sodium hydroxide that absorb carbon dioxide are added in the container above the sample level. As time passes, oxygen is consumed and carbon dioxide is released, which will then be absorbed by sodium hydroxide, and thus the pressure in the container decreases. From the drop of pressure, the sensor electronics computes and displays the consumed quantity of oxygen, which reflects the amount of organic pollutants in the wastewater.

We observed active cross-disciplinary collaborations throughout the whole process. Science students prepared the instruments for the experiments (a container and pellets of sodium hydroxide), arranged the setup of the experiment, designed the schedule of collecting readings, and interpreted the pressure readings. Engineering students prepared the necessary hardware components such as pressure sensors, microcontrollers, display monitors, and printed circuit boards. The whole team worked together to develop and deploy the system, which included applying soldering to connect various hardware components to the circuit board, installing the electronic parts into the glass container, and writing computer programs to read the values of the pressure sensor, to perform necessary calculations and to display the readings on the monitor.

Creativity is an integral part of the engineering design process. To foster creative thinking, we arranged brainstorming sessions for students to enhance the design of the current system. Students have taken a step further from the first design, and implemented the following enhancements during the trip.

- Some science students suggested that, as the device has to keep running for a few days, it would be more convenient to set up a database to store the pressure readings instead of recording them manually. To achieve this, engineering students helped to set up a server machine (Raspberry pi) and installed a database server (MySQL database). They connected the microcontroller with the server machine via Bluetooth, and updated the computer program to upload the pressure data to the database through executing SQL commands.

- Some engineering students suggested to set up a web portal for reporting the readings of multiple devices simultaneously. To achieve this, they further installed a web server (Apache web server) in the server machine and developed a web portal using web programming techniques (PHP, SQL, HTML, CSS and JavaScript) to display the pressure readings of multiple devices in a unified interface.
- Some science students suggested that temperature is also a factor in the experiment (keeping steady at 20 degrees Celsius). They suggested to enhance the system by adding temperature sensor to monitor temperature change in the entire experiment.

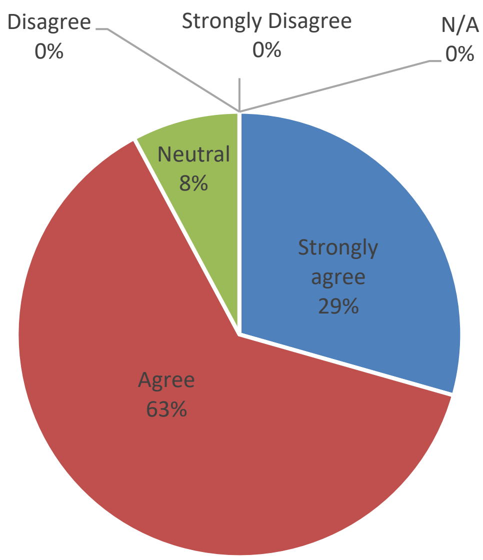
Feedback and evaluations

We conduct survey study to gather students' ratings and feedback on the effectiveness of the programme on enhancing disciplinary knowledge, cross-disciplinary knowledge, lifelong learning skills, teamwork skills and global citizenship. The programme consists of 56 participants, and we received 51 responses. In addition to the survey, students are required to write reflective essay on the followings aspects:

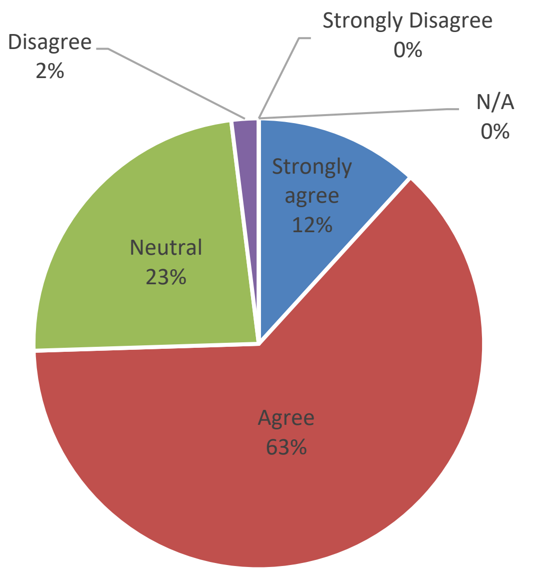
- What is your learning process and progress in the programme?
- What is the cross-disciplinary knowledge you shared / gained in the programme?
- What are the life-long learning skills you acquired in the programme?
- Have you encountered any barriers in collaborating with your teammates? What are the barriers and how did you overcome them?
- What is the most challenging aspect of your experiential learning?
- What is the biggest personal impact?

Learning disciplinary knowledge. As shown in Figure 1a, the majority of the participants agree (strongly agree: 29%; and agree: 63%) that they have enhanced their knowledge in their discipline through the programme. Neutral respondents make up the remaining 8%. We further investigate on how the T&L activities are related to students' learning by inviting them to elaborate on their learning process and progress along the journey. We observe that most students acquire solid disciplinary knowledge in the pre-trip stage through literature review, consulting senior students / professors, discussing with peers, and learning through online tutorials. In addition, the preparation of on-site knowledge exchange workshops further pushes students to revise, to integrate and to organize their disciplinary knowledge into a clear and concise presentation. (e.g., "*The "teach to learn" concept is a great opportunity for me to go through every aspect I have learnt in classroom, as my mission is to explain the concepts clearly and professionally to my friends in another field*.") Regarding the project based learning activities, students reflect that learning is mainly through applying disciplinary knowledge into practice in a real-world scenario. When they are engaged in problem solving tasks that require them to deploy their solutions on site, they face practical challenges that have never been taught in classroom settings. Students become more aware of the professional, legal and social issues and responsibilities of their discipline.

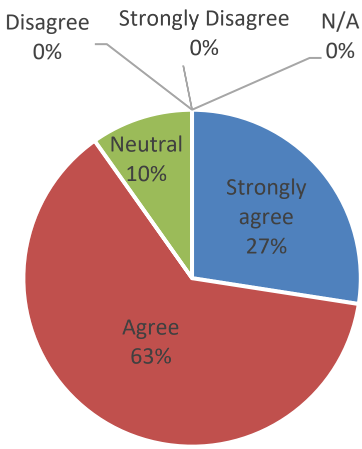
Learning cross-disciplinary knowledge. Students also gain knowledge in another discipline in this programme. Figure 1b shows that the majority of participants agree (strongly agree: 12%; and agree: 63%) that they have acquired cross-disciplinary knowledge through the programme. Participants who disagree are relatively low (disagree: 2%). To further



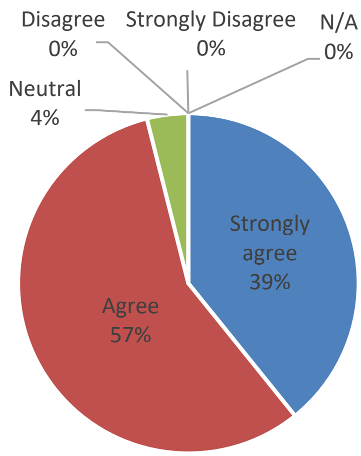
1a. Learning knowledge in my discipline



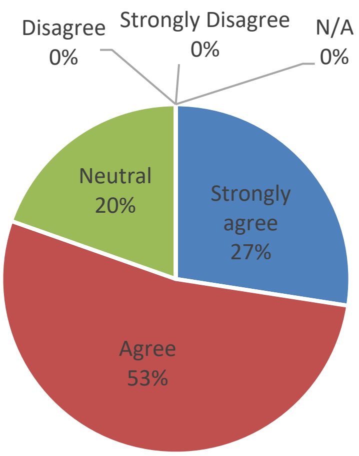
1b. Learning cross-disciplinary knowledge



1c. Life-long learning skills



1d. Teamwork skills



1e. Global citizenship

Figure 1. The result of survey study on the effectiveness of the programme on enhancing disciplinary knowledge, cross-disciplinary knowledge, life-long learning skills, teamwork skills and awareness of social responsibility.

investigate the extent to which cross-disciplinary learning is achieved, we invited students to elaborate on the knowledge they have gained in the programme. We found that students in general have acquired the concepts and techniques of other disciplines in the programme in a standalone manner (e.g., "*Due to the multidisciplinary nature of this project, we had to learn things from other engineering disciplines. The hands-on sessions allowed me to learn engineering and science concepts outside my core specialization, such as HTML, CSS, water sedimentation etc.*" - a student in civil engineering; and "*I learnt about chemistry and logistics involved in wastewater treatment.*" - a student in computer science; and "*As an electrical engineering student, I only have a little prior knowledge of chemistry and software technology. Fortunately presentations by DU students introduce the required science knowledge and the situation about wastewater in Myanmar.*" - a student in electrical engineering; and "*I learnt the basic of database and web programming from my schoolmates in HKU. They clearly explained the concepts and the operating principles of them."* - a student in mechanical engineering.). However, it is also noteworthy that the core difference between engineering design process and scientific method are not brought to the attention of the participants in their reflective writings. One of the respondents who chose "Disagree" raised a concern about the absence of an introductory session to provide a big picture on the core differences and similarities between science and engineering. In particular, engineering students should first know how scientists approach a problem. They construct hypothesis and conduct scientific experiments to test and to verify the hypothesis. Whereas science students should learn about the engineering design process, which include the process of defining an engineering problem, developing prototype, testing and redesigning the solution.

Lifelong-learning skills. The programme has also enhanced students' life-long learning skills. From the survey results in Figure 1c, we observed that majority of the respondents agree (strongly agree: 27%; and agree: 63%) that the program has enhanced their lifelong-learning skills. Neutral respondents make up the remaining 10%. We further investigated on how the programme helps our students to become good lifelong learners by inviting them to share their biggest learning gain in this regard. Students mentioned that they have learnt to design an efficient study plan under a tight time constraint. (e.g., "*Dealing with the various deadlines, preparing run-downs and drafts as well as gearing up for the challenges that lay ahead constituted a unique experience."*; and *"My time and resource management skills were tested and polished during this stage of our expedition.*"). Students also became aware that finding the right experts and asking the right questions are essential in the learning process. (e.g., "*I tried my best to dig deeper into the science topic and clear my concepts by asking a number of questions during the Q/A sessions with the students from various science fields.*"). Furthermore, students found that they got inspired and motivated when they worked and learned in a diverse team (e.g., "*I discover more aspects that I am not familiar with when I interact with non-engineering specialists. This has provoked me to learn deeper and wider. I think that is crucial in university learning, as well as lifelong learning.*").

Teamwork skills. The cross-disciplinary and cross-cultural setting in this program creates a unique opportunity for students to learn and practice teamwork skills. From the survey result in Figure 1d, we observe that most of the participants agreed (strongly agree: 39%; and agree: 57%) that the programme has enhanced their teamwork skills. Neutral respondents made up the remaining 4%. We further invite students to share the teamwork barriers they encountered and how they overcome those barriers. First of all, students found that it was challenging to explain complex disciplinary knowledge to collaborators with diverse backgrounds. (e.g., "*We had to go from the very basic definition, introducing lots of hands on and fun elements to help us put forward the concepts more efficiently.",* and "*I have to avoid technical jargons when I communicate with my teammates.*"; and *"I learnt the importance of being patient when conveying new concepts to people who might not have heard of them before, and having creative ways to explain the concepts such that the knowledge conveyed is the understanding of the subject rather than just a definition of it."*). Furthermore, students found that cultural diversity could possibly be utilized to create group synergy (e.g., *"I spent some great evenings with the Computer Science students from Dagon, we discussed about the differences in technologies and the schooling system in Myanmar and Hong Kong. To my pleasant surprise, we had some great academic and tech based conversation, I got to know about the opportunities that the CS students there have."* – a Computer Science student at HKU). In addition, nearly all respondents pointed out that language barrier is a main problem that hinders effective communication (e.g., *"This issue could be alleviated by slowing down the speaking pace and ask questions to see if they understand."*). After all, the project has been very successful in engaging students with diverse education and culture backgrounds to work together towards a common goal (e.g., "*The fact that we cherished the diversity within us and utilised the opportunity to work together to learn more about each other actually helped us overcome the cultural barriers between us and our colleagues in Myanmar.*", and "*Despite our differences, the project team members could be seen coordinating on various parts of our project, solving issues and sharing wonderful memories together.*").

Global citizenship. Figure 1e shows that the majority of the participants agreed (strongly agree: 27%; and agree: 53%) that the program has enhanced global citizenship. Neutral respondents make up the remaining 20%. The program has increased students' understanding of the wastewater and environmental sustainability issues around the world (e.g., "*I learnt things outside my field like how coding helps in environmental sustainability, wastewater treatment methods and BOD testing device technologies, and more importantly to raise the awareness of wastewater problem as well.*"). Furthermore, some students have developed sense of social responsibility (e.g., "*Being brought up in a developing country myself, I believe we can further introduce the success of our project in other countries in need of it.*"). Most importantly, some students have built commitment to the betterment of the world (e.g., "*To learn, innovate and put my technical knowledge to practical use and at the same time, allow me to give back to the community and contribute towards sustainable development in developing countries.*"; and "*To me, engineers make significant contributions to develop advanced technology to build a better world for mankind to live in. I hope that I can be one of the students who can bring new technologies and ideas to Myanmar, my experience can be useful in the future to keep helping those in need.*")

The way forward

With the experience of the pilot study, we identified two major aspects of improvement for the next visit. First of all, as modern engineering projects are often complex and involve multiple teams spanning several continents, discussion of project developments must rely on virtual communication channels such as emails or online meeting facilities. To prepare our students for such mode of working, we will engage students from both universities to start the discussion and planning virtually before the visit, preparing for more efficient on-site development and deployment, and to continue the collaboration virtually after the students return to their home universities. Furthermore, we believe it is important to incorporate business and management perspectives in the project. This will be achieved through building a more diversified team that consists of students from engineering, science, business and economics.

[1] Kolb, David A. *Experiential learning: Experience as the source of learning and development*. FT press, 2014.

[2] Herremans, Irene M., and Ron Murch. "Multidisciplinary decision making through experiential learning: Perspectives from practical trials." *Innovative Higher Education* 28.1 (2003): 63-83.

[3] Shartrand, Angela, Nathalie Duval-Couetil, and Teri Reed. "The Role of Entrepreneurship Program Models and Experiential Activities on Engineering Student Outcomes." *Advances in Engineering Education 5.1* (2016).

[4] Ng, Kok-Yee, Linn Van Dyne, and Soon Ang. "From experience to experiential learning: Cultural intelligence as a learning capability for global leader development." *Academy of Management Learning & Education 8.4* (2009): 511-526.

[5] Caulfield, Jay, and Treesa Woods. "Experiential Learning: Exploring Its Long-Term Impact on Socially Responsible Behavior." *Journal of the Scholarship of Teaching and Learning* 13.2 (2013): 31-48.

[6] Woods, Treesa R. "Experiential Learning and Its Influence on Social Change." (2011).

[7] Lutterman-Aguilar, Ann, and Orval Gingerich. "Experiential pedagogy for study abroad: Educating for global citizenship." *Frontiers: The Interdisciplinary Journal of Study Abroad* 8.2 (2002): 41-82.