From Zero to One: Integrating Engineering and Non-Engineering Students in a Service-Learning Engineering Project

C.K. LAU, The Hong Kong Polytechnic University
KENNETH W.K. LO, The Hong Kong Polytechnic University
STEPHEN C.F. CHAN, The Hong Kong Polytechnic University
GRACE NGAI, The Hong Kong Polytechnic University

1. ABSTRACT

Service-learning in engineering has been gaining attention as an effective way to provide students the opportunity to apply their theoretical knowledge to solve real-world problems faced by communities (Oakes et al., 2002; Soto & Dzwonczyk, 2015). At the Hong Kong Polytechnic University, the past few years have seen increasing numbers of non-engineering students taking service-learning subjects offered by the engineering departments, and working on engineering-type projects alongside students majoring in engineering. This is especially significant for international projects working in developing regions. This paper presents a project conducted in Cambodia in June 2016 as a case study as to how to integrate students from very different disciplines into the same project. Challenges that we faced during the training are discussed, followed by the outline of the course model, which may help educators develop a course to maximize the potential of international service-learning in engineering.

Key Words: service-learning, international projects, training

2. COURSE BACKGROUND AND PROJECT DESCRIPTION

International service-learning in engineering is defined as a form of experiential education in which students exploit hands-on field experience to address human needs, together with structured reflection to achieve desired learning outcomes (Jacoby, 1996). These projects require students to leave their communities and be immersed into a different culture and environment for a period (Ngai & Chan, 2015). The Hong Kong Polytechnic University has a long tradition of organizing engineering-related service-learning projects in local and offshore communities. Since 2005, our students have contributed over 15,000 man-hours of services to underprivileged communities, serving in China, Cambodia, Rwanda and Myanmar. In 2012, Department of Computing and Office of Service Learning co-operated and structured these projects into a credit-bearing service-learning subject which is available to all students as a general education subject. Each year, the subject enrolls around 120 undergraduate students. 40% of the students serve in the local community while 60% serve overseas. The projects also try to involve individuals from offshore universities and organizations, so the total number of participants in a given project could probably increase to 100. In 2016, the Cambodia service-learning project involved 70 students. 29 (41.4%) of them were PolyU students, 33 (47.2%) of them were university or associate degree students from Cambodia, and 8 (11.4%) of them were exchange students from various international universities. The academic disciplines of the participants are shown in Table 1.

C. K. Lau; Kenneth W. K. Lo; Stephen C. F. Chan; Grace Ngai, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, Emails: {chi-kin.lau, kenneth.wk.lo, stephen.c.chan, grace.ngai}@polyu.edu.hk

	Total number of students	Engineering- related Discipline	Non-engineering-related Discipline
Hong Kong students	29	10 (34.5%)	19 (65.5%)
Cambodian students from Royal University of Phnom Penh	12	0 (0%)	12 (100%)
Cambodian students from Human Resources Development Institute (Associate degree college)	21	0 (0%)	21 (100%)
International exchange students	8	3 (37.5%)	5 (62.5%)
	70	**13 (18.6%)**	**57 (81.4%)**

Table 1: Academic discipline distribution of the Cambodia team in 2016

There were two services involved: (1) installation of solar energy systems for rural villagers and (2) installation of a community learning center for a primary school.

(1) Solar Energy Systems

Following the principle of appropriate technology, the solar power solutions took the form of a public charging station shared between a group of nearby households. Families could recharge their battery from the station and each station could charge up to 6 batteries at the same time. Part of our projects involved wiring up homes and building LED lights from local sustainable materials, such as coconuts or palm branches.

(2) Community Learning Centre

The objective of the community learning center is to provide an informal learning space for village children and youths, both to supplement their regular school education, as well as to serve as a resource for continued education and self-guided study. The center is a second-hand 20-foot shipping container with a rooftop photovoltaic generator, ten machines installed with a full computer library, appliances (LEDs and USB devices) and a rainwater collection system.

Figure 1: Solar charging station library inside the learning centre

Figure 2: Community learning centre

Figure 3: Computer

3. CHALLENGES AND TRAINING OUTLINE

A service-learning project can be divided into three phases: preparation, execution and evaluation. The training usually starts at the beginning of the preparation phase and is a critical factor that directly affects the results of the project, especially

when engineering solutions are involved, and non-engineering students are participating. Some key challenges for teachers during the training includes: (a) equipping students with necessary knowledge, technical skills and hands-on experience; (b) empowering the non-engineering students to work on aspects of the projects, such as product design and system testing, that are more human-oriented and multidisciplinary; and (c) strengthening the teamwork between students from different disciplines and cultural background.

Recent observation suggests that the typical lecture-based learning as a teaching method seems not to be the most effective and efficient way to equip students, engineering or otherwise, with the necessary knowledge and hands-on skills within a short period. Therefore, problem-based learning pedagogy has been used. It is an instructional learner-centered approach that encourages the students to conduct research, integrate theory, and apply knowledge and skills to develop a solution to resolve a defined problem (Savery, 2015). For example, when we taught students about the abstract concept of electrical circuits, such as series and parallel connection, students were easily confused by the concepts of voltage and current. However, students could easily associate the characteristics with the phenomenon of light after experimenting with real circuits and real connections.

Therefore, apart from the lectures, different components were integrated into the training, for example, discussions on various case studies, practical workshops, site visit and intensive training. The training was carried out in a group approach; Students were divided into six groups and each group consisted of students from different disciplines, nationalities and seniority. The outline of the training for the students was shown in Table 2.

	Hong Kong				**Cambodia**			
	Lectures & Case Studies **6 hrs**	**eLearning module** **10 hrs**	**Workshops** **15 hrs**	**Intensive Training & Preparation** **15 hrs**	**Orientation** **3 hrs**	**Site Visit** **4 hrs**	**Intensive Training & Preparation** **32 hrs**	
Hong Kong Students	√	√	√	√	√	√	√	**85 hrs**
International Students		√		√	√	√	√	**64 hrs**
Cambodian Students					√	√	√	**39 hrs**

Table 2: Outline of the training

In summary, 46 hours of training were conducted in Hong Kong while another 39 hours of preparation were completed in Cambodia. For the training in Hong Kong, the lectures, eLearning module, workshops and case studies were conducted in February

and March, which was 3-4 months before the Cambodia trip.

Including the case studies from the university and international organizations, the lectures covered the topics of the digital divide and appropriate technology, which educate the students on the social aspects of the project. At the same time, to help students to understand the concept and practices of service-learning, and to equip them with the knowledge and attitudes for planning and conducting the projects, a 10-hour eLearning module covered these general background concepts. Starting from March to May, six workshops were conducted, focusing on the technical knowledge and hands-on skills as follows:

1. Usage of power and mechanical tools;
2. Basic electronic circuitry;
3. Laser cutting skill, soldering skill and assembly of LEDs;
4. Safety precautions on conducting engineering project in rural area, for example, risk assessment;
5. Installation of solar system; and
6. The introduction of Raspberry PI, a single-board computer was used as a server hosting e-Learning resources such as electronic books.

During the workshops, instructors presented a problem statement to the students first, followed by 30-45 minutes of lecturing. Then, each team had 90 minutes to conduct experiments or practice the skills. For example, for the solar panel tutorial, after introducing the installation procedures and presenting the basic construction of the station, each team had to identify the flaws and problems of the station and come up with solutions that used local resources, such as using palm leaf mats to prevent rain water contact; and using water pipes to construct a frame to direct rainwater off the surface of the solar panels. Since the international students arrived in Hong Kong 2 weeks before the project, they only participated in the 2-week intensive training and completed the eLearning module. During the intensive training, with the guidance of instructors, each group attended five sessions, during which they implemented, tested and evaluated their design of the solar charging system, LEDs and learning center accessories.

Once the team got onto the ground, the second phase training was put into motion and 33 Cambodian students joined the team. Their major was either in English or development studies. Even though they did not previously have contact with the team from Hong Kong, working in the same group for 7 hours a day and participating in various orientation and site visit activities strengthened the team spirit and helped them to understand the situation in the target community. The team spent four days testing and training in a local university to finalize the design, assemble the solar systems, LEDs and test all the deliverables. This on-site training allowed the Hong Kong and international students to transfer the knowledge and skills to the Cambodian students.

The training was followed by the project in which the deliverables were installed and the target community was trained to use the new equipment. The community was pleased with the project and they were put to use almost immediately. On the students' part, many of them suggested that the tangible nature of the engineering-type project was rewarding:

> "Besides, as a physics student, I know circuit diagram very well, while if I hadn't participated in the SL, I would never know how the circuit

> diagram is different from the real situation. In the diagram, all I need to do is to draw lines to connect electronic elements in series or parallel as long as it won't lead to short circuit. When I did the indoor wiring for a house, I realized the real situation was much more complicated. The diagram is only two dimensional, while indoor wiring is three dimensional. I had splitters, wires, clippers, lights, displays and switches on my hand, some of which I even hadn't heard in electric diagram before. I needed to design where I would place these stuff and connect them together to make all the lights function."

The engineering students felt that they had learned more about the human factors aspect of technology:

> "We were acting as a human factor in three layers: utilization, development, and popularization. First, to act the utilization layer, we were trying to adapt the technology into a practical form that can benefit the villagers. Secondly, I had a responsibility that I should help develop the current technology to make it become friendlier and bring more benefit to us. The last point, which is also the most important thing is that this factor should help ordinary people who have no engineering or science background understand how to use those technologies properly. The last step is the most important one."

Moreover, the students also felt that they gained an insight into the contribution of engineering to development:

> "I used to doubt why we choose to give them electricity and the Internet rather than giving them help in agriculture or education. Now I know that it breeds more possibilities. Having electricity can be the chance to continue your study, to enlarge your business or even to create something new. Engineering to me, is the basis for the development of a country, an auxiliary to other dimensions, and also an important way of making a difference."

Figure 4: Working together on the solar charging system

Figure 5: The charging station at full capacity, one day after installation

1. CONCLUSION

This paper has presented the challenges and solutions of guiding a mixed group of engineering and non-engineering students to conduct an engineering project. We have described the necessary teaching and learning activities that were used to help students understand the theory and concept of service-learning, motivate them to conduct the projects and workshops and equip them with the necessary technical skills while strengthening the intra-team communication and rapport.

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