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International service-learning projects on sustainable water management in higher education: a case study on improving water quality in a Cambodian village

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Abstract

Purpose: The first aim of this paper was to discuss the learning experience of university students who participated in a service-learning project on sustainable water management. By investigating the students' engagement in a real-world, community-based project, this study also aimed to provide insights into the effectiveness of service-learning as a pedagogical approach for sustainable development education.

Design/methodology/approach: This paper presented a service-learning project organized by The Hong Kong Polytechnic University on improving water quality in low-income communities. An overview of the project was provided, including the curriculum design, project contents, implementation process, as well as students' assessments, evaluation, and feedback. Based on students' assessments, the outcomes and impacts of this project were discussed. Additionally, several barriers were identified during this project, and corresponding suggestions were proposed to improve the service quality and increase its positive impacts.

Findings: The students established twelve water filtration systems to improve the water quality in an underserved village overseas. Apart from the benefits to the service recipients, the participating students experienced personal development and civic engagement measured in 10 aspects, including the application of classroom learning, adaptive problem-solving, creative thinking, community contribution, commitment to helping the disadvantaged, empathy and compassion, concern for those in need, moral commitment to civic affairs, multi-perspective analysis and informed decision-making.

Originality: Although the recorded project was not the first international service-learning project on sustainable water management, to the best of the authors' knowledge, this is the first time that the whole procedure of the service-learning project was documented as a compulsory credit-bearing subject in

Hong Kong universities. With the water sustainability project example, this paper demonstrated how to integrate service-learning subjects into university curricula and showed the benefits and challenges they presented.

Keywords: International service-learning, water quality, sustainable water management, higher education, underserved community

1. Introduction

1.1 Service-learning

Service-learning is an experiential education approach that enables students to apply the knowledge and skills learned from courses to real-world situations. This method was first proposed and developed in the U.S., with several similar definitions found in previous studies (Berry & Chisholm, 1999; Bringle & Hatcher, 1996; Foss et al., 2003). Students can gain a deeper understanding of course content and develop civic responsibility through this practice. It involves academic institutions cooperating with underserved communities, benefiting both parties simultaneously (Bringle & Hatcher, 2002).

The benefits of service-learning for students are well documented. It enhances academic learning by allowing students to practice theoretical knowledge in real-world settings, fostering a deeper understanding of course material (Eyler & Giles Jr., 1999). Service-learning also promotes students' academic performance, including retention rates and critical thinking skills), (Simonet & Vista, 2008) and personal development, including leadership skills and civic responsibility (Huda et al., 2018). From the communities' perspective, service-learning projects provide valuable resources and knowledge to address local issues, leading to sustainable community development (Sandy & Holland, 2006). Additionally, service-learning enhances the university's role as a civic institution and strengthens its ties with communities. Universities incorporating service-learning into their curricula often experience better development through new teaching and research opportunities (Bringle & Hatcher, 1996).

With the growing interest in service-learning, more and more universities began offering service-learning subjects and listed it as one of the mandatory courses for undergraduate students (Astin et al., 2006; Bringle & Hatcher, 1996; Nickols et al., 2013). Universities in Hong Kong are no exception (C. Chan et al., 2006). The Hong Kong Higher Education Service-Learning Network was established in 2007 to promote the development of service-learning projects. Three years later, the Hong Kong senate debated and approved the implementation of the service-learning subject in the 4-year undergraduate degree program curriculum, stipulating that all undergraduate students must complete one three-credit service-learning subject before graduating. Subsequently, the Service-Learning Asia Network was set up (Ma & Chan, 2013). Under the auspices of government institutes, service-learning has become mainstream in Hong Kong universities. All government-funded universities and several private universities in Hong Kong have adopted service-learning as an essential part of their education system (Chan & Snell, 2022).

Despite being adopted by many universities in Hong Kong for over a decade, service-learning continues to encounter challenges. Common issues include misalignment between the service-learning project and the course content, miscommunication between students and the community, and underestimation of issues that students cannot adequately address(Chan & Snell, 2022). More feasible, innovative, and practical projects must be developed to enhance the student learning experience. Considering that Hong Kong is a relatively developed and small region compared to nearby cities, local service-learning projects often bring limited improvements to the community's quality of life. Therefore, overseas service-learning projects should be considered to provide students with broader and more impactful learning experiences.

1.2 Water sustainability

As a limited and indispensable resource, water is essential for sustainable development. It is fundamental to healthy ecosystems, socioeconomic development, and human life. With industrialization and urbanization, water pollution has increased significantly, especially in Asia and Africa. According to a global disease investigation, Southeast Asia, East Asia, and Oceania have experienced the worst deterioration in water quality (Frostad et al., 2017). The drinking water source of approximately 2 billion people is contaminated, which has resulted in millions of illnesses (Tortajada, 2020). Although

water management has been given priority in most developing countries, providing clean water is still not accomplished in many regions due to the lack of financial and technical support (Tortajada, 2020).

To raise public awareness of water issues and motivate governmental, non-governmental, and private entities at both national and local levels to enhance water management and the people's living quality, the United Nations General Assembly introduced an urgent call named "Clean Water and Sanitation", among other sustainable development goals (SDGs), to "ensure availability and sustainable management of water and sanitation for all" (United Nations Development Programme, 2015). It was realized that achieving sustainable management required the cooperation of all entities, not only between governments but also between civil society, academia, and private sectors (United Nations Sustainable Development Group, 2019).

Higher education, a place that promotes knowledge, research, and innovation, can be a powerful aid in achieving sustainable development (Aramburuzabala and Cerrillo, 2023). To date, water-sustainable management-related courses and degrees have been offered in many higher education institutes where students can learn the fundamental knowledge and technologies for water supply, filtration, and recycling (Ostad-Ali-Askari & Eslamian, 2019). Moreover, this education provides opportunities for the development of professional water technicians. Although many higher education institutes offer lectures on water management, many graduates still cannot handle practical projects because of the lack of related training programs. There seems to be a gap between basic knowledge and applied skills (Jeffrey & Gearey, 2006). Serving learning was proposed to be integrated into water management education to help students understand how to apply their knowledge to solve real-world challenges.

1.3 Limitations of previous studies and aims of the current study

Although the combination of service-learning with water management has already been explored in higher education (Matthew et al., 2017; Younos et al., 2003), there is a lack of detailed descriptions of the project contents and discussions on the benefits and limitations of these service-learning projects in the existing literature. For instance, Matthew et al. (2017) presented an international service-learning project focused on installing water filtration systems in Guatemala, but their paper primarily identified the challenges encountered during field visits, such as miscommunication and differing expectations between students and local partners. Furthermore, these challenges were discussed from the perspective of social workers, rather than engineers. Similarly, Younos et al. (2003) described a case study of a service-learning program for watershed management, summarizing the lessons learned, including time management and interdisciplinary collaborations, and discussing the opportunities it provided for students, such as civic education and sustainable practices. However, to the authors' knowledge, there is still a shortage of detailed descriptions of the project contents or comprehensive discussions on the benefits and limitations of service-learning projects as compulsory courses in universities available in the scientific literature.

Considering the challenges mentioned above of current service-learning projects and the research gap in water management, The Hong Kong Polytechnic University launched a new service-learning subject to improve the water quality in underserved communities in 2018. The current paper introduces this service-learning project's objectives, components, and evaluation mechanisms. Additionally, it records this project's first implementation process, which involved 20 students' participation, and documents these students' assessments and reflections. Furthermore, this study analyses the outcomes, impacts, and limitations based on the collected questionnaires and reports. By sharing these findings, the paper aims to provide new insights into effective service-learning pedagogies and encourage other higher education institutes to adopt similar service-learning into their curricula for sustainable development education.

2. Project description

2.1 Overview of the project

The reported project- Living Environment for Low-income Communities in Developing Regions - aimed to improve the water quality in a low-income community in Kampong Speu Province of Cambodia. Unsafe drinking water has been a long-standing issue in the selected community because of poor financial conditions. Due to the lack of knowledge and apathy, local people directly drink the collected rainwater or river water (Aguilar & Brown, 2010). This service-learning project was designed to help the underserved community build several water filtration systems in a village the Cambodian Non-Governmental Organization chose to improve water quality for local people's living conditions. Some local students from the Royal University of Phnom Penh (RUPP) participated in this program as volunteers. These students were all voluntarily registered and underwent a selection process mainly based on their communication skills.

As shown in Figure 1, this project consists of four parts: e-learning and self-study (35 hours), lectures and workshops (29 hours), on-site service (40 hours), and reflective seminars (25 hours). Brief introductions to these components were provided in section 2.2. The whole project lasted one semester (around 5 months). Students are required to spend at least 129 hours on it, and they can get 3 credits if they pass the assessment, which was given based on their performance in each part of this project.

Figure 1. Overview of the service-learning project.

2.2 Components of the project

The e-learning, including readings, tasks, and evaluations, was the first stage of this program. The specific topics of the e-learning were included in Appendix A. It was intended to introduce students to the fundamental concepts and procedures of service-learning. E-learning was mandatory for this project. All the students had to finish the e-learning within the first four weeks after the program started. A series of exercises and assessments were designed for students to assess the effectiveness of their learning. Students who completed this module should be able to understand their role and responsibility during the serving-learning process.

The lectures and workshops were the preparatory stages of on-site service. The lectures focused on the importance of indoor environmental quality/ water quality and methods to investigate, analyze, and improve them. Students should learn the basic knowledge related to the service-learning project through these lectures. After the lectures, they were asked to work in groups to design and write service

proposals to elucidate their plans to apply the knowledge to help the underserved community (i.e., build a water filtration system in the current project). Then, students were required to participate in several workshops where they had hands-on practices in designing, developing, and renovating products/systems to improve local people's quality of life. Professional technicians were invited to give instructions during this process.

The main stage of this project was the on-site service in the underserved community, i.e., a village in Kampong Speu Province of Cambodia. Several host country students of the RUPP were invited to participate in this project and assigned to each group to assist the Hong Kong students in delivering the on-site service to host villagers who did not speak English. Each group comprised up to four Hong Kong students and two Cambodian students. The task of each group was to set up two household-size water filtration systems for the underserved community within eight days. The first four days were spent preparing and setting up the system. Students needed to collect all the materials and build the system in the RUPP laboratory. The lecturers gave professional evaluations and suggestions on the system's function, and students were asked to improve their work accordingly. The next four days were the on-site investigation and installation of the system. During this, students needed to conduct questionnaire surveys with the host villagers to understand their current living conditions and behavior regarding water use. Then, each group was asked to install two water filtration systems for two host country families and instruct the villagers on how to use the systems.

The last stage was the review and reflection session, aimed at educating students through self-reflection, peer review, and experience sharing. Reflective seminars were organized at fixed periods during the service-learning program to identify any problems that bothered the students and correct them in time. Additionally, students were required to present several term papers throughout the project to outline their experiences and reflections at different periods. Different scopes and emphases of the papers were indicated clearly, which included the connection between living conditions and service-learning, the issues on the indoor environment and living conditions in underserved communities, the results of field investigations, and recommendations to improve host country people's living quality.

2.3 Learning objectives of the project

The learning objectives of this project are:

a) To introduce the concepts and practices of service-learning and link the service-learning method and academic topic taught in the project;
b) To raise students' awareness of the importance of suitable living environments and water quality and the fundamental human rights issues concerning living conditions;
c) To heighten students' consciousness about the reality of living environments of the underprivileged in low-income areas;
d) To educate students on significant issues related to the impact of poor living conditions, including psychological and physiological impacts on low-income communities and individuals;
e) To acquaint students with knowledge and skills to carry out basic indoor environmental assessments and perform basic environmental improvements;
f) To nurture a sense of civic responsibility and engagement in our students by applying their knowledge to improve the water conditions of low-income areas.

2.4 Evaluation of the project

The university policy used a letter grading scale from A+ to F to evaluate student performance in this course. Table 1 shows a breakdown of how each assessment component was weighted:

Table 1. The relative weighting of the different assessment components of the course evaluation.

Specific assessment methods/tasks	% weighting	Related learning objectives (see section 2.3)					
		a	b	c	d	e	f
1. e-learning	5	√					√
2. proposals for service	25	√	√	√		√	√
3. performance in on-site service	40	√	√	√	√	√	√
4. reflective paper/report	30	√	√	√			√
Total	100						

The reasons why the assessment techniques are suitable for evaluating the desired learning objectives (L.O.) are listed below:

1. The e-learning process includes assignments and learning tasks to evaluate students' ability to connect service-learning with the project's academic contents (L.O. a) and understand their social obligations (L.O. f).
2. Students must submit project proposals as part of the preparation for their on-site service to demonstrate their understanding of critical scientific knowledge related to evaluating water conditions and their capacity to apply their knowledge and skills to improve the conditions faced by low-income families (L.O.s a-d).
3. In the on-site service stage, students are required to undertake the planned services, including investigating the living quality (especially water quality) in the community, understanding the requirements of host villagers, communicating with team members, developing an effective solution to improve water quality, and implementing the solution (L.O.s a-f).
4. The reflective papers/reports are used to evaluate students' abilities to connect service-learning with the academic contents of the course (L.O. a, c, e), to consider the difficulties, in terms of water quality, posed by the underserved community (L.O. f), and to evaluate the problems encountered by host villagers (L.O. b).

2.5 Self-assessment during the project

To determine what students learned through the service-learning and to assess their attitudes and opinions on service, civic responsibility, challenges, etc., self-assessed pre-course and post-course surveys (see Appendix B) were distributed to students at the beginning and end of this project (i.e., before the e-learning and after the on-site service, respectively). Regarding the questionnaire design, the Cronbach's alpha values of the questions in the two parts were 0.872 and 0.887, respectively. These values were well above the commonly accepted threshold of 0.7, indicating good reliability and consistency of the questions. Students' participation in the survey was optional, and they could skip any questions they did not want to answer and withdraw at any time if they were uncomfortable answering them. The pre-course survey included only one part (i.e. the "assessment of your current abilities" of the survey in Appendix B) with 10 questions to investigate students' abilities in 10 aspects, including the application of classroom learning, adaptive problem-solving, creative thinking, community contribution, commitment to helping the disadvantaged, empathy and compassion, concern for those in need, moral commitment to civic affairs, multi-perspective analysis and informed decision-making. The post-course survey comprised two parts: the first part was the same as the pre-learning survey, which was used to measure students' experienced improvements; the second part, including 13 questions, was about students' ratings on the impacts of this project. The students were asked to respond to each question by indicating an answer on a Likert scale of 1 (strongly disagree/significant negative impact) to 7 (strongly agree/significant positive impact), as shown in Appendix B.

2.6 Data analyses after the project

The evaluation of this service-learning project utilized three sets of data: quantitative data from self-assessed surveys completed by the students, qualitative data from the students' reflective reports, and observational data collected by the research team. The quantitative data collected through the surveys was imported into IBM SPSS Statistics 27.0 (SPSS Inc., Chicago, IL, USA) to assess the changes in students' abilities and opinions. Before the analysis, the data was cleaned by removing incomplete responses and cases where participants provided the same rating for all questions.

The analysis was conducted in four steps:

1. Cronbach's alpha values were calculated separately for the 10 questions in the first part and the 13 questions in the second part to assess the reliability and internal consistency of the questionnaire.
2. Descriptive analyses were performed to calculate each question's mean and standard deviation (SD).
3. A series of Shapiro-Wilk tests were conducted to examine the normal distribution of the responses collected through the pre-course and post-course surveys. Depending on the normality test results, paired-sample t-tests (for the normally distributed data) or Wilcoxon Signed-Rank tests (for the non-normally distributed data) were used to compare the answers to the ten common questions between the pre-course and post-course surveys.
4. Finally, Principal Component Analysis (PCA) was applied to the data collected on students' ratings of the project outcomes. This procedure helped extract essential information and further understand students' opinions and abilities towards the service-learning project.

In addition to the quantitative analysis, the qualitative data collected through students' reflective reports were also analyzed to identify the project's impacts on students' skills and attitudes. Specifically, the frequencies of words in students' reflective reports were analyzed using the Voyant Tools (Alhudithi, 2021), a web-based text analysis application. By examining the visual representations generated by Voyant, the key themes in the students' narratives can be identified. The qualitative data from the reflective reports were used as supplementary information to contextualize and enrich the interpretation of the quantitative findings. The qualitative analysis offered deeper insights into the effects of students' perception of the service-learning project on their development. By integrating quantitative and qualitative data, this study provided a more comprehensive understanding of the project's impacts on the participating students. The qualitative reflections helped to illuminate the nuances and personal experiences that may not have been fully captured by the numerical survey responses alone.

3. Outcomes and impacts of the international service-learning project

This section summarizes the outcomes of the service-learning project from the perspective of different stakeholders. First, the benefits to the vulnerable community that received the water filter tanks were presented in section 3.1. Second, the benefits to the students who enrolled in this project were discussed, based on the data analysis results, in section 3.2. Then, the opportunities provided to the host country students who assisted as translators were also revealed in section 3.3. Lastly, the benefits to the teachers who participated in this project were explored in section 3.4. It is worth noting that section 3.2 is based on the data collected from the students, whereas sections 3.1, 3.3, and 3.4 are mainly based on the researchers' observations and interpretation of the results.

3.1 Benefits to the vulnerable community

One of the most remarkable outcomes of this project was the twelve water filter tanks built by the students (see Figure 2). The basic theory of the filtration system is the slow sand filter, which utilizes the biofilm formed above the sand to reduce bacteria, viruses, microbes, etc. (Verma et al., 2017). Despite its simple design and installation, this filtration system was tested to be functional. Besides, all the systems were installed at a specific location and height, considering the safety, filtration efficiency,

and convenience of water taking. This filtration system could improve the local villagers' living standards, especially water quality. The primary water sources of the underserved community in this project were rainwater, pond water, and well water. The rainwater was collected from the dirty roof, while the nearby industries and animals contaminated the yellowish-brown pond water. The local villagers barely had any clean water and just drank the water from these sources directly without any treatment. According to a previous field investigation conducted by Engineers Without Borders at The University of Alabama (EWB-UA) on water quality in several sites of the same province (i.e., Kampong Speu), almost all the sampled water was at high risk, in terms of thermotolerant coliform count. Based on the results, the researchers concluded that water treatment (e.g., filtration or disinfection) was necessary to avoid sickness (Aguilar & Brown, 2010).

Figure 2. Examples of the water filter tanks built by the students in the service-learning project.

To fully achieve the benefits of the filtration system, the students also made operation and maintenance manuals in Khmer words, featuring pictures to instruct the host villagers on how to operate and maintain the systems on their own. The water quality survey conducted by EWB-UA indicated that the lack of knowledge and apathy toward water treatment seemed to impede the popularization of water filtration in this region (Aguilar & Brown, 2010). Therefore, apart from the filtration system, students of the current project also paid a lot of attention to disseminating knowledge about water sanitation and hygiene. Hopefully, the interactions among the service team members could raise the host country's people's awareness of water filtration and disinfection, thereby promoting and popularizing the water filtration system developed by this project.

3.2 Benefits to the students

In total, 20 undergraduate students, including twelve females and eight males, participated in this service-learning project from January to June 2018. They came from different majors and grades (year 1: eight; year 2: two; year 3: nine; year 4: one), and none of them obtained any education on water treatment technology before this project. These students were divided into six groups, with three or four students per group to conduct the on-site service. Among them, 18 students completed both the pre-course and post-course surveys eligibly and were included in the present study's analysis. The following subsections focus on the outcomes and impacts of the service-learning project on these students.

The results of the Shapiro-Wilk tests showed that the answers to most questions were not normally distributed. Therefore, Wilcoxon signed-rank tests were applied to check the differences between students' answers before and after the courses. According to the results shown in Table 2, the students' ratings were higher after the project for all the assessments, though the differences were not significant ($p>0.05$). These subtle and insignificant changes might be related to the high pre-course assessments, which inevitably limited the room for improvement. Before the project, students' ratings were about 5.2 (out of 7) for almost all the questions, except for question 4 (reflection of contribution to community). The measurement results indicated they felt confident in their knowledge and skills, understanding of service-learning, social responsibility, and empathy. Additionally, these high ratings before the project might explain why these students selected this project.

Although the increases in students' ratings before and after the service-learning project were not obvious when analyzing these questions individually, a significant difference was identified when comparing the average ratings for these questions, i.e., by conducting a Wilcoxon signed-rank test based on the ten pairs of pre-course and post-course average student answers, where each pair represents the mean of students' answers to the same question before and after the course ($Z=-2.83$, $p=0.005$). Notably, after the project, there was a significant increase in students' ratings across all the 10 examined aspects, indicating a significant overall improvement in these abilities.

As shown in Table 2, the most apparent increments (post-pre ≥ 3) were identified for questions on problem-solving (i.e. Q3 in Table 2), social responsibility (Q6), and critical thinking (Q10). Many previous studies often reported the development of problem-solving ability and civic responsibility (Astin et al., 2006), and they can be seen as the expected benefits of service-learning. Moreover, since these students came from different majors, their diverse perspectives enabled them to solve problems by exploring new possibilities, bridging their knowledge gaps, and proposing alternative solutions for the issues they encountered during the on-site service. Through this, students learned to think from different angles and to make overall evaluations and informed judgments.

Table 2. Comparison of students' self-assessment before and after the service-learning project.

Question ID	Questions	Mean (SD)		Rank		Z (p-value) [a]
		Pre	Post	Pre	Post	
1	I know how to apply what I learn in class to solve real-life problems encountered in service-learning projects.	5.3 (1.14)	5.6 (0.76)	7.0	8.9	-0.643 (0.520)
2	I often modify my strategies to solve a problem based on the situation.	5.1 (1.32)	5.3 (0.57)	4.5	6.9	-1.393 (0.163)
3	I am able to think of different strategies and options for dealing with a problem.	5.3 (1.07)	5.4 (0.76)	5.0	5.7	-1.308 (0.191)
4	I am able to reflect on how I can make a meaningful contribution to my community.	3.2 (1.63)	3.6 (2.03)	7.0	6.3	-0.924 (0.356)
5	I am committed to helping the disadvantaged in the community.	5.6 (0.83)	5.8 (0.98)	6.6	6.4	-0.487 (0.626)
6	I feel a personal obligation to do what I can to help those who are less fortunate than me.	5.3 (1.76)	5.4 (1.47)	5.7	5.4	-1.115 (0.265)
7	I care about people who are facing great difficulties in life.	5.3 (0.89)	5.7 (1.33)	7.3	7.6	-0.553 (0.580)
8	I believe all of us have a moral commitment to civic affairs, no matter how busy we are.	5.4 (0.84)	5.8 (0.96)	4.5	6.5	-0.540 (0.589)
9	I often look at complex issues or problems from different angles.	5.2 (1.73)	5.6 (1.65)	6.1	5.9	-0.237 (0.813)
10	I am able to analyse complex issues to make informed decisions.	5.1 (0.89)	5.4 (1.17)	3.0	5.4	-1.299 (0.194)
Average [b]		5.1 (0.68)	5.4 (0.64)	0	5.5	-2.827 (0.005)

Note: a. results were obtained from Wilcoxon signed-rank tests; b. the result was obtained based on the comparison between 10 pairs of pre-course and post-course average student responses, where each pair represents the mean of students' answers to the same question before and after the course.

Concerning students' assessment of the outcomes of this project (the second part of the post-course survey), the result of PCA suggested four components (see Table 3). Component 1 has a substantial loading for Q11, 'linkage between service-learning and the academic content of the subject', Q13, 'solving real-life problems', and Q14, 'critical thinking'. These variables were necessary for the application of knowledge to solve problems. Therefore, component 1 was labelled as 'problem-solving". Component 2 has a loading for Q17, 'understanding the problems facing underprivileged community',

Q18, ‘interest to serve people in need’, Q21, ‘responsible global citizen’, and Q23, ‘overall learning’. These questions were more relevant to civic responsibility; therefore, component 2 was labelled ‘civic responsibility’. Component 3 has a loading for Q16 ‘communication with peers/collaborators/service recipients’, Q20 ‘respect for people from different backgrounds’, and Q22 ‘self-understanding’. These questions are more about communication-related skills. Therefore, component 3 was labelled as “communication”. Component 4 has a loading for Q12, ‘application knowledge to deal complex issues’, Q15, ‘working effectively in teams’, and Q19, ‘being a responsible community member’. These skills were important for teamwork. Therefore, component 4 was labelled as “cooperation”. Correspondingly, four new variables were created by calculating the mean values of the related questions.

Table 3. Descriptive analysis results of the four variables corresponding to the components of the PCA.

New variables	Related questions	Mean (S.D.)	Min-Max
1. Problem-solving	11, 13, 14	5.45 (0.85)	4.0-7.0
2. Civic responsibility	17, 18, 21, 23	6.05 (0.58)	5.0-7.0
3. Communication	16, 20, 22	5.90 (0.73)	4.0-7.0
4. Cooperation	12, 15, 19	5.90 (0.73)	4.3-7.0

Table 3 shows the descriptive analysis results of these variables (i.e., problem-solving, civic responsibility, communication, and cooperation). Their mean values are all higher than 5, indicating positive impacts of the project on these aspects. These variables were often considered soft skills that are difficult to acquire through lectures and workshops. University students easily overlook them; however, they are necessary for students to contribute to society better. In addition, the 200 most frequently occurring words in students' reports are summarized in Figure 3. Besides terms directly related to the project, such as “water,” “service,” “village,” “project,” and “filter,” several words associated with the four components identified by the PCA—such as “help,” “team,” “communication,” “problem,” “enhance,” “cooperation,” and “responsibility”—ranked among the highest. Notably, these terms were mentioned in all group reports.

Figure 3. 200 high-frequency words appeared in students’ reports.

3.3 Benefits to the host country students

Due to the language barrier, several Cambodian students were invited as translators to assist them in communicating with host villagers during the service-learning. To help the Cambodian students better understand this project, the students from Hong Kong, with the help of their teachers, first introduced the basic knowledge and technical skills to the Cambodian students before the on-site construction. The host country students also gained related scientific knowledge and skills to which they were rarely exposed. Additionally, the engagement in the service deeply impressed the Cambodian students since most of them were born and raised in urban areas and had not visited rural villages before. This service trip offered them a different perspective and helped them better understand their country. Last but not least, the cooperation between international students opened the eyes of the Cambodian students because not many have contacted foreigners before, let alone cooperating with them. This experience allowed the host country students to learn a different culture, lifestyle, and language, which had the same impact on Hong Kong students.

3.4 Benefits to the teachers

The teachers of the service-learning program are essential to the quality of the courses and services (Salam et al., 2019). They are responsible for the design of the course, organization of the workshop, communication with the community, and supervision of the service project. Participating in the service project allows them to conduct field research to test their teaching achievements in the real world. By closely observing the students and working with them during the service process, teachers identified the weaknesses of current course contents and teaching methods. This action-based research enhanced the applicability of the knowledge and skills students learned during this program and improved the quality of the next service-learning project.

Moreover, personal involvement in the fieldwork lets the service team understand the community's real needs, which helps them effectively design more appropriate solutions to improve the living conditions of underserved people (Stewart, 2012).For example, during the on-site construction, some students found that the ground surface was too soft to support the filtration tanks, and they needed to build a foundation with bricks, which they had no experience with, thus having to ask their teachers for help. The students learned to tackle practical problems from the teacher's advice and demonstration. A student described this experience and attached the teacher's suggestions in the final report as follows:

"*As the filter tank is hefty and the soil will be compressed, to prevent the significant impact of consolidation on the system, the concrete base was applied on site 2, which had very soft clay as the ground. …For the brick layout, thanks to Dr. **'s preparation, example 2 of his suggestion was selected for its simplicity and stability*".

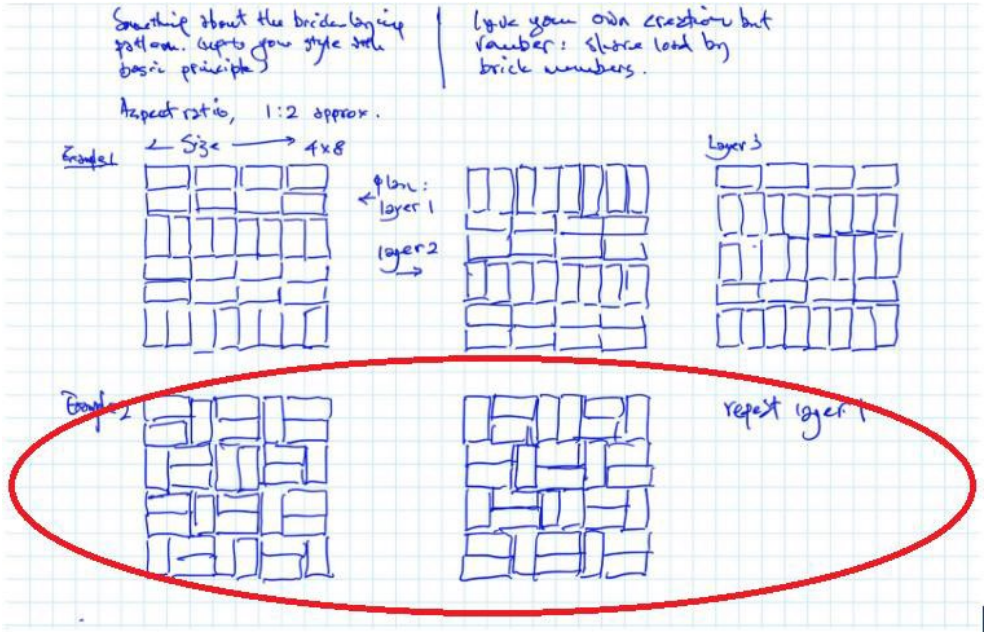

Figure 4. The layout of the foundation with the pattern of Khmer-style bricks (exerted from the student's final report)

Although full of changes, this process offered the teachers personal fulfilment, especially when they received appreciation or positive feedback from the students, as this reflected their values. Furthermore, witnessing students help the underserved community using the knowledge and skills they learned from them also gave teachers a sense of achievement, which positively motivated them to improve their teaching quality and styles (Salam et al., 2019).

4. Barriers and future suggestions

As a first attempt, this project is, of course, not perfect. Barriers and challenges have been encountered during the service rendering. Three barriers to communication, time management, and cooperation were identified from students' reflection reports. These barriers are consistent with challenges highlighted in previous research by Matthew et al. (2017) and Younos et al. (2003). Besides, one challenge was noticed in this project during the pre-course analysis. Corresponding suggestions were proposed to address these problems and improve the quality of future service-learning projects.

4.1 Communication

One of the most apparent barriers mentioned by the students was the communication. Since the students did not understand the host country language (i.e. Khmer) and the host villagers did not speak English, there was a communication barrier between the students and the service recipients. Although at least one host country student was assigned to each student group to help them translate the message to the villagers, the communication was still ineffective, according to students' review and reflection, because of the misunderstanding between the host country students and students enrolled in this project. For example, one student mentioned this barrier in the reflective report:

"*Since we do not know Khmer, requiring the RUPP students to translate and communicate with the villagers creates a communication barrier between us and the clients. The RUPP students may be unable to deliver the same messages we expressed to them, and we could not fully understand the villagers"*.

Effective communication is crucial in service-learning contexts, particularly when working in foreign countries. As noted by Mathew et al. (2017), language and cultural differences can lead to

misunderstandings, particularly when local community may defer to the expertise of students and faculty. This often results in a lack of open dialogue, where community members might too respect the students to express concerns. To address this issue, the project plans and service proposals can be described through an infographic in the future, which visually represent the purpose and procedure of the service. Besides, different icons or illustrations can be used to show participants' roles, such as students, host country's assistants, and host villagers. This arrangement makes it easier for host country students to understand this project and effectively deliver the correct messages to the underserved villagers. Moreover, future projects are encouraged to leverage new technologies, such as translation tools, to enhance direct communication between students and the underserved community. This approach will help ensure that all voices are heard and respected, enabling students to overcome language barriers, communicate more effectively, and ultimately deliver better service to the host villagers.

4.2 Time limitation

Since this is an overseas project, arranging accommodation and travel for a long time was difficult. Therefore, this project was limited to a short period (i.e., eight days). This limitation inevitably constrains the impacts of this project because only 12 water filtration systems have been built during this period, which is like a drop in the bucket towards the water issues faced by the visited region. Besides, as indicated by a student, the limited time also led to insufficient preparation and an imperfect understanding of local students in RUPP:

"*With the time limitation, we could not educate or publish a proper manual for the RUPP students to understand the system thoroughly. Therefore, it is observed that sometimes they were probably lost or inattentive*".

Time management was also mentioned as a critical barrier in the study conducted by Younos et al. (2003) who pointed out that scheduling service-learning activities around academic calendars is essential for maintaining student engagement. To improve overcome the time limitation, projects should consider adopting flexible scheduling that accommodates academic commitments while allowing for longer-term cooperation between the two universities. Additionally, as mentioned in section 4.1, future projects are suggested to contact the local volunteer students earlier and provide them with basic information about the service-learning in advance. Moreover, it would be more helpful if local teachers and NGOs could be involved in this project to create their service-learning programs in the future to continue the popularization of water treatment and sustainable management.

4.3 Cooperation

This project is not the only international service project aimed at improving water quality in Cambodia. During the service-learning, students found a pumping well in the underserved community, drilled by a previous aid project offered by foreigners. Unfortunately, this well was no longer used because of neglected maintenance and wasting resources and effort. To avoid such waste and to develop more sustainable service-learning projects, cooperation between different institutions in different countries/regions and between other disciplines is suggested. It could be a challenge for the teachers of the projects, but it might be easier to implement if they can get support from the universities. As highlighted by Yusof et al. (2020), based on the service-learning projects conducted in Malaysia, the collaboration between the university administration and service-learning instructors was essential and could benefit both.

To better support the service-learning projects, many universities established special offices, such as the Office of Service-learning at Lingnan University and the Service-Learning and Leadership Office (SLLO) at The Hong Kong Polytechnic University (Ma & Chan, 2013). These offices gathered experiences from the past years, promoted cooperation between different institutions, and even trained teachers. At PolyU, the SLLO plays a crucial role in the institution's adoption of service-learning as an

integral part of the curriculum. In the present project, the SLLO helped to bridge the gap between faculty and community organizations, explore the service sites, identify and assess risks to students and the community, supervise students during their service, and conduct relevant research and development on service-learning.

In the future, a service-learning network can be developed between the offices in other universities to support more successful projects and help more underserved communities. Furthermore, fostering cooperation between the service-giving universities and local universities is also crucial. Take the current project as an example. If the water filter tank is broken, the local university will assist in fixing it. This collaboration ensures the sustainability and longevity of the project outcomes.

5. Conclusions

Participation in a service-learning project effectively enhances students' academic knowledge and helps underserved communities. Service-learning as an integral part of higher education curricula has drawn more and more attention in recent years. The Hong Kong Polytechnic University launched a new international service-learning project named Living Environment for Low-income Communities in Developing Regions to strengthen students' water management education and achieve the goal of sustainable water development, i.e., clean water and sanitation. This paper documents the whole process, outcomes, impacts, and limitations of this service-learning project to share the experiences and lessons learned from it.

This two-semester service-learning project offers the university students lectures, workshops, on-site service, and a reflective seminar. During lectures and workshops, students learned water management-related knowledge and skills they practised in real-life situations during the eight-day on-site service. The service was conducted in a village in Kampong Speu Province of Cambodia, which was among the worst for access to clean water. Students worked in groups with several local students to build twelve water filtration systems for the local community. Although students encountered several challenges during the service, they all had valuable lessons that fostered their communication skills, cooperation skills, civic responsibilities, and awareness of water conservation. By grappling with these real-world challenges within the structure of the service-learning curriculum, the students applied their academic knowledge in meaningful ways and developed a more nuanced, empathetic understanding of the complexities involved in community engagement. The tangible growth was identified across multiple domains, demonstrating this project's efficacy in facilitating transformative learning experiences for the participants. Apart from students, this project also offered multiple benefits for the teachers and local students. For example, the on-site service allowed the teachers to perform action research that helped them assess the current pedagogy and further improve it. It allowed the local students to engage with and learn from people and perspectives beyond their immediate community.

As a first attempt, this project also had some limitations. The most obvious ones were the language barrier, limited time, and small size of participants. Due to these challenges, this project couldn't develop a far-reaching water management system. Therefore, more future projects were called to continue this service-learning, and more collaborations between local institutions and universities were suggested. Moreover, the service-learning offices in universities should display their full abilities to optimize the curriculum system and develop a holistic generalized framework for service-learning implementation. By sharing this experience, this study contributes to the discourse by inspiring and encouraging more higher education institutes to adopt sustainable development as a topic of their current service-learning curricula.

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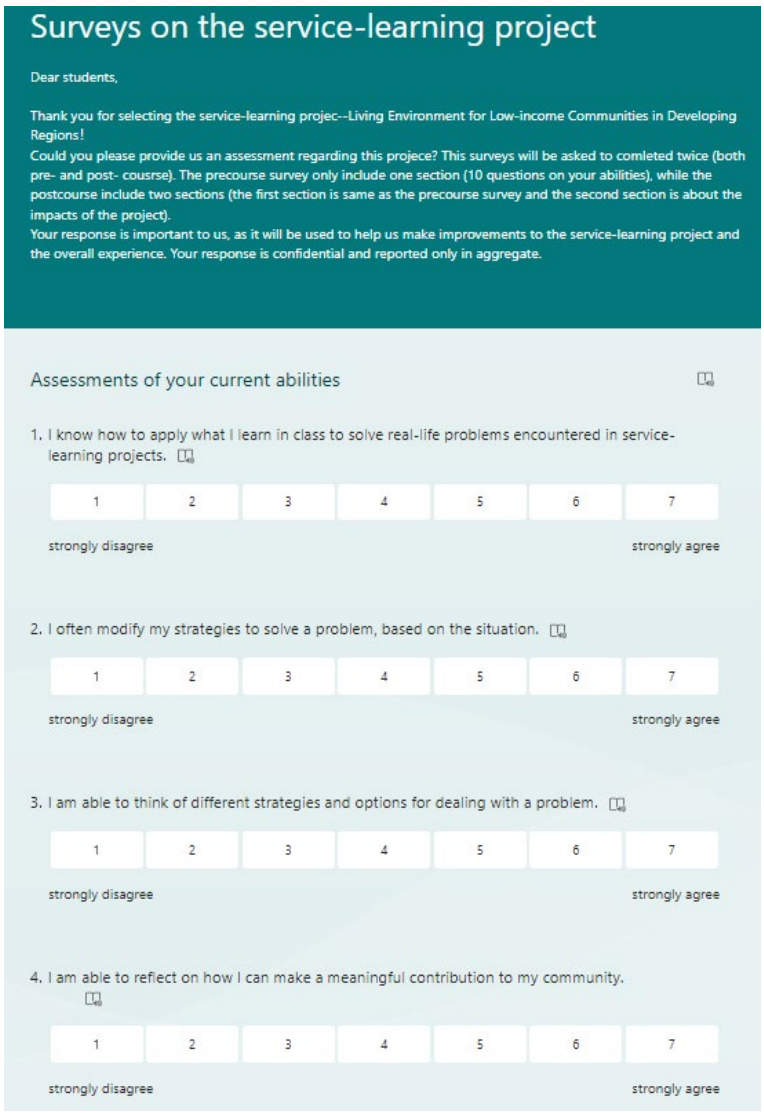
Appendix A

Topics of the e-learning, lectures, and workshops.

Activity	Topic	Duration (h)
e-learning	What is service-learning?	3
	Benefits of Service-Learning	3
	Responsibilities, Attitudes, and Ethics in Service-Learning	2
	Reflecting on Your Service-Learning Experience	2
Lecture	Briefing & Introduction	3
	The Service	3
Workshop	Reflection & Reflective Journal Writing	3
	Cultural training/ Logistic for service (Travel health consultation/ vaccination/ visa receipt collection)	3
	Pre-departure check and material distribution	2

Appendix B

Self-assessment questionnaire



5. I am committed to helping the disadvantaged in the community.

1	2	3	4	5	6	7

strongly disagree — strongly agree

6. I feel a personal obligation to do what I can to help those who are less fortunate than me.

1	2	3	4	5	6	7

strongly disagree — strongly agree

7. I care about people who are facing great difficulties in life.

1	2	3	4	5	6	7

strongly disagree — strongly agree

8. I believe all of us have a moral commitment to civic affairs, no matter how busy we are.

1	2	3	4	5	6	7

strongly disagree — strongly agree

9. I often look at complex issues or problems from different angles.

1	2	3	4	5	6	7

strongly disagree — strongly agree

10. I am able to analyse complex issues to make informed decisions.

1	2	3	4	5	6	7

strongly disagree — strongly agree

Surveys on the service-learning project

Ratings of the impacts of this service-learning project on the following aspects

11. Deeper understanding of the linkage between service-learning and the academic content of the subject.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

12. Applying/integrating knowledge to deal with complex issues.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

13. Solving challenging real-life problems.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

14. Thinking critically.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

15. Working effectively in teams.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

16. Communicating effectively with peers, collaborators, and service recipients.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

17. Better understanding of the problems facing underprivileged members of the community.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

18. Better understanding of the problems facing underprivileged members of the community.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

19. Becoming a more responsible member of your community.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

20. Increased understanding and respect for people from different backgrounds.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

21. Increased understanding and respect for people from different backgrounds.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

22. Increased understanding and respect for people from different backgrounds.

1	2	3	4	5	6	7

significant negative impact — significant positive impact

23. Overall learning gain.

1	2	3	4	5	6	7

significant negative impact — significant positive impact