MEASUREMENT OF STUDENTS' DEVELOPMENTAL OUTCOMES FOR SERVICE-LEARNING INCORPORATED INTO THE CURRICULUM OF AN ENGINEERING DESIGN MODULE

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Abstract

This study investigates the developmental impact of mandatory service-learning within Republic Polytechnic's (RP) Engineering Design module. Employing a quantitative approach, the research utilizes a modified Service-Learning Outcomes Measurement Scale (S-LOMS) to assess changes in engineering students across four categories: Knowledge application, Personal and professional skills, Civic orientation and engagement, and Self-awareness. Results indicate significant positive impacts ($p < .001$) on overall student development. While most domains demonstrated improvement, relationship and team skills, and critical thinking showed limited change. Further analysis revealed that team skills, specifically, contributed to the lack of significant improvement in the relationship and team skills domain. Notably, the study also explores the implications of contextualizing the S-LOMS questions within the specific service-learning framework of the module. The findings suggest that integrating face-to-face service-learning within the Engineering Design curriculum effectively enhances students' developmental outcomes, warranting further investigation into the nuanced application of the S-LOMS in this context.

Keywords: *S-LOMS, Service-learning, engineering, students' engagement*

Introduction

Service-learning in Singapore, RP and the School of Engineering (SEG)

In 2000, Singapore's Ministry of Education (MOE) introduced service-learning elements into the curriculum, which later evolved into the Values in Action (VIA) program. VIA aims to cultivate socially responsible individuals by emphasizing civic responsibility, social cohesion, and personal development. This program, implemented in primary and secondary schools, utilizes community service and reflection to shape students into responsible citizens. Recognizing the positive outcomes, several tertiary institutions in Singapore have adopted service-learning initiatives.

RP adopts a collaborative approach involving lecturers and students from diverse diploma programs to conceive and execute Service-Learning projects, under the auspices of the Office of Student and Graduate Affairs (OSG). This strategy empowers students to apply their academic competencies and knowledge to address community needs. As part of their Year 1 Life Skills module, all RP students partake in an Introduction to Service-Learning workshop. Following this, they have the opportunity to participate in organised projects or initiate service-learning projects independently. Importantly, these endeavours are not linked to specific courses nor credit requirements, and no formal academic evaluation is attached to them. Instead, students engage in reflective discussions and maintain journals to enrich their individual learning journeys.

The Engineering Design (ED) module in RP's School of Engineering (SEG) takes on service-learning with a more structured approach by providing SEG students with distinctive opportunities to interact with beneficiaries. These interactions consist of offering instruction in mobile app usage, on-site visits to technologically advanced companies, and ability to conduct user interviews to understand enhancement necessary for the beneficiaries' daily lives. Over the course of a week, this service-learning segment lays the groundwork for the ideation phase of students' engineering projects and inspires the development of prototypes within the ED module. Collaborating closely with five voluntary welfare organisations, the students complete these projects in teams. This program offers a distinctive platform for first year SEG students to innovate ideas and develop prototypes addressing societal needs and real-life problems, fostering meaningful service-learning experiences through direct interaction with the beneficiaries, which are the elderly. In total, students spend ten weeks creating and refining prototypes after understanding users' requirements. Eventually, the beneficiaries are then invited to test these prototypes and provide feedback.

The incorporation of service-learning into a module has been exceptionally well-received by all stakeholders involved as it provides an authentic experience with key outcomes such as: creating a solution to a real-world problem, ideation of potential solutions through design-thinking methodologies, community engagements, social responsibility and promoting skills development of the students.

The success of this initiative is evident in the accolades received: the MOE Innergy Award (Silver) in 2019, PAYM Service-Learning Champions Project Accolade (Silver) in 2019, and the RP Curriculum Innovation Award in 2019.

The Service-Learning Outcomes Measurement Scale (S-LOMS)

The Hong Kong Polytechnic University, in collaboration with Lingnan University, Hong Kong Baptist University, and The Education University of Hong Kong, initiated a joint project titled 'Cross-institutional Capacity Building for Service-Learning in

Hong Kong Higher Education Institutions' (Ngai et al., 2019). This collaborative effort aims to advance service-learning as a transformative pedagogy across institutions. Within this project, investigators from Lingnan University, supported by peers from collaborating universities, developed the Service-Learning Outcomes Measurement Scale (Snell & Lau, 2020).

The S-LOMS is used by students in Hong Kong to evaluate their developmental outcomes arising from their engagement in service-learning. These outcomes encompass 11 learning domains categorised under knowledge application, personal and professional skills, civic orientation and engagement, and self-awareness. In service-learning courses, students acquire soft skills, attitudes, and personal attributes that may not be clearly reflected in their academic performance. Through assessing self-perceived changes before and after participating in service-learning, the S-LOMS captures these developmental impacts (Lau and Snell, 2021).

Two studies have validated the Service-Learning Outcomes Measurement Scale (S-LOMS), with one specifically comparing scores from samples in Hong Kong and Singapore, notably Republic Polytechnic (Lau and Snell, 2020). As Lau and Snell considered that S-LOMS could be a feasible instrument for measuring the developmental outcomes of service-learning in Asian jurisdictions beyond Hong Kong, they have included Singapore in one of their studies. In this study, the students in RP volunteered to participate in service-learning outside their scheduled class time, whereas Hong Kong students were required to contribute to service-learning to fulfil university requirements. RP had collected the data from this group of students using S-LOMS and contributed the data to this study to validate the S-LOMS. Interestingly, the research revealed consistently higher perceived pre-test and post-test results for service-learning amongst Hong Kong students compared to Singaporean students. While this difference may partly stem from the diverse backgrounds of the respondents, it is also suggested that variations in the design of service-learning programs undertaken by students in each region contribute to this divergence.

Research indicates that students derive greater benefits from systematically designed service-learning programs that align with course content, grading requirements, and service criteria (Astin et al., 2000; Mabry, 1998). Several studies recommend that educational institutions with similar service-learning arrangements contemplate integrating these programs into regular academic courses or modules (Hanover Research, 2014; Jenkins & Sheehey, 2012; Snell & Lau, 2020), which SEG has accomplished.

Methodology

This study addresses the following research question: What are the developmental changes in engineering students arising from mandatory service-learning taking place as part of the 'Engineering Design' module?

We employed a quantitative research design to analyse the impact of service learning on the developmental changes of engineering students. We measured the students' self-perceived developmental outcomes using an online survey, slightly modifying the wording of items in the S-LOMS survey to specifically contextualize them for the service learning incorporated into a module, rather than using general service-learning statements (refer to Appendix A for a complete list of the original S-LOMS survey and the modified statements).

An online survey was used to measure 56 items, on a 10-point Likert scale, (1= strongly disagree to 10= strongly agree), administered at two points, namely, the inception of the service-learning project in Week 2 and at the end of the semester around Week 12. The items from S-LOMS cover 11 domains and 15 sub-domains, which are grouped into four major categories as illustrated in Figure 1. First year engineering students enrolled in the 'Engineering Design' module were invited to voluntarily complete the S-LOMS survey before as well as after their service-learning projects. Figure 2 depicts the list of events with the service-learning projects as the intervention.
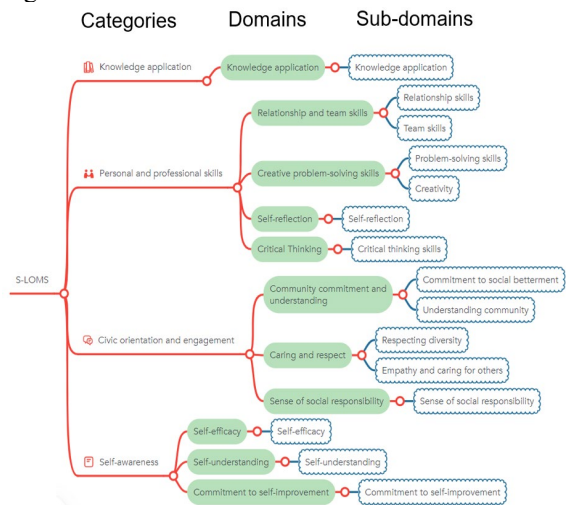
Figure 1:

Figure 2:

Quantitative Methods

By utilising the S-LOMS (Lau and Snell, 2021) survey, this research project aims to investigate if there are any significant developmental changes in first-year engineering students arising from service-learning taking place as part of their mandatory contribution.

A total of 397 students participated in the pre-survey and post-survey, forming the sample for the cohort (800 students) who participated in the face-to-face service-learning projects.

When determining if there is a significant difference between the means of two paired measurements, like pre- and post-test scores, paired t-tests are typically employed. Hence, 15 paired sample t-tests were employed for this group of 397 engineering students using the pre-test and post-test scores to determine whether there were significant developmental changes arising from service-learning across the 11 domains and 4 major categories. This allows us to assess if the students have achieved the desired learning outcomes of the students under Introduction, paragraph 4 of this research paper.

The assumption of normal distribution was established with the use of Q-Q plots in Figure 3, and this sets the precedence to conduct the paired t-tests. Normality has been satisfied for all paired t-tests. An example of the normal Q-Q plot for the mean under knowledge application before survey is shown in Figure 3, where the observed values match closely to the expected normal.

Figure 3:
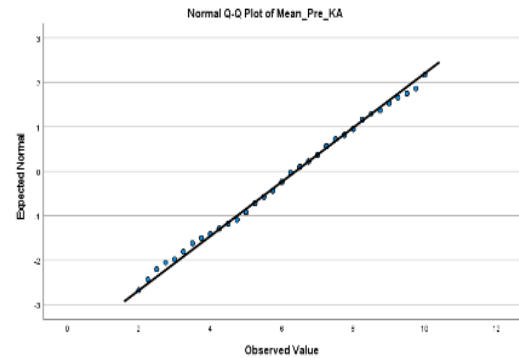
Results and Discussion

Four paired samples t-tests, comparing the pre- and post- survey data across the four categories of knowledge application, personal and professional skills, civic orientation and engagement, and self-awareness were conducted, and results showed significant improvement in the developmental changes for all four categories. The results are summarised in Table 1.

Table 1: Paired Sample t-tests Results across Four Categories

	Group	N	Mean	SD	t	Degrees of freedom	p
Knowledge application	Pre	397	6.39	1.64	-9.89	396	< .001
	Post	397	7.25	1.35			
Personal and professional skills	Pre	397	6.85	1.47	-5.10	396	< .001
	Post	397	7.21	1.27			
Civic orientation and engagement	Pre	397	6.65	1.56	-12.36	396	< .001
	Post	397	7.56	1.20			
Self-awareness	Pre	397	6.76	1.54	-7.11	396	< .001
	Post	397	7.29	1.28			

Thereafter, we delved into the 11 domains that are within the four categories, results are in Table 2. Two domains, namely relationship and team skills, and critical thinking, did not exhibit significant improvements. The domain of self-understanding demonstrated significant enhancement with $p<.01$, while the remaining eight domains displayed significant improvement ($p<.001$).

Table 2: Paired Sample t-tests Results across 11 Domains

	Group	N	Mean	SD	t	Degrees of freedom	p
Knowledge application	Pre	397	6.39	1.64	-9.89	396	< .001
	Post	397	7.25	1.35			
Relationship and team skills	Pre	397	7.08	1.49	-1.29	396	0.197
	Post	397	7.18	1.38			
Creative Problem-solving skills	Pre	397	6.54	1.62	-8.69	396	< .001
	Post	397	7.21	1.32			
Self-reflection	Pre	397	6.75	1.60	-5.35	396	< .001
	Post	397	7.18	1.42			
Critical thinking	Pre	397	7.19	1.61	-1.39	396	0.166
	Post	397	7.31	1.28			
Community commitment and understanding	Pre	397	6.51	1.61	-9.41	396	< .001
	Post	397	7.23	1.26			
Caring and respect	Pre	397	6.89	1.57	-13.27	396	< .001
	Post	397	7.94	1.31			
Sense of social responsibility	Pre	397	6.48	1.75	-11.77	396	< .001
	Post	397	7.50	1.40			
Self-efficacy	Pre	397	6.35	1.70	-11.40	396	< .001
	Post	397	7.33	1.38			
Self-understanding	Pre	397	7.14	1.60	-2.51	396	0.013
	Post	397	7.35	1.32			
Commitment to self-improvement	Pre	397	6.79	1.70	-4.15	396	< .001
	Post	397	7.16	1.52			

For domain on relationship and team skills, further t-tests were conducted on the sub-domains namely relationship and team skills. Further analysis, documented in Table 3, to separately examine relationship skills and team skills revealed that within the domain, relationship skills has shown a significant improvement with p<.01, and team skills is the factor that has not shown significant improvement arising from the service-learning. This indicates that students have shown improvement in all sub-domains except for critical thinking and team skills.

Table 3: Paired Sample t-tests Results across Two Sub-domains

	Group	N	Mean	SD	t	Degrees of freedom	p
Relationship skills	Pre	397	6.88	1.54	-2.91	396	0.004
	Post	397	7.14	1.55			
Team skills	Pre	397	7.27	1.58	0.644	396	0.52
	Post	397	7.22	1.38			

Conclusions

From the quantitative results outlined above, we conclude that integrating service-learning into the academic curriculum of the Engineering Design module whilst conducted face-to-face yields positive and significant impacts on students' developmental outcomes across the four main categories of Knowledge application, Personal and professional skills, Civic orientation, and engagement, as well as Self-awareness (p <.001). Further analysis in relationship and team skills in Table 3 has shown that students have shown improvement in all sub-domains except for critical thinking and team skills. The sub-domain of critical thinking showed improved mean scores for the post-survey (M=7.31, SD=1.28) compared to the pre-survey (M=7.19, SD=1.61), however, the difference was not significant, t(396)= -1.39, p=0.166. Based on studies, improvement in critical thinking takes place when students are able to assess reality critically and endure perplexity (Dewey, 1933; Freire, 1993). When students are culturally competent, specifically the ability for intergenerational interactions, they can make insightful decisions under different situations through analysis and interpretations (Goldberg & Coufal, 2009). Positioned at this stage whereby students were still in the process of attempting to build their cultural competence, this might be possibly one of the contributing factors as to why significant differences in the sub-domain of critical thinking did not emerge.

However, we should note that pre-existing attributes not presented as part of this research paper may have affected the post-test results due to the high collaborative nature of the students being in the same class, reflecting the students' existing proficiency in teamwork.

It is important to contrast the results of the S-LOMS study done previously in RP together with Hong Kong students (Lau & Snell, 2021) where a comparison of RP students pre-test and post-test scores across the 11 domains took place. In this case, there were eight domains that showed significant improvements in mean scores, whereas domains of caring and respect, sense of social responsibility, and commitment to self-improvement had p>.05 for RP students. One possible reason attributing to the different impacts on the students' development across the 11 domains could be due to the nature of the curated activities during the service-learning project.

Moreover, we hypothesise that the variable of team skills which did not show significant differences in our study when compared to the past S-LOMS of Lau & Snell's (2021) study might be largely due to the fact that students were already working in smaller teams before this project, in comparison to S-LOMS of Lau & Snell's (2021), where students are coming together for the first time, from various classes for a one-off service-learning engagement.

Challenges and Limitations

In this research, there were certain limitations that occurred, it is clear that there were non-significant improvements in key domains due to pre-existing attributes that cannot be accounted for during the duration of the project. This is highlighted in earlier text on the proficiency of the team's skills, resulting in non-significant changes. There are also methodological limitations whereby S-LOMS modifications were adjusted in the context of our survey that may affect compatibility that may require further validation to ensure reliability. Similarly, challenges were faced during data collection, especially due to the incomplete details in the survey collected. Additionally, RP's collaborative classroom approach seen in problem-based learning may have skewed team skill results as students are working in prior groups before the service-learning project.

Acknowledgements

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Appendix 1

Edited S-LOMS questions:

Category: Knowledge Application

1 I know how to transfer knowledge from the design-thinking process to a service-learning project.
2 I can make connections between theory (service-learning concepts) and practice in a service-learning project.
3 I am able to apply/integrate classroom knowledge (providing design solutions) to deal with complex issues faced by the elderly.
4 I know how to apply what I learned to solve real-life problems faced by the elderly.

Category: Personal and Professional Skills

5 I am good at building relationships between the elderly.
6 I can easily establish effective relationships with the elderly.
7 I can build long-term relationships with the elderly.
8 I am good at keeping in touch with the elderly.
9 I have the necessary skills for making groups function effectively in a service-learning project.
10 I am good at resolving conflicts in a service-learning project.
11 I am confident in leading others toward common goals in a service-learning project.
12 I participate effectively in group discussions and activities in a service-learning project.
13 I am able to solve challenging real-life (service-learning) problems.
14 I feel confident in dealing with a problem related to service-learning.
15 I often modify my strategies to solve a problem related to service-learning when the situation changes.

16 I feel confident in identifying the core of a problem related to service-learning.
17 I am not afraid of trying new things in a service-learning project.
18 I am able to generate original ideas in a service-learning project.
19 I am able to look at an issue from a fresh perspective in a service-learning project.
20 When necessary, I can think of alternatives in a service-learning project.
21 I always think how I can improve myself in a service-learning project.
22 I will evaluate myself after completing a task in a service-learning project.
23 I consider circumstances when reflecting on how well I have performed in a service-learning project.
24 I reflect on myself regularly in a service-learning project.
25 I can analyze an issue comprehensively in a service-learning project.
26 I often look at complex issues from different angles in a service-learning project.
27 I can understand others' viewpoints when we are making decisions together in the service-learning project.

Category: Civic Orientation and Engagement

28 I think about how I can serve the elderly after graduating.
29 I will play my part to reduce social problems for the elderly.
30 I always actively discuss possible improvements for the elderly.
31 I will contribute my abilities to make a better place for the elderly.
32 I can identify challenges in the elderly community.
33 I can investigate the challenges faced by the elderly in need.
34 I can identify issues that are important for a disadvantaged elderly community.
35 I can identify useful resources of an elderly community.
36 I can respect the elderly whose background is different from mine.
37 I am willing to try to understand the elderlies whose backgrounds are different from mine.
38 I respect the needs of the elderly from different backgrounds.
39 I appreciate the ideas of the elderly from different backgrounds.
40 I observe the elderlies' feelings and emotions.
41 I consider the elderlies' points of view.
42 I care about the elderly.
43 I believe that taking care of the elderly, who are in need, is everyone's responsibility.
44 I feel obligated to help the elderly who are less fortunate than me.
45 I believe that everybody should be encouraged to participate in civic affairs.

Category: Self-awareness

46 Most things I do, I do well.
47 I have many good qualities when dealing with the elderly.
48 I am satisfied with my achievement in dealing with the elderly so far.
49 I am positive about myself in a service-learning project.
50 I have a clear picture of what I am like as a person when dealing with the elderly.
51 I know my strengths and weaknesses when dealing with the elderly.
52 I have a clear understanding of my own values and principles when dealing with the elderly.
53 I know what I need in my life.
54 I am always motivated to learn more about service-learning.
55 I always keep my service-learning knowledge and skills up-to-date.
56 I look out for new service-learning skills or knowledge to acquire.