Design of an Innovative Assessment Instrument Integrating Service-Learning Malaysia University for Society Approach for Engineers in Society Course during Covid19 Pandemic

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Abstract
Service-Learning Malaysia-University for Society (SULAM) has served as a learning experience in Malaysia for the past few years, merging theories and practices to expose students to real-world community problems. SULAM was developed as a cutting-edge teaching and learning technique in Malaysia's higher education institutions (HEIs). Alternative assessment is one of the instruments for evaluating students' work in a real-world environment. It can also help students develop their higher-order thinking skills (HOTs), particularly at engineering HEIs. However, there is a dearth of research on SULAM in engineering programmes, particularly in terms of the assessment instruments utilised in achieving the essential skill sets for societal well-being. This study improves on the ordinary way of assessment by creating a unique alternative assessment instrument for the Engineers in Society (EIS) course integrated with SULAM (EIS-SULAM) to analyse the expected outcomes and evaluate its success. The EIS-SULAM course and its curricula were assessed in this study through document analysis and the creation of an assessment instrument by subject matter experts. The assessment instrument was used by 415 respondents utilising a purposive sampling of civil engineering students taking the EIS-SULAM course during the February–July 2020 semester (starting of Covid19 Pandemic) to determine its usefulness in measuring students' skill sets. The students submitted 90 projects using the Google Classroom platform and were assessed by three (3) lecturers using a syndicated marking method to assure fairness and uniformity in the report's marking. The results show that the student's grades are distributed normally, with around 20% of the 415 students receiving A+, A, and A- grades, 70% receiving B+, B, and B- grades, and 10% receiving C+ and C grades. Overall, all students met the 50% cut-off mark for the EIS-SULAM course, which satisfies the EAC Standard 2020 criterion. It is envisaged that the findings of this study will be used to improve engineering assessment instruments to increase societal well-being.

Keywords: *Engineers in Society, Innovative Alternative Assessment, Complex Engineering Problems, Outcome Attainment, SULAM*

Background of Study

One of the Engineering Accreditation Council (EAC) standards' requirements is to ensure that graduates of accredited engineering programmes meet the minimum academic standards for registration as graduate engineers with the Board of Engineers Malaysia (BEM) (EAC, 2020). To achieve these objectives, the EAC established several evaluation criteria, including Program Educational Objectives (PEOs), Program Outcomes (POs), and Academic Curriculum for Malaysian Higher Education Institutions (HEIs). Students must demonstrate the achievement of the 12 EAC's POs. As a result, it is critical to ensure that the programme outcomes are also not simply a list of course outcomes, but rather broad statements about basic transferrable skills that prepare students to be well-prepared (Mutalib et al., 2012).

The fundamental component of learning is assessment, which aids students in learning and determines their degree of comprehension of course material. Alternative assessments, such as problem-based and project-based assessments, could be linked to performance exams or authentic assessments to verify a student's ability to solve the specific work that is given. Furthermore, an alternative assessment focuses on applied proficiency rather than knowledge in a subject. In today's higher education, alternative assessment can be used to critically evaluate the student's performance and the development of reflective thinking, both of which can aid in deep learning (Woyessa, 2009; Kiew et.al., 2020). Othman et al., (2015) investigated the implementation of an integrated project (IP) course, in which aspects from many areas were creatively combined to help students better comprehend how the topics linked to one another.

Since engineering education is the process of transferring knowledge and concepts to engineers who work in the field, the authors advocated using an alternative assessment in the Engineers in Society course to measure students' ability to apply their knowledge and abilities in a real-world setting. The Department of Higher Education, Ministry of Education Malaysia (Ministry of Higher Education (MoHE, 2019) launched Service-Learning Malaysia, also known as SULAM (Service-Learning Malaysia-University for

Society). The creation of this curriculum contributes significantly to the Ministry of Education Malaysia's goal of preparing university students to become public intellectuals accountable for solving society's problems and assisting people in improving their lives in every way. As a result, HEIs should promote and implement SULAM approach inaugurated on April 13th, 2019. This curriculum exposes students to a learning environment that includes both theory and practical problem-solving in the community. SULAM was viewed by Truong et al., (2020) as a teaching technique to examine students' reflections on structured activities to satisfy the demands of their target community as well as get real-world experience for their professional development and other benefits.

SULAM is currently being integrated into the Engineers in Society (EIS) in a civil engineering undergraduate programme at the School of Civil Engineering, Universiti Teknologi MARA (UiTM), Shah Alam. The project-based learning (PrbL) course is offered in the final year of the curriculum. The project is carried out as a structured service activity, which is a civil engineering community project that addresses identified community needs through complex engineering problem-solving. Students must also understand the role of engineering ethics and the engineer's professional duty to safeguard public safety, as well as the economic, social, cultural, environmental, and sustainability consequences of engineering activity (Kiew et al., 2020). Furthermore, today's engineering profession is continually confronted with uncertainty and competing (sometimes conflicting) requirements or needs from clients, governments, environmental agencies, and the public which demands both interpersonal and technical abilities (Liew et al., 2020).

Engineers must deal with constant technical and organizational change in the workplace while seeking to incorporate more human qualities into their knowledge base and professional practices. They must also deal with the reality of modern industrial practices, as well as the legal implications of every professional decision they make. Students can use service-learning to produce a real-world result for society while also deepening their understanding of themselves and the community. As a result, students will be able to understand how to deal with complex issues in real-life application, such as societal needs.

Mamat et al. (2019) used a qualitative approach to investigate the practice and implementation of service-learning in four (4) public universities in Malaysia, using interview sessions to ask questions about practice, implementation methods, evaluation, documentation, and the impact of positive teaching-learning using the most recent service-learning method, while Yusof et al. (2020) focused on the perspectives of lecturers and students on the challenges they have faced. With the use of scoring rubrics, McGowan (2017) discovered that there are quantitative (i.e., work hours, pre and post experience survey results, and ratings of learning experience) and qualitative (i.e., portfolio, diary, and content analysis) assessment methods for evaluating learning outcomes effectiveness. The importance of a top-down approach in the assessment of experiential learning outcomes is emphasized by Krieger and Martinez (2012). Chan (2012) cited a scarcity in research on outcomes-based assessment methods in community service experiential learning.

Based on the identified problems, research questions to address the study's objective are: (1) Why was the new alternative assessment required during the pandemic? (2) How was the alternative assessment instrument developed? (3) What are the performance criteria used to effectively assess the intended learning outcomes set for the course, and finally (4) How effective were the assessment tools used in this exercise. Thus, this study was conducted to design and develop an effective alternative assessment instrument for the Engineers in Society course that incorporates the SULAM concept and addresses the EAC standard 2020 requirements for complex engineering problem characteristics.

Methodology

The design and development of the new innovative assessment tool for the EIS course was carried out after the faculty received the directive from the university to replace final examination with continuous assessment during the COVID-19 pandemic, starting March 2020. In addition, it is also regarded as a pilot SULAM project as mandated by Universiti Teknologi MARA (UiTM) that aligns to the Ministry of Education Malaysia requirements. Thus, the EIS-SULAM project was specifically developed to fulfil a continuous assessment for ODL as a replacement for the final examination.

The design and development of the assessment was carried out by five (5) internal experts, namely the Resource Person, Course Coordinator and three (3) lecturers teaching the course. The design and development processes are: (1) Document review on the syllabus, course contents, lesson plan and the assessment tools relevant to the Engineer in Society course, EAC Standard 2020 requirements to address complex problems (WPs) and knowledge profile (WKs); (2) Development of project brief and problem statement and assessment tools; (3) Development of the learning outcomes, detailed task breakdown with mark distribution(see Table 2) complemented by the performance criteria matrix or assessment rubrics for project report (see Table 3).

First, based on the document review, the course's prior evaluation mechanisms included a final examination (40%), a common test (20%), and a group assignment (40%). The new assessment tools for the course are EIS-SULAM project constitutes of 60% weightage while, the balance of 40% weightage is allocated for Test 1 and Test 2. This paper presents the

new and innovative tool that has been developed as a main component of the continuous evaluation, with an overall percentage of 60% assessed as a group (30%) and individually (30%).

As stated in Table 1, the project addresses three (3) course outcomes (COs) that are mapped to two (2) programme outcomes (POs), as well as complex engineering problems (WPs) with the required knowledge profiles (WKs) specified by the EAC Standard 2020. Students apply engineering fundamental (WK3) and specialist knowledge (WK4) for engineering problem identification and solving problems in the project through research literature (WK8) such as valid sources, resources and past knowledge and experiences, in addition to understanding of issues and approaches (WK7) of professional conduct and the roles of civil engineers in broad contexts. Students working in an engineering team with knowledge in engineering procedures (WK5) emphasize stakeholders' conflicts, analyses, and make judgements based on societal demands.

Table 1. Mapping of CO-PO with WP and WK in EIS-SULAM Project

Course Outcome (CO)	Programme Outcome (PO)	Complex Engineering Problems Characteristics (WP) and Knowledge Profiles (WK)
CO2: Ability to explain the roles of engineering professional bodies.	PO6: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7);	WP1: Depth of Knowledge Required (WK3, WK4, WK6 & WK8) & WK7 WP2: Conflicting requirements WP3: Depth of Analysis – Non-obvious solutions WP4: Familiarity of issues or infrequently encountered issues WP5: Extent of applicable codes
CO4: Ability to understand the local and federal authorities' Regulations.		
CO3: Ability to describe the Code of Ethics and Professional Conduct for engineers	PO8: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice (WK7).	WK7: Comprehension on issues and approaches in engineering practices

Next, the EIS-SULAM project brief and problem statement was developed for a group of 4 to 5 students and comprised of open-ended problems related to the COVID19 pandemic. During the February to July 2020 semester at the Faculty of Civil Engineering, UiTM, Shah Alam, Selangor, 415 students took this course, which was facilitated by three (3) lecturers. A clear problem statement with an effective assessment method in terms of project report together with a detail assessment rubric have been established to measure the COs and POs for this course to ensure a fair and consistent assessment for the students. The problem statement initially lays out the students' overall scenario for the COVID-19 pandemic's effects on society, health, safety, legal, economic, social, cultural, environmental, and sustainability around the world. It then stimulates students' thinking by relating the pandemic's implications to the construction industry, which they will soon be working in. The full problem statement is given to the students as follows:

"The novel coronavirus disease that emerged at the end of 2019 began threatening the health and lives of millions of people. Highly contagious with the possibility of causing severe respiratory disease, it has quickly impacted governments and public health systems. This situation has been responded to by declaring a public health emergency of national and international concern and adopting extraordinary measures to prevent the contagion and limit the outbreak. As a result, millions of lives have been significantly altered, and a global, multi-level, and demanding stress-coping-adjustment process is ongoing. The COVID-19 disease has now achieved pandemic status. The World Health Organization has issued guidelines for managing the problem from both biomedical and psychological points of view. During the past few years, this unprecedented pandemic has changed the world in many ways regarding society, health, safety, legal, economic, social, cultural, environmental, and sustainability. COVID-19 has not only changed how we live by bringing us closer together as a society, but it has also disrupted financial markets, including professional engineering practices. One of the examples is the construction sector. Even though the sector contracted more challenges during the 1985 and 1998 recessions, this time around involved no construction work. This situation has a different dynamic, and we are currently in uncharted territory."

In addition, a poem dedicated by one of the lecturers teaching the course on how the COVID-19 pandemic affected civil engineering practices as shown in Figure 1 was also shared with the students.

Finally, the learning outcomes with seven (7) main tasks together with the performance criteria matrix was developed with the problem statement to measure the learning outcomes directly and explicitly in relation to the PO attainments. The rubric components expressed as tasks explicitly inform the students about the activities' requirements and were created to assess

three learning outcomes (LOs) that were closely related to the COs and POs.

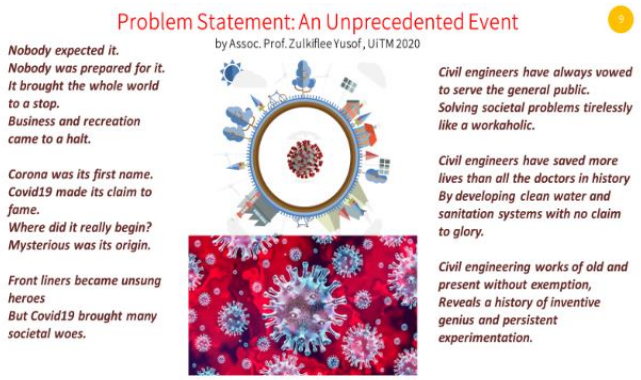

Figure 1. A Poem on role of civil engineers in an unprecedented event

Student learning activities should be centred on the role and contributions of civil engineers through professional conduct in society. The first targeted learning outcome (LO1) emphasises the student's capacity to identify current engineering problems that society is facing, as well as the responsibilities that come with them in civil engineering practises. Task 1: Identification and evaluation of infrequently encountered civil engineer-related issues in the new normal; Task 2: Identification and justification of conflicts between these issues; and Task 3: Proposal of engineering solutions and identification of new issues related to the proposal are the three rubric components associated with LO1.

The student's understanding of professional ethics and obligations was designated as the second targeted learning outcome (LO2). Task 4: Discussion of potential ethical issues and professional misconduct; and Task 5: Proposal of a remedy to overcome the potential ethical and misconduct issues are two rubric components of LO2. The students' ability to develop solutions to difficulties faced by professional engineering bodies discussing and addressing stakeholder conflicts is the third intended learning outcome. Task 6: Identification of challenges in executing offered solutions; and Task 7: Proposal of solutions to stakeholders' involvement and conflicts are two rubric components that can be used to assess LO3.

The rubrics were also created with the examination of advanced engineering problem-solving abilities in mind to address the three learning objectives (LOs) that students should achieve at the end of the project submission. Table 2 shows an overview of the tasks' breakdown, including mark distribution and mapping of COs, POs, LOs, and WPs. Table 3 shows the detailed performance criterion matrix which complements the expected learning outcomes intended for the EIS-SULAM project.

The is based on the following five-point scale: Scale 1 indicates "does not meet expectations," Scale 2 indicates "developing," Scale 3 indicates "meets expectations," Scale 4 indicates "proficient," and Scale 5 indicates "distinguished." "Distinguished" signifies student performance that exceeds "meets expectations" in terms of knowledge of the intended LOs and complex engineering problem-solving skills. The student was given the project specifics, including the rubrics, during the first week of the semester. In Week 14 of the semester, each group of students must present a report addressing all the responsibilities by chapter based on the tasks. Both students and lecturers benefit from the design rubrics to help them comprehend the "must-include" crucial features of each segment.

Results and Discussion of Findings

The EIS-SULAM project was specifically developed as a continuous assessment tool to replace the final examination during the COVID-19 pandemic starting March 2020. This new and innovative instrument has been developed as a main component of the continuous evaluation, with an overall percentage of 60% comprised of group (30%) and individual (30%) assessments.

Figure 2 depicts the submission of 90 projects by 415 students from 15 groups facilitated by three lecturers via the Google Classroom platform at the end of week 14. All lecturers participated in a moderation process that included syndicated marking: Lecturer A marked Task 1, Task 2, and Task 3; Lecturer B marked Task 4 and Task 5; and Lecturer C marked Task 6 and Task 7 using the designed performance criterion matrix (see Table 3).

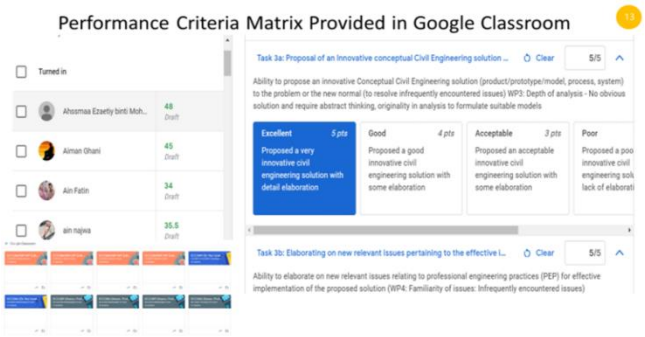

Figure 2. Google classroom used as an assessment platform

Each group of students proposed unique solution, although there is only one problem statement given to them in the project. Since the communities that the students engaged are different among groups, each group of students have diverse learning experiences particularly during the observations and identifications of specific problems faced by the community. Some of the submitted conceptual, innovative civil engineering solutions are shown in Figure 3.

Table 2. Learning outcomes and detailed task breakdown with mark distribution

Performance Criteria and Learning Outcomes with WKs and WPs		**CO-PO**	**Marks**
LO1: Identify, assess, and justify a current problem faced by society within economic, social, cultural, environmental and sustainability contexts and the consequent responsibilities relevant to professional civil engineering practices.			
Task 1 <u>Performance criteria:</u> a. Knowledge Profiles b. Evaluation of the identified problems **(WP1: Depth of Knowledge Required & WP4: Familiarity of issues or infrequently encountered issues)**	a. Identify a specific problem or a New Normal that have arisen during or due to the Movement Control Order (MCO) that have consequent responsibilities relevant to professional civil engineering practice	CO2-PO6	2%
	b. Evaluate the infrequently encountered issue/problem under various circumstances related to economic, social, cultural, health, safety, legal, environmental and sustainability aspects towards providing effective solutions.		3%
Task 2 <u>Performance criteria</u> a. Standards and codes of practice relevant to the problem or new normal b. Nature of conflict between the standards and codes of practice relevant to the problem or new normal. **(WP2: conflicting requirements & WP5: Extent of applicable codes)**	a. Identify with justification the technical, engineering, and other issues (due to the rules and regulations of authorities, code of professional practices, health and safety regulations, etc.) (WK7) relevant to the problem or the new normal arising from the pandemic, supported by relevant and validated information (reports, press statement, online news etc.) (WK8)	CO2-PO6	2%
	b. Highlight and explain the nature of conflict between the technical, engineering, and other issues (due to the rules and regulations of authorities, code of professional practices, health, and safety regulations, etc.) relevant to the problem or new normal.		3%
Task 3 <u>Performance criteria</u> a. Proposal of an Innovative conceptual Civil Engineering solution b. New relevant issues pertaining to the effective implementation of the proposed solution **(WP3: Depth of analysis & WP4: Familiarity of issues)**	a. Propose an innovative Conceptual civil engineering solution to the problem or the new normal	CO2-PO6	5%
	b. Elaborate on new relevant issues relating to professional engineering practices (PEP) for effective implementation of the proposed solution		5%
LO2: Propose solutions to potential ethical issues and misconduct among the engineers carrying out the above responsibilities.			
Task 4 <u>Performance criteria</u> Potential ethical issues and professional misconducts **(C5)**	Discuss in detail, potential ethical issues, and professional misconduct (based on the code of conduct by professional bodies) among engineers when implementing your proposed solution. (i) Provides at least 5 ethical issues and professional misconducts	CO3-PO8	5%
	(ii) Detail and excellent elaboration on at least 5 ethical issues and professional misconducts		5%
Task 5 <u>Performance criteria</u> Individual proposal to solve the problem and justify **(C6)**	Each student is required to propose an individual solution on how to overcome the potential ethical and misconduct challenges identified Task 4**.** (i) Excellent and innovative individual proposal	CO3-PO8	5%
	(ii) Excellent and very clear justification		5%
LO3: Identify with justifications, the challenges from the relevant local and federal authorities' regulations to the professional engineering practice and propose solutions to overcome them.			
Task 6 <u>Performance criteria</u> Challenges that could be faced by the engineering professional bodies in implementing the proposed solution (**WP5: Extent of Applicable Codes)**	Each student is required to identify the challenges that could be faced by the engineering professional bodies in implementing the proposed solutions (Task 3) due to the rules and regulations imposed by the local and federal authorities. (i) Identified more than 4 challenges	CO4-PO6	5%
	(ii) Excellent elaboration on the standards imposed by authorities		5%
Task 7 <u>Performance criteria</u> Development of solution to overcome the challenges **(WP6: Extent of Stakeholders)**	Each student is required to propose how to overcome the challenges posed by the rules and regulations imposed by the authorities. (i) Discussion addresses more than 3 stakeholders addressed	CO4-PO6	5%
	(ii) Detail explanation of conflicting requirements between stakeholders		5%
		Overall Marks	**60%**

Table 3. Performance Criteria Matrix for EIS-SULAM Project Assessment using Report

Performance Criteria	Complex Engineering Problem Characteristics/ Taxonomy Level	Description of Performance Criteria				
Task 1a: a. Identification of specific problem using relevant Knowledge Profiles **(CO2-PO6)**	**WP1:** Depth of Knowledge Required = in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 (WK's) fundamental, first principles analytical approach	Ability to identify a specific problem or a New Normal (WP4: Infrequently encountered issues) that have arisen during or due to the Movement Control Order (MCO) that have consequent responsibilities relevant to professional civil engineering practice **(WK4- specialitst knowledge, WK6 -Engineering Practices; WK7-comprehension and WK8 – literature research)**				
		1	**2**	**3**	**4**	**5**
		Demonstrate only two (2) or less specified of WKs	Demonstrates only three (3) specified WKs	Acceptable demonstration of all four (4) specified WKs	Good demonstration of all four (4) specified WKs	Excellent demonstration of all four (4) specified WKs
Task 1b. Evaluation of the identified problems **(CO2-PO6)**	**WP4: Familiarity of issues**: Infrequently encountered issues	Ability to evaluate the infrequently encountered issue/problem under various circumstances related to **economic, social, cultural, health, safety, legal, environmental and sustainability** aspects towards providing effective solutions.				
		1	**2**	**3**	**4**	**5**
		No evaluation of any circumstance	Evaluate 1 circumstances with acceptable justification	Evaluate 2 circumstances with acceptable justification	Evaluate 3 circumstances with acceptable justification	Evaluate more than 3 circumstances with acceptable justification
Task 2a: Identifying and justifying standards and codes of practice relevant to the problem or new normal. **(CO2-PO6)**	**WP5: Extent of applicable codes**: outside problems encompassed by standards and codes of practice	Ability to identify with justification *the* ***technical, engineering and other issues (due to the rules and regulations of authorities, code of professional practices, health and safety regulations, etc.) (WK7)*** relevant to the problem or the new normal arising from the pandemic, supported by relevant and validated information (reports, press statement, online news etc.) **(WK8**)				
		1	**2**	**3**	**4**	**5**
		Lack of supporting sources (not valid and not relevant)	Supported by 2 sources literature search but not relevant and validated	Supported by 2 sources of literature search	Supported by 3 sources of literature search	Supported by more than 3 sources of literature search
Task 2b: Highlighting and explaining the nature of conflict between the standards and codes of practice relevant to the problem or new normal. **(CO2-PO6)**	**WP2:** Conflicting requirement Wide-ranging or conflicting technical, engineering, and other issues	*Ability to highlight and explain the nature of conflict between the technical, engineering and other issues (due to* ***the rules and regulations of authorities, code of professional practices, health and safety regulations, etc****.) relevant to the problem or new normal.*				
		1	**2**	**3**	**4**	**5**
		Provide technical, engineering and other issues with poor explanation on the nature of conflict.	Provide technical, engineering and other issues with **quite** acceptable explanation on the nature of conflict between at least 2.	Provide technical, engineering and other issues with acceptable explanation on the nature of conflict between 2.	Provide technical, engineering and other issues with quite acceptable explanation on the nature of conflict between 3	Provide technical, engineering and other issues with quite acceptable explanation on the nature of conflict between more than 3.
Task 3a: Proposal of an Innovative conceptual Civil Engineering solution **(CO2-PO6)**	**WP3: Depth of analysis** No obvious solution and require abstract thinking, originality in analysis to formulate suitable models	Ability to propose an innovative Conceptual Civil Engineering solution **(product/prototype/model, process, system)** to the problem or the new normal (to resolve infrequently encountered issues)				
		1	**2**	**3**	**4**	**5**
		Proposed a non-civil engineering solution	Proposed a poor civil engineering solution with poor elaboration	Proposed an acceptable innovative civil engineering solution	Proposed a good innovative civil engineering solution with some elaboration	Proposed a very innovative civil engineering solution with detail elaboration
Task 3b:	**WP4:** Familiarity of issues: Infrequently encountered issues	Ability to elaborate on new relevant issues relating to professional engineering practices (PEP) for effective implementation of the proposed solution				

Elaborating on new relevant issues pertaining to the effective implementation of the proposed solution **(CO2-PO6)**		**1**	**2**	**3**	**4**	**5**
		Provide new issues but not relevant to PEP	Provide at least 1 new issue relevant to PEP with brief elaboration,	Provide 2 new issues relevant to PEP with elaboration,	Provide 3 new issues relevant to PEP with elaboration	Provide more than 3 new issues relevant to PEP with elaboration
Task 4: Elaboration of potential ethical issues and professional misconducts **(CO3-PO8)**	**C5 - Evaluation**	Ability to elaborate in detail on potential ethical issues and professional misconduct (based on the code of conduct by professional bodies) among engineers when implementing your proposed solution				
		1	**2**	**3**	**4**	**5**
		Elaborate 1 ethical issue and professional misconduct	Elaborate 2 ethical issues and professional misconducts	Elaborate 3 ethical issues and professional misconducts	Elaborate 4 ethical issues and professional misconducts	Elaborate in detail more than 4 ethical issues and professional misconducts
Task 5: Individual proposal to solve the problem and justify **(CO3-PO8)**	**C6 - Creation**	Ability to propose an individual solution on how to overcome the potential ethical and misconduct challenges identified in Task 4				
		1	**2**	**3**	**4**	**5**
		Poor proposal with no justification	Acceptable proposal with poor justification	Acceptable proposal with justification	Good proposal with justification	Excellent proposal with clear justification
Task 6: Identification of the challenges that could be faced by the engineering professional bodies in implementing the proposed solution **(CO4-PO6)**	**WP5: Extent of applicable codes**: outside problems encompassed by standards and codes of practice	Ability to identify the challenges that could be faced by the engineering professional bodies in implementing the proposed solutions (in Task 3) due to the standards, code of practice, and rules and regulations imposed by the local and federal authorities				
		1	**2**	**3**	**4**	**5**
		Identified 1 challenge with no elaboration	Identified 2 challenges with some elaboration	Identified 3 challenges with acceptable elaboration	Identified 4 challenges with good elaboration	Identified more than 4 challenges with excellent elaboration
Task 7: Development of solution to overcome the challenges **(CO4-PO6)**	**WP6:** Extent of stakeholder involvement and conflicting requirements = diverse groups of stakeholders with widely varying needs	Ability to propose ways/means/solution to overcome the challenges posed by the rules and regulations imposed by the professional bodies, authorities, and other stakeholders				
		1	**2**	**3**	**4**	**5**
		Stakeholders addressed but with no consideration of conflicting requirements	Stakeholders addressed but with brief explanation of conflicting requirements	2 Stakeholders addressed with detail explanation of conflicting requirements	3 Stakeholders addressed with detail explanation of conflicting requirements	More than 3 Stakeholders addressed with detail explanation of conflicting requirements

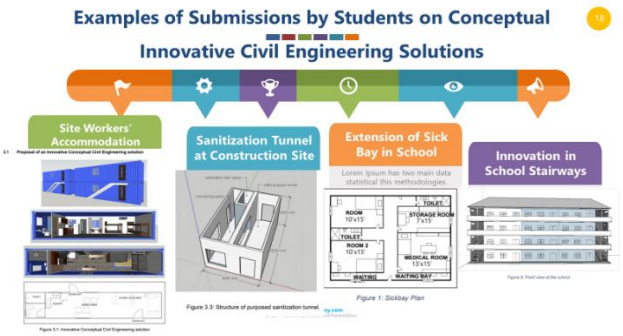

Figure 3. Examples of students' innovative solutions

The instructors play an important role in monitoring and controlling the process of selection the right community for their students to avoid duplication of the project themes. The students proposed a total of 90 different projects related to civil engineering fields. Some of the examples are Innovation in School Stairways, Sanitization Tunnel at Construction Site, Extension of Sick Bay in School, Site Workers Accommodation, Canvas Covered Building System with QR Code, Portable Quarters for Workers, Temporary Health Inspection System (THIS), Malaysia Emergency Special Force (KESF), Social Distancing System, Disinfection Tunnel of Site Workers, Portable Cabin Clinic, etc. Each project is unique in nature, and none of the projects is the same since the students need to choose different communities and observe and identify specific problems faced by the selected community. Next, the outcomes attained by the students for PO6 and PO8 are discussed in the following section.

Course Outcome and Programme Outcome Attainments based on EIS-SULAM Project

Table 4 displays the average grades awarded to each group for each task in the EIS-SULAM project. The following is a breakdown of the group and individual assessments: The group assessment was based on Tasks 1, 2, 3, and 4 and received a total score of 30%, while the individual assessment was based on Tasks 5, 6, and 7 and received a total score of 30%. CO2 and CO4 deal with PO6, whereas CO3 deals with PO8. While group assignments can achieve learning results those individual assignments cannot, they are notoriously difficult to grade properly for a variety of reasons, including but not limited to first, work is generally distributed unevenly among group members. Second, because collaboration limits a single student's ability to "control" the final product, lecturers may require members of a group to individually suggest a grade for "effort" for each of the group members, including themselves (peer assessment); and second, group work may not perfectly reflect the true abilities or effort of either a struggling student or an outstanding student. As a result, both individual and collective accountability were evaluated in this alternative assessment. The average individual achievement is only 61%, compared to 69% for the group. Task 3, which addresses CO2-PO6, has the lowest average mark (64%) in group assessment, while Task 5, which addresses CO3-PO8, has the lowest average in individual assessment. Thus, lecturers must propose an action to improve CO2 attainment for CQI purposes, which is the ability to explain the roles of engineering professional bodies to students, where they must propose an innovative conceptual civil engineering solution to the problem or the new normal, and further elaborate on new relevant issues relating to professional engineering practises for effective implementation of the proposed solution.

Figure 4 shows that, based on the EIS-SULAM project, each group has attained more than 50% of the cut-off point (red solid line) with an average PO6 of 68% (black perforated line). The distribution of marks is quite consistent among all groups with variances between 11 (max) and 8 (min).

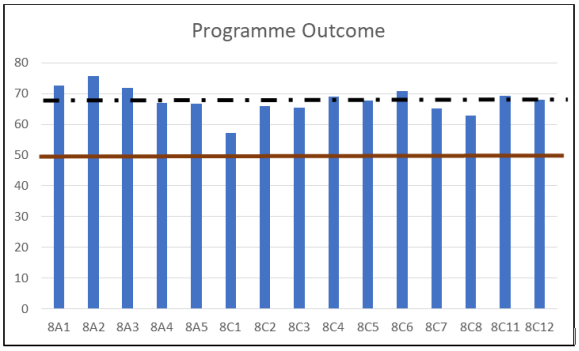

Figure 4. Programme Outcome (PO6) – Engineers in Society

Similarly, Figure 5 shows that, based on the EIS-SULAM project, each group has attained more than 50% of the cut-off point (red solid line) with an average PO8 of 60% (black perforated line).

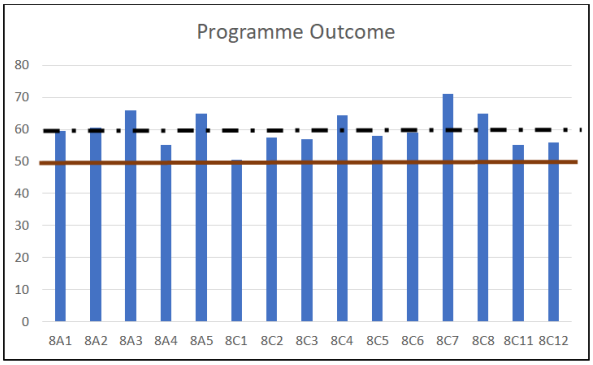

Figure 5. Programme Outcome (PO8) – Ethics

Table 4: Raw Marks for EIS-SULAM Project consisting of Group and Individual Assessment.

	Group Assessment (30%) (PO6-20% &PO8-10%)					**Individual Assessment (30%) (PO6-20% & PO8-10%)**							
Task & Group	Task 1 (5%) CO2-PO6	Task 2 (5%) CO2-PO6	Task 3 (10%) CO2-PO6	Task 4 (10%) CO3-PO8	**Total**	Task 5 (10%) CO3-PO8	Task 6 (10%) CO4-PO6	Task 7 (10%) CO4-PO6	**Total**	**Total (PO6&PO8) (60%)**	**PO6& PO8%**	**PO6 (%)**	**PO8 (%)**
8A1 (24)	4.1	3.8	7.9	6.6	22	5.3	6.5	6.7	19	40.9	68	73	60
8A2 (26)	4.3	4.1	7.3	6.8	23	5.3	7.6	7.0	20	42.4	71	76	61
8A3 (30)	3.8	3.9	7.2	7.7	23	5.5	6.7	7.1	19	41.9	70	72	66
8A4 (29)	3.3	3.7	6.6	6.0	20	5.0	6.9	6.3	18	37.8	63	67	55
8A5 (28)	4.6	3.6	5.5	7.5	21	5.5	6.0	7.0	19	39.7	66	67	65
8C1 (12)	4.2	3.2	5.3	4.8	18	5.3	4.1	6.1	16	33.0	55	57	51
8C2 (30)	4.1	3.8	5.8	5.9	20	5.6	6.1	6.6	18	37.9	63	66	58
8C3 (30)	4.4	3.6	6.2	6.6	21	4.8	5.3	6.7	17	37.6	63	66	57
8C4 (31)	4.0	3.9	6.9	7.4	22	5.5	6.4	6.4	18	40.5	68	69	65
8C5 (35)	3.5	3.6	5.8	6.0	19	5.6	7.0	7.2	20	38.7	65	68	58
8C6 (34)	4.0	2.9	7.6	6.3	21	5.5	6.7	7.1	19	40.1	67	71	59
8C7 (18)	3.4	3.4	6.3	8.3	21	5.9	5.9	7.1	19	40.3	67	65	71
8C8 (26)	3.5	3.4	6.0	7.2	20	5.8	6.2	6.0	18	38.1	64	63	65
8C11 (31)	4.5	4.3	6.0	5.7	21	5.3	6.5	6.4	18	38.7	65	69	55
8C12 (31)	4.3	3.5	6.1	6.0	20	5.2	5.8	7.5	19	38.4	64	68	56
Average	**4.0**	**3.6**	**6.4**	**6.6**	21	**5.4**	**6.2**	**6.7**	**18**	39.1	**65**	**68**	**60**

As shown in Figure 6, the mark distribution is relatively consistent among all groups, with variances for both PO6 and PO8. The average attainment of PO6 is 60%, which is lower than that of PO8, which is 68%. PO6 is measured through two (2) course outcomes, CO2 and CO4, while PO8 is measured through one (1) course outcome, CO3. Overall, the EIS-SULAM project constitutes 60% (40% for PO6 and 20% for PO8). The balance of 40% of the mark was from Test 1 (20% for PO8) and Test 2 (20% for PO6).

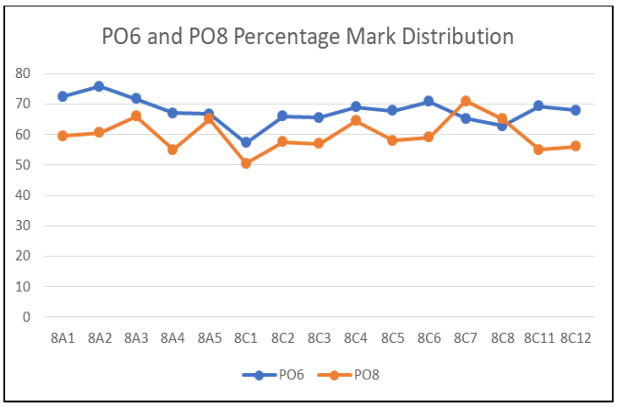

Figure 6. PO6 and PO8 distribution among groups

Figure 7 shows a bell curve that is symmetrical and indicates the normal distribution of grades achieved by the students based on the four assessments. It is concentrated around the peak and decreases on either side. In a bell curve, the peak represents the most probable event in the dataset, while the other events are equally distributed around the peak.

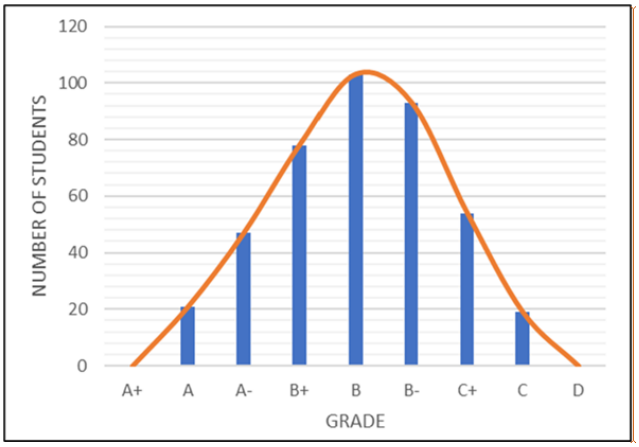

Figure 7. Normal distribution of Grade by Students for March – July 2020 Semester

Conclusions

During the COVID-19 pandemic, this study was carried out to design an innovative alternative assessment instrument for the Engineers in Society (EIS) course that incorporates the SULAM technique (EIS-SULAM) as the key element of the continuous assessment (60%). The instrument was developed to replace the final test in the Open and Distance Learning (ODL) using rubrics with comprehensive descriptors for each criterion. This exercise also served as a dry run for the SULAM project, as directed by Universiti Teknologi MARA (UiTM) and the Malaysian Ministry of Higher Education. Based on the measured course learning and programme outcomes, a document review was conducted to examine the assessment and student performance. Overall, this innovative alternative assessment instrument was utilized to evaluate students' performance in a real-world setting (community service) to develop engineering students' critical and creative thinking. The lecturers evaluated 90 reports submitted by 415 students using the assessment instrument, which was based on criteria established by the intended course outcome, programme outcomes, and the requirements for complex engineering problem characteristics. Students received a normal distribution of grades, with 20% receiving A+, A, and A-, 70% receiving B+, B, and B-, and 10% receiving C+ and C, according to the findings. All students scored higher than the program's 50% cut-off point for PO6 (Engineers in Society) and PO8 (Ethics), with 68 % and 60%, respectively. It is envisaged that the results of this study will be used to improve alternative assessment instruments in engineering courses involving community service learning, with the goal of improving societal well-being. The scope of this research is limited to a document evaluation of one engineering course at a Malaysian HEI. Future studies could include gathering input from students and lecturers on the assessment's implementation to improve the course's quality over time, comparing outcomes before and after SULAM implementation, and expanding to a few HEIs.

References

Chan, C. K. Y. (2012). Assessment for community service types of experiential learning in the engineering discipline. *European Journal of Engineering Education*, *37*(1), 29–38. https://doi.org/10.1080/03043797.2011.644763

Engineering Accreditation Council. (2020). *Engineering Programme Accreditation Standard 20207* (2020th ed.). Engineering Accreditation Department, Board of Engineers Malaysia.

Kiew, P.L., Liew, C.P., Puteh, M., Tan, K.G. (2020). The Impact of Alternative Assessments in Assessing the Seventh Component of the Washington Accord's Knowledge Profile. In: Auer, M., Hortsch, H., Sethakul, P. (eds) The Impact of the 4th Industrial Revolution on Engineering Education. ICL 2019. Advances in Intelligent Systems and Computing, vol 1134. Springer, Cham. https://doi.org/10.1007/978-3-030-40274-7_67

Krieger, S. H., & Martinez, S. a. (2012). Performance Isn't Everything: The Importance of Conceptual Competence in Outcome Assessment of Experiential Learning. *Clinical L. Rev.*, *19*, 251.

Liew C.P., Hamzah S.H., Puteh M., Mohammad S., Badaruzzaman W.H.W. (2020) A Systematic Approach to Implementing Complex Problem Solving in Engineering Curriculum. In: Auer M., Hortsch H., Sethakul P. (eds) The Impact of the 4th Industrial Revolution on Engineering Education. ICL 2019. *Advances in Intelligent Systems and Computing*, vol

1134. Springer, Cham. https://doi.org/10.1007/978-3-030-40274-7_86

Maharam Mamat, Najah Nadiah Amran, Hamdi Ishak, & Maznah Ibrahim. (2019). Service-Learning In Malaysia: Practice And Implementation In Four Public Universties. *International Journal of Civil Engineering Technology*, *10*(4), 1682–1691.

Ministry of Higher Education (MoHE). (2019). *Service learning malaysia - university for society*.

Mutaliba AA, Riza A. A. Rahmata & Zamri Chik. The Achievement of Program Outcomes from the Perspective of CSED, UKM Final Year Students: Part 1-Session 2005/2006. *Procedia - Social and Behavioral Sciences 60 (2012) 343 – 349.*

Othman, N. A., Sheikh Abdullah, S. R., Takriff, M. S., Rahman, N. A., Kofli, N. T., Ismali, M., & Hassan, S. Z. (2015). Achievement of programme outcomes through integrated project as an innovative approach from a teaching and learning perspective. *Journal of Engineering Science and Technology*, *10*(Spec. Issue 1 on UKM Teaching and Learning Congress 2013, June 2015), 61–73.

Truong, V., Bui Phu, H., & Truong Thi Tu, L. (2020). Integrating Community Service Learning into University Curriculum: Perspectives from EFL Teachers and Students. *Language Related Research*, *11*(5), 201–226. https://doi.org/10.29252/lrr.11.5.201

Veronica F. McGowan, U. of C. O. (2017). *An Investigation Into The Transparency Of Institutional Assessment Of Service Learning Objectives And Outcomes In Higher Education Settings*, (2015), 36–37. https://doi.org/10.2753/MER1052-8008240201.

Woyessa, YE, Van Tonder, SP & Jaarsveldt DV, 2009. A*lternative student assessment in engineering education: Lecturers' perceptions and practices.* The 2nd International Multi-Conference on Engineering and Technological Innovation IMETI 2009, pp 224-229.

Yusof, N., Ariffin, T. F. T., Rosna Awang Hashim, H. N. &, & Kaur, A. (2020). Challenges of Service Learning Practices: Student and Faculty Perspectives from Malaysia. *Malaysian Journal of Learning and Instruction:*, *17*(2), 279–309.