Effectiveness of SDG 6-Aligned Assignments on PO4 and PO6 Attainment in a Water Engineering Laboratory Course

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ABSTRACT

Sustainability has become an important element of graduate competency, especially with the Malaysian Qualifications Framework (MQF) emphasizing the Sustainable Development Goals (SDGs). One of the key goals, SDG 6 (Clean Water and Sanitation), is closely related to the ECW341 Water Engineering Laboratory course in Civil Engineering at UiTM. However, its practical application in laboratory courses remains limited. This study was conducted to explore the impact of embedding SDG 6 in a laboratory-based assignment on Program Outcome (PO) attainment in this course. Two Programme Outcomes (POs) were assessed: PO4, evaluated through laboratory observation and testing, and PO6, assessed through written reports and assignments. Before the implementation of SDG 6 (October 2022–February 2023), 59%–75% of students achieved grades in the A range, with most of the remainder in the B range. After SDG 6 was introduced, grade distributions varied across campuses but remained consistently concentrated in the A–B ranges, with only a small proportion (≤20%) in the C range and no grades below C. Improvements in PO4 and PO6 were particularly evident in the October 2024 to February 2025 semester, with mean attainment ranging from 75% to 82% (PO4) and 75% to 80% (PO6). These findings suggest that SDG 6-themed assignments not only enhance students' technical investigation skills but also increase their awareness of environmental and societal responsibilities. The results also highlight the importance of integrating sustainability into laboratory teaching, contributing to both student learning and broader educational goals, although the study is limited by the absence of student feedback and the lack of controls for cohort and instructor variations.

Keywords: PO4, PO6, SDG 6, outcome-based learning, laboratory assessment

INTRODUCTION

Sustainability has become a critical agenda in higher education [1], particularly in engineering, where graduates are expected to address environmental and societal challenges alongside technical requirements [2]. Globally, engineering curricula are increasingly integrating the Sustainable Development Goals (SDGs) to prepare future engineers for real-world challenges [3], [4]. This study also situates UiTM's efforts within global contexts, where universities such as Tecnologico de Monterrey [4] and institutions in Spain [5] have reported similar benefits of embedding SDGs. This study focuses on SDG 6 (Clean Water and Sanitation), which is directly relevant to the Water Engineering Laboratory course.

The Malaysian Qualifications Framework (MQF) and Outcome-Based Education (OBE) framework require Programme Outcomes (POs) that balances technical and non-technical competencies [6], [7]. Specifically, for this study, PO4 (investigation) focuses on the ability to conduct experiments and analyze data, while PO6 (the engineer and society) emphasizes awareness of environmental, societal, and ethical considerations, which are integrated into students' laboratory reports and assignments. The ECW341 Water Engineering Laboratory course builds upon concepts introduced in basic fluid mechanics, hydraulics, hydrology, and water quality. Students engage in group-based laboratory experiments with written reports, while individual performance is evaluated through practical tests.

Historically, PO4 and PO6 were assessed without SDG integration in diploma-level civil engineering courses at UiTM. An SDG 6-aligned assignment was introduced in October 2024 to strengthen accreditation alignment

and real-world relevance. This study evaluates the effectiveness of embedding SDG 6 in the ECW341 course by examining its impact on PO4 and PO6 attainment as well as students' grade performance across five consecutive semesters (October 2022–February 2025).

LITERATURE REVIEW

The Malaysian Qualifications Framework [7] and the Code of Practice for Programme Accreditation (COPPA) [6] align engineering education in Malaysia and emphasize five clusters of learning outcomes: knowledge, cognitive skills, functional work skills, personal and entrepreneurial skills, and ethics and professionalism. These outcomes are operationalized through Outcome-Based Education (OBE) and measured using POs, as stipulated by the Engineering Accreditation Council (EAC). In this framework, engineering graduates are expected not only to demonstrate technical competencies but also to uphold ethical values, sustainability awareness, and professional responsibility. Recent revisions of the MQF highlight the importance of embedding Education for Sustainable Development (ESD) across curricula, ensuring alignment with global agendas such as the United Nations Sustainable Development Goals (SDGs).

Overview of OBE and Programme Outcomes

OBE requires every course to be mapped to specific POs, which serve as measurable targets for evaluating students' attainment of essential knowledge, skills, and values. For engineering students, these POs go beyond technical competence to include higher-order skills such as investigation of complex problems, communication, teamwork, and responsibility to society and the environment. By positioning POs as the primary benchmark of achievement, OBE ensures that engineering graduates are not only technically capable but also prepared to meet professional, ethical, and sustainability challenges in line with national and global standards.

Definition and Role of PO4 and PO6

The Engineering Technology Programme Accreditation Standard (ETAC) 2024 defines PO4 as the ability to investigate broadly defined engineering problems by locating, selecting, and applying relevant data and technologies to reach valid conclusions [8]. PO6 emphasizes the application of contextual knowledge to assess the impact of engineering solutions on sustainability, society, the economy, health and safety, legal frameworks, and the environment.

SDG Integration in Higher Education

Higher Education Institutions (HEIs) play a critical role in addressing global sustainability challenges and advancing the SDGs [9]. Future leaders, as students today, will shape the trajectory of sustainability in the coming decades through their decisions as professionals, policymakers, and citizens [10]. Thus, integrating sustainability into the educational fabric is not only desirable but also imperative. The challenge lies in how related parties in the tertiary education system support changes to the current educational system to deliver learning and teaching more robustly and effectively in achieving sustainability [11]. Universities in Malaysia have started including the Sustainable Development Goals (SDGs) in engineering courses, but they still need to improve their implementation.

Gaps in Previous Studies

Recent studies have explored the integration of Sustainable Development Goals (SDGs) in engineering education across various contexts. [4] examined all engineering courses at Tecnologico de Monterrey, highlighting that universities are increasingly embedding SDGs through learning activities, academic projects, competency definitions, courses, and extracurricular activities, thereby contributing to a more sustainable world. Similarly, [5] collected data from a master's degree in industrial engineering, which integrated SDGs using active learning strategies from a chemical engineering perspective, and reported improved academic performance, reduced failure rates, and fewer low-grade passes. [12] analyzed online syllabi for engineering, science, and technology courses, finding that only three SDGs were entirely unaddressed, and mechanical

engineering courses demonstrated higher integration compared to other disciplines. Existing studies largely emphasize graduate programs or whole institutions, while undergraduate and laboratory-based courses receive little attention. These gaps indicate the need for research on practical strategies to integrate SDGs into undergraduate engineering education.

METHODOLOGY

This study adopted a quantitative approach to examine how effectively SDG 6 was integrated into a laboratory assignment and its impact on students' achievement of POs and students' grades. The course enables students to grasp core concepts in hydraulics, fluid mechanics, and water quality through practical experiments and written lab reports and assignments. The study did not control differences in cohorts or instructors, and systematic student feedback (e.g., surveys or reflections) was not collected. These limitations restrict the qualitative interpretation of findings.

Students and Study Period

This study involved Semester 5 Diploma in Civil Engineering students from four UiTM campuses: Johor, Pahang, Sarawak, and Penang. Data was collected over five consecutive semesters, from October 2022 to February 2025.

Assignment Design

A sustainability-themed laboratory assignment was introduced in the March–September 2023 semester to align with SDG 6 (Clean Water and Sanitation). Table I below presents an overview of the assignment across five consecutive semesters (from October 2022 to February 2025). It incorporated practical rain gauge construction, rainfall data analysis using the Thiessen Polygon method, comparison with Infobanjir datasets, and climate-related discussions. By October 2024, the assignment combined hands-on fabrication, Excel-based analysis, and real-world database application, explicitly aligning with SDG 6.

Table I Summary of ECW341 Assignment (October 2022 – February 2025)

Semester	Assignment	SDG 6 Implemented
Oct 2022- Feb 2023	**Assignment:** Rain Gauge, Isohyetal Method. **Focus:** Hands-on, construct rain gauge with props, measure rainfall, draw isohyets, calculate mean areal rainfall. **Characteristics:** Experiential learning (students build simple apparatus). Limited real-world connection No explicit link to sustainability, climate change, or water management.	No
Mar 2023- Sep 2023	**Assignment:** Thiessen Polygon, Infobanjir Data, Climate Change. **Focus:** Rainfall data analysis using Thiessen Polygon, compare with official Infobanjir data, interpret trends, discuss climate change/monsoon/ El-Nino and El-Nina impacts. **Characteristics:** Uses real data from Public Infobanjir. Requires students to connect rainfall variability with climate change and	Yes

	extreme weather.	
Oct 2023-Feb 2024	Similar question as March 2023-September 2023	Yes
Mar 2024-Sep 2024	Similar question as March 2023-September 2023	Yes
Oct 2024- Feb 2025	**Assignment:** Fabricated Rain Gauge, Analyze by MS Excel, Thiessen Polygon Method, Infobanjir, Climate Context. **Focus:** Combination of practical rain gauge fabrication, Excel-based data analysis, Thiessen Polygon method, comparison with Public Infobanjir data, discussion of climate change and monsoon impacts. **Characteristics:** Combines hands-on experiments, digital analysis, and real-world database. Encourages critical thinking about climate variability and resilience. Explicit alignment with SDG 6 (Clean Water and Sanitation)	Yes

Fig. 1 below illustrate the assignment's practical components implemented for SDG 6 alignment, showcasing students' engagement in constructing the rain gauge for field application and analysis. The activities shown in Figure 1 demonstrate the practical implementation of sustainability-focused learning tasks within the CEEC110 Civil Engineering program in the Water Engineering Laboratory course.

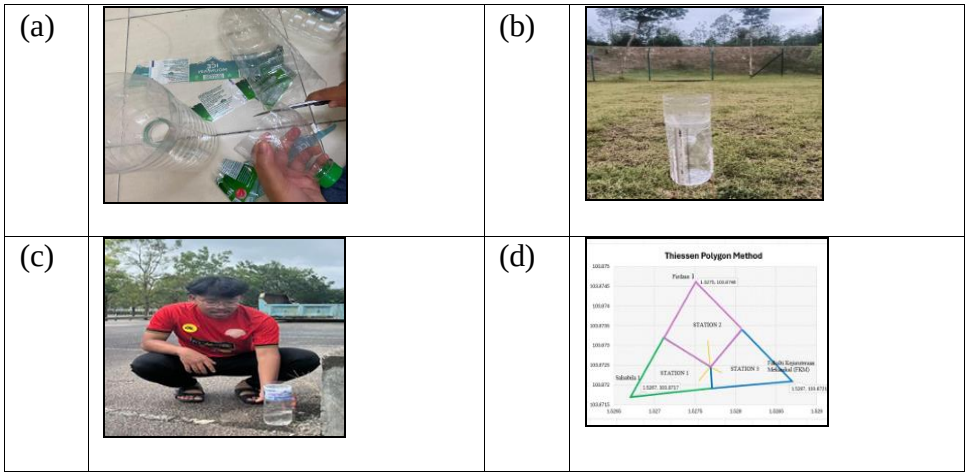

Fig. 1 Examples of Student Activities in the SDG 6-Aligned Assignment: (a) fabrication of rainfall gauge, (b) rainfall gauge installed at open area, (c) student placed the rainfall gauge at parking area, (d) Thiessen polygon method used to analyze the precipitation.

Through the activity in Fig. 1, students applied investigation and data analysis skills (PO4) by collecting, measuring, and interpreting rainfall using the Thiessen Polygon method. At the same time, the students compared their recorded rainfall data (PO6) with information from the Public Infobanjir website published by the Department of Irrigation and Drainage (DID) Malaysia. This process aligns with the SDG 6.

RESULTS AND DISCUSSION

Data were collected from Semester 5 Civil Engineering students at four UiTM campuses: Johor, Penang, Sarawak, and Pahang, over five semesters from October 2022 to February 2025. Between October 2022 and February 2023, students completed a traditional assignment that did not incorporate SDGs. From March 2023

to February 2025, the SDG 6-aligned assignment was implemented. Students' performance in PO4 and PO6 was compared using a bar chart to visually illustrate differences before and after the implementation of the SDG 6-aligned assignment. Figure 2 shows a bar chart of PO4 which mean score trends from October 2022 to February 2025.

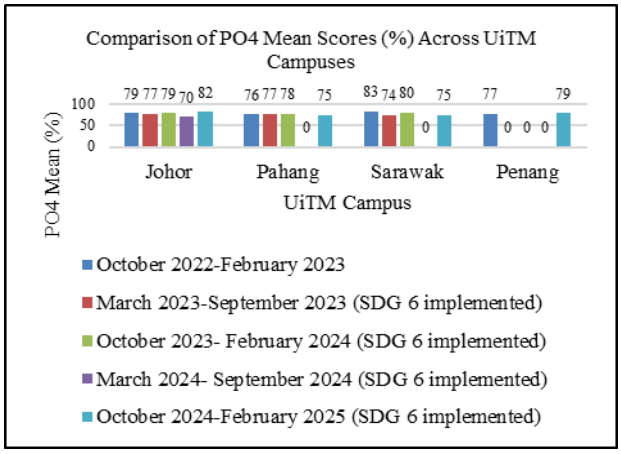

Fig. 2 Comparison of PO4 Mean Scores (%) Across UiTM Campuses from Semester October 2022 to February 2025

As shown in Fig. 2, PO4 mean scores across campuses also varied throughout the semesters. The scores were increased in the March–September 2023 semester for UiTM Johor, UiTM Pahang, and UiTM Penang, after the period without SDG 6 integration (October 2022 – February 2023), with ranges of 79%–82%, 76%–78%, and 77%–79%, respectively.

After the implementation began in March 2023, most campuses maintained stable performance, while some campuses experienced a slight drop because no students enrolled in the semester from March 2024 to September 2024 (UiTM Pahang and Sarawak) and the semester from March 2023 to September 2024 (UiTM Penang). The increase in PO4 achievement was due to the integration of real-world data analysis and scientific investigation through the application of the Thiessen polygon method. Students were actively engaged in collecting and interpreting rainfall data, which enhanced their ability to investigate complex engineering problems using appropriate analytical tools and methods. This upward trend suggests that integrating SDG 6 into the assignment had a positive impact on students' ability to conduct investigations and analyze data. Fig. 3 shows a bar chart of PO6 mean score trends from October 2022 to February 2025.

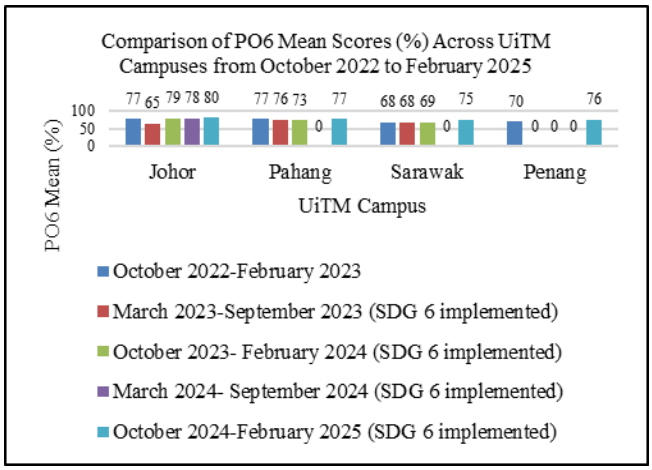

Fig. 3 Comparison of PO6 Mean Scores (%) Across UiTM Campuses from October 2022 to February 2025

As shown in Fig. 3, PO6 mean scores across campuses varied throughout the semesters. Prior to SDG 6 integration, the PO6 mean scores ranged moderately between 68% and 77%. After the implementation began in March 2023, performance remained stable in most campuses, with some fluctuation due to no student enrollment in the semester from March 2024 to September 2024 (UiTM Pahang and Sarawak) and the

semester from March 2023 to September 2024 (UiTM Penang). However, a consistent improvement is visible by the final semester (October 2024–February 2025), where all campuses reported increasing scores—Johor (80%), Pahang (77%), Sarawak (75%), and Penang (76%). The students' ability to relate engineering practices to societal and environmental impacts contributed to the increase in PO6 achievement.

Table II presents the percentage distribution of student grades (A–F) for the ECW341 Water Engineering Laboratory course across four UiTM campuses (Johor, Pahang, Sarawak, and Penang) over five consecutive semesters from October 2022 to February 2025. The percentages reflect the proportion of students in each grade band relative to the total enrolment at each campus. The table highlights student performance both before and after the implementation of SDG 6-aligned assignments, allowing for comparison across semesters and campuses.

As shown in Table II, before the implementation of SDG 6 (October 2022–February 2023), student performance was already strong, with 59%–75% of students achieving grades in the A range and the remainder mostly in the B range, with only 2%–3% in the C range. After SDG 6 was introduced in March 2023, the distribution of grades shifted, with some campuses showing notable improvement, such as Pahang recording 100% of students in the A range, while others experienced fluctuations, such as Johor with 40% in A, 40% in B, and 20% in C.

Table II Percentage Distribution Of Student Grades (A–F) In The Ecw341 Water Engineering Laboratory Course Across Uitm Campuses (October 2022–February 2025)

Semester	UiTM Campus	A+, A, A- (%)	B+, B, B- (%)	C+, C (%)	C-, D+, D (%)	E (%)	F (%)
October 2022-February 2023	Johor	75	23	2	0	0	0
	Pahang	73	24	3	0	0	0
	Sarawak	75	23	2	0	0	0
	Penang	59	41	0	0	0	0
March 2023-September 2023 (SDG 6 implemented)	Johor	40	40	20	0	0	0
	Pahang	100	0	0	0	0	0
	Sarawak	25	75	0	0	0	0
	Penang	-	-	-	-	-	-
October 2023-February 2024 (SDG 6 implemented)	Johor	85	14	1	0	0	0
	Pahang	71	29	0	0	0	0
	Sarawak	74	22	4	0	0	0
	Penang	-	-	-	-	-	-
March 2024-September 2024 (SDG 6 implemented)	Johor	0	100	0	0	0	0
	Pahang	-	-	-	-	-	-
	Sarawak	-	-	-	-	-	-

	Penang	-	-	-	-	-	-
October 2024-February 2025 (SDG 6 implemented)	Johor	68	32	0	0	0	0
	Pahang	13	86	1	0	0	0
	Sarawak	17	83	0	0	0	0
	Penang	43	57	0	0	0	0

In the later semesters, especially October 2024–February 2025, performance remained concentrated within the A and B ranges across all campuses, with only 1%–20% of students in the C range and no grades below C. Some campuses, however, had no student enrolment in particular semesters—for example, Penang in March–September 2023 and October 2023–February 2024, as well as Pahang and Sarawak in March–September 2024—which explains the absence of data for these periods. Despite these fluctuations, overall achievement remained stable within the A–B grade ranges, indicating that the integration of SDG 6 into the laboratory assignment helped maintain consistent academic performance across cohorts and campuses. As reviewed by [13], students' interest in sustainability has increased when sustainability-focused activities were embedded in coursework. In this study, although direct measures of interest such as surveys were not collected, the consistent achievement within the A–B grade ranges across multiple cohorts suggests that the SDG 6-aligned assignment was well-received and may have supported students' engagement with sustainability themes.

CONCLUSIONS

This study examined the impact of incorporating SDG 6 (Clean Water and Sanitation) into the ECW341 Water Engineering Laboratory course. The findings indicate that the SDG 6-aligned assignment contributed to improvements in PO4 (investigation) and PO6 (the engineer and society), while student performance consistently remained within the higher-grade ranges across five semesters and four UiTM campuses. Embedding sustainability into laboratory coursework thus strengthened students' technical competencies and fostered their environmental and societal awareness, which are essential attributes for future civil engineers. Nonetheless, the study is limited by the absence of systematic student feedback and the lack of controls for cohort and instructor variations. Future research should incorporate surveys or focus groups to capture students' perspectives and extend the analysis through comparisons with other institutions implementing SDG-related pedagogy.

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