Teaching and Learning for Sustainability: Embedding Sustainable Development Goals into Educational Frameworks

Nurul Elma Kordi*, Che Khairil Izam Che Ibrahim, Norashikin Ahmad Kamal,
Noor Azreena Kamaluddin, Mohd Raizamzamani Md Zain

Faculty of Civil Engineering, Universiti Teknologi MARA,
40450 Shah Alam, Selangor, Malaysia
elma8207@uitm.edu.my
chekhairil449@uitm.edu.my
norashikin7349@uitm.edu.my
azreena@uitm.edu.my
raizam@uitm.edu.my
*Corresponding Author

https://doi.org/10.24191/ajue.v21i3.45

Received: 14 November 2024
Accepted: 26 May 2025
Date Published Online: 1 October 2025
Published: 1 October 2025

Abstract: The global call for sustainable development has prompted educational institutions to rethink teaching methodologies and curriculum design to align with the United Nations Sustainable Development Goals (SDGs). Tertiary education plays a pivotal role in shaping future professionals capable of addressing complex sustainability challenges. This paper explores an innovative approach to embedding the 17 SDGs into the educational frameworks of the School of Civil Engineering at the College of Engineering, Universiti Teknologi MARA (UiTM). By mapping civil engineering subjects to the SDGs, sustainability principles are integrated into the teaching and learning process, fostering a comprehensive understanding of global sustainability issues among students. This study employs content analysis to systematically identify the alignment between core civil engineering subjects and specific SDG targets. The analysis highlights how civil engineering contributes to multiple goals, including SDG 4 (Quality Education), SDG 6 (Clean Water and Sanitation), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 11 (Sustainable Cities and Communities). The paper further presents a strategic framework for embedding sustainability in project-based learning, community engagement, and research initiatives within the civil engineering curriculum. By embedding SDG concepts into civil engineering education, this paper demonstrates a transformative approach to sustainability education that not only equips future engineers with the knowledge, skills, and attitudes necessary to address environmental, social, and economic challenges, but also shows measurable enhancements in learning outcomes such as critical thinking, interdisciplinary collaboration, and problem-solving skills. This contribution to the integration of sustainability in higher education provides actionable insights for academic institutions aiming to align their curricula with global sustainability imperatives, thereby fostering more impactful educational outcomes.

Keywords: Content Analysis, Curriculum Mapping, Engineering Education, SDGs Sustainability Education

1. Introduction

The global community faces unprecedented challenges, ranging from climate change to growing social inequality that require urgent and coordinated action. Recognising the need for a shared framework to address these pressing issues, the United Nations introduced the 2030 Agenda for Sustainable Development in 2015, comprising of 17 Sustainable Development Goals (SDGs). These goals provide a universal blueprint for achieving a more sustainable and equitable future, touching on key areas such as education, environmental protection, economic growth, and social inclusion. The SDGs emphasise that these challenges are interconnected and must be addressed holistically (United Nations, 2015).

Education plays a pivotal role in realising the Sustainable Development Goals (SDGs), shaping future generations' understanding of sustainability and equipping them with the knowledge, skills, and values needed to address complex global challenges (Thürer et al., 2018). Tertiary education, especially within technical disciplines like civil engineering, bears a unique responsibility to cultivate professionals who can advance these goals due to the discipline's profound impact on infrastructure, the built environment, and societal well-being (Mochizuki & Fadeeva, 2018). Despite this critical role, structured frameworks for integrating SDGs into civil engineering curricula remain limited, leading to a gap in systematically embedding sustainability principles into technical education. Addressing this gap requires a deliberate, strategic approach to curriculum design and pedagogy, ensuring that students acquire both technical competencies and a deep understanding of sustainability principles (Barth & Rieckmann, 2020). This challenge is amplified in engineering education, where many subjects do not immediately appear related to social or environmental sustainability (Leal Filho et al., 2020).

Despite several studies making efforts to include the SDGs in educational curricula, the majority of these studies focus predominantly on humanities and social science programs, with limited research on the integration of SDGs in engineering disciplines, particularly civil engineering (Leal Filho et al., 2020; Lozano et al., 2019). Civil engineering plays a pivotal role in advancing the SDGs due to its direct impact on critical infrastructure, sustainable urban development, and environmental management (Wu & Shen, 2021). In developing countries, the integration of SDGs into engineering programs faces unique challenges, such as a lack of resources, institutional capacity, and awareness among educators (Nakad et al., 2024). For instance, in Ghana and other African nations, limited access to technology and infrastructural support has hindered the full inclusion of SDG-aligned content in engineering education, particularly for civil engineering (Price & Robinson, 2015). Civil engineering contributes significantly to achieving SDG 9 (Industry, Innovation, and Infrastructure), SDG 6 (Clean Water and Sanitation), and SDG 11 (Sustainable Cities and Communities), which are central to the development of resilient infrastructure, sustainable cities, and resource-efficient systems (Chau, 2007). Therefore, integrating SDGs into civil engineering education is crucial to equipping future engineers with the competencies to address global sustainability challenges, particularly in developing countries where infrastructure and sustainability gaps are more pronounced.

This paper explores the integration of the 17 SDGs into the educational framework of the School of Civil Engineering at Universiti Teknologi MARA (UiTM), Malaysia. Through a systematic mapping process, civil engineering subjects are aligned with specific SDG targets based on their relevance to each goal’s objectives and competencies. This mapping illustrates how sustainability principles can be embedded into technical education, identifying synergies between civil engineering curricula and global sustainability goals. This approach supports the development of a new generation of engineers equipped to address societal needs sustainably. The integration aligns with growing accreditation requirements from bodies such as the Engineering Accreditation Council (EAC) in Malaysia, the Accreditation Board for Engineering and Technology (ABET) in the United States, and similar organisations globally, which now emphasize sustainability and SDG inclusion as core components of engineering education (UNESCO, 2020).

By embedding SDG concepts into the civil engineering curriculum, the study not only enhances students' awareness of global challenges but also provides a strategic framework that other academic institutions can adopt. This initiative demonstrates that sustainable development is not an isolated discipline but a comprehensive approach that should permeate all aspects of higher education, particularly in fields with far-reaching impacts on society and the environment (Lozano et al., 2021). The research contributes to fostering a global movement toward education for sustainable development

by ensuring sustainability in teaching and learning, thus producing graduates who can contribute to solving complex sustainability challenges in their professional careers. Focusing on how SDGs can be integrated into educational frameworks, this study delivers key messages for educators, policymakers, and developers, encouraging a shift toward more sustainable teaching and learning methods. In doing so, it underscores the role of higher education in advancing global sustainability through producing skilled graduates equipped to meet complex sustainability demands in professional practice.

2. Literature Review

The integration of sustainability into higher education has gained significant momentum since the introduction of the United Nations' SDGs in 2015. These 17 goals aim to balance economic growth, social inclusion, and environmental protection, and their integration into academic curricula is essential for fostering a new generation of professionals capable of addressing global sustainability challenges. Civil engineering, in particular, plays a pivotal role in this effort due to its direct impact on infrastructure development, water management, and urban planning—key sectors closely linked to SDG targets (Sterling, 2019; Lozano et al., 2021). For example, the implementation of green infrastructure technologies such as permeable pavements and bio-retention systems has supported SDG 11 (Sustainable Cities and Communities) by addressing urban flooding and enhancing sustainable urbanization (Watson, 2013). In the Civil Engineering curriculum, innovations in water management systems are directly aligned with SDG 6 (Clean Water and Sanitation), emphasizing the discipline's role in addressing global water security challenges through sustainable design, efficient resource management, and advanced treatment technologies. This integration within the curriculum not only equips students with the technical skills necessary for sustainable water solutions but also reinforces the critical role of civil engineers in achieving global sustainability goals.

The incorporation of sustainability within civil engineering curricula underscores the broader need for holistic educational frameworks that foster sustainable development competencies. Education for Sustainable Development (ESD) is one such framework, designed to equip learners with the knowledge, skills, values, and attitudes necessary to contribute to a more sustainable future. ESD not only supports the technical aspects of sustainability but also emphasises interdisciplinary collaboration, critical thinking, and active participation in addressing complex societal challenges (UNESCO, 2017). As civil engineering plays a pivotal role in achieving SDGs, it becomes crucial to explore how ESD principles can be effectively embedded into technical education. By aligning civil engineering education with ESD frameworks, students are not only trained in technical competencies but also develop the ability to apply sustainable practices in real-world settings (Burke, 2018). The following section delves deeper into the principles of ESD, the best practices for integrating SDGs, highlighting its relevance to the engineering sector and its potential to transform the way sustainability is taught and applied in higher education institutions.

2.1 Education for Sustainable Development (ESD)

ESD is a framework that promotes integrating sustainability into all levels of education, emphasising the need for transformative learning approaches. The core objective of ESD is to empower individuals to engage with and address sustainability challenges through critical thinking, problem-solving, and interdisciplinary collaboration (Barth & Rieckmann, 2020; UNESCO, 2020). ESD encourages learners to not only acquire knowledge about sustainability but also develop the competencies necessary to enact change within their professional fields.

Despite the growing recognition of ESD, its implementation remains inconsistent across tertiary education institutions (Sterling, 2019). Many universities have integrated sustainability into their curricula; however, balancing technical content with broader social, environmental, and economic dimensions is still challenging. In civil engineering, ESD is applied through case studies on sustainable infrastructure, courses on resilient urban planning, and hands-on projects in renewable energy systems, which guide students in developing not only technical skills but also the capacity for holistic problem-solving. These ESD-driven initiatives encourage students to consider sustainability implications alongside technical proficiency, aligning engineering practice with sustainable development goals.

2.2 Best Practices for Integrating SDGs

The SDGs provide a practical framework for embedding sustainability in higher education. Recent studies have shown that incorporating the SDGs into curricula helps students contextualize their learning within broader global challenges (Cebrián et al., 2019; Leal Filho et al., 2020). Several higher education institutions have embraced this approach, mapping existing subjects and disciplines to specific SDG targets.

Curriculum mapping is one of the most commonly used methods for aligning education with the SDGs. It involves systematically reviewing course content to identify opportunities for integrating sustainability principles (Lozano et al., 2021). For example, civil engineering courses can be mapped to SDG 6 (Clean Water and Sanitation) through water resource management topics, or SDG 11 (Sustainable Cities and Communities) through sustainable urban planning content. However, research suggests that this approach, while valuable, is often fragmented and lacks a cohesive, institution-wide strategy for embedding sustainability across all disciplines (Mochizuki & Fadeeva, 2018). Institutions frequently treat sustainability as an add-on or elective topic rather than embedding it into core courses and competencies.

Moreover, many universities have implemented sustainability education initiatives, but these efforts tend to be concentrated in environmental sciences or business studies rather than technical fields such as engineering (Leal Filho et al., 2021). This limited application to engineering and technical disciplines highlights a critical gap in how we prepare future professionals to address sustainability issues.

2.3 Civil Engineering and the SDGs

Civil engineering has a profound influence on achieving sustainable development, given its role in designing, building, and maintaining infrastructure. Several SDGs are directly relevant to civil engineering, including SDG 6 (Clean Water and Sanitation), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 11 (Sustainable Cities and Communities), (United Nations, 2015). Civil engineers are crucial for developing resilient infrastructure, ensuring water security, and creating sustainable urban environments.

However, civil engineering education has traditionally focused on technical proficiency, often neglecting the social and environmental dimensions of infrastructure development (Crawley et al., 2019). While some progress has been made toward integrating sustainability principles into civil engineering curricula, many programs still fail to treat sustainability as a core element. For example, the concept of “green infrastructure” is often taught as a specialized or advanced topic rather than a fundamental principle that underpins all civil engineering work (Sterling, 2019). This gap is particularly evident when addressing the social implications of engineering projects, such as community resilience or equitable access to infrastructure.

Although there is a growing body of literature on the integration of sustainability and SDGs into higher education, several critical gaps remain. First, much of the existing research focuses on environmental sustainability, while social and economic dimensions of sustainability are underexplored in technical education (Cebrián, 2018; Mochizuki & Fadeeva, 2018). For example, while civil engineering students may learn about reducing carbon footprints or managing water resources, they are less likely to engage with topics related to social equity, such as ensuring access to infrastructure for marginalized communities.

Another gap is the fragmented approach to curriculum development. Many universities employ a piecemeal strategy to embedding the SDGs, focusing on individual courses or subjects rather than adopting an institution-wide framework for sustainability (Lozano et al., 2021). This lack of integration limits students' ability to see the connections between different sustainability challenges and the role their future profession can play in addressing them. Moreover, many civil engineering programs still treat sustainability as a niche topic, addressing it in elective courses or specialised modules rather than making it a core competency.

The literature also reveals a need for more critical approaches to teaching sustainability in civil engineering. Current pedagogical approaches often focus on the technical aspects of sustainability, such

as energy efficiency or material recycling, without considering the broader, systemic changes required to achieve sustainable development (Crawley et al., 2019). This narrow focus risks overlooking the role that civil engineers can play in promoting social justice, reducing inequality, and fostering inclusive communities, all of which are key components of the SDGs. Lastly, while there is a growing emphasis on the role of higher education in addressing the SDGs, there is limited empirical research on the outcomes of embedding sustainability into technical disciplines. Few studies have assessed how well civil engineering graduates are prepared to tackle sustainability challenges or how deeply they engage with sustainability principles in their professional work (Sterling, 2019). There is a need for longitudinal studies that track the impact of sustainability education on engineering students' career trajectories and their contributions to the SDGs.

3. Methodology

This study adopts a comprehensive methodological approach to embed the SDGs into the civil engineering curriculum at the School of Civil Engineering, UiTM. The methodology is structured into four phases: curriculum review and subject mapping, stakeholder consultation, gap analysis and SDG alignment, and the development of an SDG-embedded framework. These phases form a coherent strategy to ensure that sustainability principles are integrated into the educational framework, fostering future engineers capable of addressing complex global challenges related to sustainability.

3.1 Research Design

The study employs a qualitative content analysis approach combined with curriculum mapping to systematically align civil engineering courses with specific SDGs. This approach was chosen to capture the depth and complexity of sustainability topics and to ensure that the integration of SDGs reflects both theoretical and practical insights. Content analysis provides a structured way to examine existing course materials for alignment with SDG themes, while curriculum mapping identifies specific gaps and opportunities within the syllabus. The process is further strengthened by consultations with key stakeholders, including academics and students, to validate findings and gather diverse perspectives on curriculum relevance and improvement. The research design follows a four-phase methodology that promotes a comprehensive and practically applicable integration of SDGs across the curriculum

The process begins with an in-depth content analysis of the existing civil engineering curriculum. This analysis involves a detailed review of course syllabi, objectives, and learning outcomes to identify subjects that have potential connections to the SDGs. Each subject is mapped to one or more relevant SDGs based on its content, thereby creating a structured matrix that categorizes the curriculum according to its alignment with sustainability goals. Following the initial curriculum mapping, a stakeholder consultation phase is conducted. This step involves engaging faculty members and students through interviews. These consultations are critical for validating the curriculum mapping and ensuring that the alignment between subjects and SDGs reflects real-world practice and educational objectives. The engagement of students also provides valuable insights into their perceptions of sustainability education and areas where the curriculum could be strengthened.

The third phase involves conducting a gap analysis to identify areas where the current curriculum may be lacking in terms of SDG coverage. This phase focuses on detecting underrepresented SDGs within civil engineering subjects and determining where revisions or enhancements are necessary. The analysis emphasises the need for a holistic approach to sustainability education, ensuring that both the technical and social dimensions of civil engineering practice are addressed.

Finally, the research culminates in the development of a strategic framework for embedding SDGs into the civil engineering curriculum. This framework not only integrates the SDGs into course content but also promotes project-based learning, interdisciplinary collaboration, and community engagement as key pedagogical strategies. The framework aims to ensure that sustainability becomes a core element of the educational experience for civil engineering students, equipping them with the skills and knowledge needed to address the multifaceted challenges of sustainable development.

3.1.1 Phase 1: Curriculum Review and Subject Mapping

The first phase of the study involves a thorough curriculum review to map civil engineering subjects to the relevant SDGs. This phase begins with a content analysis of course descriptions and syllabus, focusing on identifying the connections between subject matter and sustainability themes. Each subject is mapped to the SDGs based on its potential to contribute to specific targets and indicators. This process results in a curriculum mapping matrix, which serves as a tool for organizing subjects according to their alignment with the SDGs.

The mapping exercise reveals several natural alignments between civil engineering subjects and specific SDGs. For instance, subjects related to water resources and environmental (WRES) are mapped to SDG 6 (Clean Water and Sanitation), and those focusing on urban planning and infrastructure development are linked to SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities). Additionally, courses that address broader topics such as "Geology" and "Hydrology and Water Resources" are mapped to SDG 13 (Climate Action) and SDG 15 (Life on Land). By systematically mapping subjects to the SDGs, this phase establishes a foundation for identifying where sustainability principles are currently embedded and where further integration is needed.

3.1.2 Phase 2: Stakeholder Consultation

In the second phase, a series of stakeholder consultations are conducted to validate the curriculum mapping results and gather input on areas for further enhancement. Stakeholders include faculty members from the civil engineering department and students enrolled in the program. Through individual interviews, stakeholders provide diverse perspectives on the relevance of the SDGs in civil engineering practice and evaluate the adequacy of sustainability content in the current curriculum. Faculty insights highlight specific challenges—such as balancing technical rigor with sustainability principles—and propose strategies for embedding SDG-related case studies and project-based learning into technical subjects. Students contribute by reflecting on their learning experiences and expectations, expressing a desire for practical applications of sustainability, especially in courses like water resources management, urban planning, and construction materials. This feedback is instrumental in refining the curriculum mapping; for example, it led to the inclusion of targeted SDG-aligned modules and hands-on projects to better bridge theory and practice. Overall, the data gathered during this phase ensures that the SDG alignment not only meets academic standards but also prepares students for sustainability challenges in professional settings.

3.1.3 Phase 3: Gap Analysis and SDG Alignment

Following the stakeholder consultation, a gap analysis is conducted to identify areas of the curriculum that do not adequately address the SDGs. This phase focuses on detecting gaps in SDG coverage and proposes strategies for revising the curriculum to better integrate sustainability principles. For example, while many technical subjects are aligned with environmental SDGs, social and economic dimensions of sustainability may be underrepresented. This gap analysis highlights the need to incorporate more content related to equity, social justice, and community resilience, particularly in courses that address infrastructure development and urban planning.

The gap analysis also reveals that some subjects, while aligned with certain SDGs, may not fully explore the broader dimensions of those goals. For example, while the course on Statics (ECS416) addresses concepts like structural efficiency and the optimisation of resources, it tends to focus on the technical aspects of material strength and load distribution. However, it may not sufficiently cover the social implications of material sourcing, such as the environmental and societal impact of extracting raw materials or the effects of construction practices on marginalized communities. This highlights the need for a more comprehensive approach to integrating sustainability in technical subjects. Based on this analysis, recommendations are made for enhancing the curriculum, such as introducing new modules on sustainable design principles, emphasizing cross-disciplinary collaboration, and integrating SDGs into capstone projects.

3.1.4 Phase 4: Development of an SDG-Embedded Framework

The final phase involves the creation of a strategic framework for embedding the SDGs into the civil engineering curriculum. This framework outlines a comprehensive approach to sustainability education, emphasizing the need for project-based learning, research integration, and community engagement. The framework is designed to ensure that sustainability becomes a core component of the educational experience, rather than an isolated topic covered in specialized courses.

Key elements of the framework include the integration of SDG-related projects into civil engineering courses, fostering interdisciplinary collaboration with other departments, and encouraging students to focus their research on addressing sustainability challenges. The framework also promotes community engagement by involving students in real-world projects that align with the SDGs, such as designing infrastructure solutions for underserved populations or contributing to local sustainability initiatives. This approach not only enhances students' understanding of sustainability but also equips them with practical skills for implementing sustainable solutions in their future careers.

By adopting this comprehensive four-phase methodology, the study ensures that SDG principles are systematically embedded into the civil engineering curriculum at UiTM. This approach not only strengthens the curriculum but also prepares students to become future engineers capable of contributing to sustainable development at both local and global levels.

4. Results and Discussions

This section presents the findings from the mapping of civil engineering subjects to the 17 SDGs, followed by a critical discussion focused on the top SDGs most addressed in the curriculum. The results are analysed based on academic year, subject divisions, and assessment types used to evaluate SDG components within the curriculum.

4.1 Research Design Demographic Results of SDG Extraction Based on Subjects

A total of 52 civil engineering subjects were analysed and mapped to the 17 SDGs. The mapping revealed that different SDGs were covered with varying frequencies across the four years of the civil engineering program. The breakdown of SDG coverage is summarized in Table 1, which presents the dominant SDGs for each academic year.

Table 1

Distribution of SDGs across civil engineering curriculum

Year	Distribution of SDGs (%)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	0	2.5	0	0.8	0.8	1.7	4.2	0	1.7	0	0.8	0	0.8	0	0
2	0	0	0	4.2	0	0	0	0.9	4.2	0	1.7	1.7	0.8	0	0	0	0
3	0	0	0	1.7	0	1.7	0	0	4.2	0	4.2	0	0.8	1.7	0	0	0.8
4	0	0	4.2	2.5	1.7	3.4	2.5	5	11.8	0.8	12.6	1.7	2.5	2.5	1.7	3.4	1.7
%	0.0	0.0	4.2	10.9	1.7	5.9	3.4	7.6	24.4	0.8	20.2	3.4	5.0	4.2	2.5	3.4	2.5

The distribution of SDGs across the civil engineering curriculum reveals significant gaps, particularly with SDG 1 (No Poverty) and SDG 2 (Zero Hunger), which are not represented at all in the curriculum. This absence indicates a lack of focus on addressing social sustainability challenges, such as poverty reduction and food security, which are increasingly important in the global sustainability discourse. On the other hand, SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities) dominate, especially in Year 4, with 11.8% and 12.6% of the curriculum respectively, reflecting the technical focus of civil engineering on infrastructure development and urban planning. The curriculum also incorporates SDG 5 (Gender Equalities) and SDG 10 (Reduced Inequalities), but their presence is more limited, particularly in the early years, where students could

benefit from early exposure to broader sustainability issues. This selective mapping suggests the need to integrate more comprehensive sustainability education, particularly in terms of social equity and environmental justice, ensuring students gain a well-rounded understanding of the full spectrum of global sustainability challenges.

4.2 SDGs by Division

The School of Civil Engineering at UiTM is divided into several academic divisions, each focusing on specific areas of civil engineering. Each division contributes to achieving different SDGs based on the subjects taught and their alignment with sustainability principles. The following table summarizes the dominant SDGs for the four key divisions: Construction Business Project Management (CBPM), Water Resources and Environmental (WRES), Structural & Materials (StrucM) and Geotechnical & Transportation Engineering (GeoTren). The analysis also examined SDG coverage across different divisions within the civil engineering program. The following table categorizes the dominant SDGs addressed by each division based on the subjects they offer:

Table 2

Division-wise distribution of SDGs across civil engineering subjects

Division	Dominant SDGs Addressed	Key Subjects
CBPM	SDG 4 (Quality Education), SDG 11 (Sustainable Cities)	Engineer in Society Construction Technology
WRES	SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action)	Water and Wastewater Engineering Hydrology and Water Resources
STRUCM	SDG 9 (Industry, Innovation, Infrastructure)	Reinforced Concrete Design Integrated Design Project
GEOTREN	SDG 15 (Life on Land), SDG 11 (Sustainable Cities and Communities)	Engineering Geology Traffic Engineering

The division-specific focus on SDGs within the civil engineering curriculum lays a solid foundation for aligning academic subjects with global sustainability goals, but a deeper examination reveals critical opportunities for improvement in fostering comprehensive learning outcomes and enhancing professional preparedness. For instance, the CBPM division's alignment with SDG 4 and SDG 11, addressed through courses such as Engineer in Society and Construction Technology, equips students with foundational knowledge in societal roles and urban planning. However, there is a missed opportunity to deepen students' understanding of social sustainability; the curriculum could incorporate modules on community-driven development and equitable resource distribution, enabling future engineers to approach urban design with a more inclusive, people-centred perspective.

In the WRES division, focused on SDG 6 and SDG 13, students gain technical expertise in water management and climate mitigation, essential for addressing resource sustainability. However, a primarily technical approach may not fully prepare students to tackle the socio-political challenges of water governance. Incorporating case studies on water scarcity and access in marginalized communities would provide students with a broader understanding of water management as a social issue, thus enriching their professional readiness to address sustainability beyond engineering solutions alone.

The STRUCM division's focus on SDG 9, through subjects like Reinforced Concrete Design, prioritises innovation and resilience in materials, key for sustainable infrastructure development. However, the curriculum could be expanded to include life-cycle assessments, promoting critical thinking on the environmental impact and sustainability of material supply chains. This would prepare students to make informed, sustainable choices in material selection, aligning technical proficiency with environmental responsibility.

Finally, in the GEOTREN division, where SDG 15 and SDG 11 are emphasised through sustainable land use and urban transport, the curriculum addresses environmental degradation but lacks depth in exploring the social implications of land development, such as displacement and inequity.

Providing a more interdisciplinary lens would ensure that students understand the societal impact of engineering decisions, critical for creating equitable and sustainable urban spaces.

This targeted categorisation highlights each division's role in addressing sustainability through technical and social lenses, showcasing how an interdisciplinary approach can enhance students' readiness for complex, real-world sustainability challenges. Integrating these broader perspectives across divisions not only improves alignment with SDGs but also develops a new generation of civil engineers who are holistically prepared to contribute to sustainable development in their professional practices.

4.3 Top 3 SDGs

The focus of this discussion is on the top three SDGs that were most frequently addressed across the civil engineering curriculum: SDG 9 (Industry, Innovation, Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 4 (Quality Education). Table 3 provides examples of subjects, types of assessments, and questions associated with these SDGs.

Table 3

Top 3 SDGs – Subject, Assessment Type, and Question Examples

SDG	Subject	Assessment Type	Sample Assessment Question
SDG 9 (24.4%)	Integrated Design Project	Project-based learning	"Design a small pedestrian bridge for an urban park that uses sustainable materials and innovative construction methods"
SDG 11 (20.2%)	Basic Timber and Steel Design	Exam	"According to Eurocode 3 (EC3), the classification of a cross-section may be defined by the aspect width to thickness ratio, and categorised into four classes which are Class 1, 2, 3 and 4. With the aid of sketches, explain all section classifications concerning the stress Distribution"
SDG 4 (10.9%)	Geotechniques	Exam	"Differentiate between a natural slope and an artificial slope"

The top three SDGs—SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 4 (Quality Education) reveals both strengths and opportunities for enhancement in the integration of sustainability within civil engineering education. SDG 9 (24.4%) such as subject Integrated Design Project utilizes project-based learning, effectively engaging students in practical, real-world challenges. This approach fosters innovation in design and material selection, crucial for sustainable infrastructure development. However, while the project encourages creativity, it may not adequately address the deeper implications of resource sourcing, lifecycle impacts, and long-term sustainability. To enrich students' understanding, incorporating interdisciplinary perspectives, such as environmental impact assessments and community stakeholder engagement, could be beneficial.

For SDG 11 (20.2%) like subject Basic Timber and Steel Design course, assessments focus on technical knowledge, particularly concerning structural design codes. While foundational, this focus may lack a direct connection to the social, environmental, and economic dimensions of urban infrastructure. To strengthen alignment with sustainable cities, the curriculum could include questions that explore the implications of material choices on energy efficiency and social inclusivity in urban planning. This shift would encourage students to consider how their technical expertise can contribute to broader urban sustainability goals.

For SDG 4 (10.9%) such as subject Geotechniques primarily assesses basic conceptual knowledge. While this is essential for quality education, opportunities exist to deepen the connection to

sustainability by incorporating applied questions. For instance, exploring slope stability's impact on urban planning or disaster resilience would enhance students' practical problem-solving skills necessary for sustainable development. This shift would encourage a more comprehensive understanding of geotechnical principles in real-world contexts.

While the curriculum demonstrates a commendable effort to embed sustainability through SDG-aligned assessments, the emphasis largely remains on technical skills, which limits students' holistic understanding of sustainability challenges. Project-based learning, for example, offers an innovative way to engage students, but without broader sustainability assessments, it risks a narrow focus on technical problem-solving. By primarily addressing technical aspects, students may miss critical exposure to interdisciplinary sustainability issues, which are essential for addressing the multifaceted nature of global challenges. Traditional exam-based subjects, on the other hand, often prioritize rote memorization of concepts over critical thinking and sustainability-driven problem-solving, potentially limiting the development of students' practical, real-world competencies.

To improve curriculum effectiveness and deepen students' engagement with SDG principles, cross-cutting issues—such as resource efficiency, environmental justice, and community engagement—should be integrated into both project- and exam-based assessments. For instance, incorporating resource management scenarios in exams or including community impact assessments in project work could encourage students to consider the broader social and environmental contexts of their technical solutions. This approach would foster a more comprehensive skill set, preparing students to navigate complex sustainability challenges with an interdisciplinary and socially responsible mindset.

Such enhancements would significantly benefit students' professional preparedness, equipping them with both the technical knowledge and the critical, sustainability-oriented thinking necessary to contribute meaningfully to sustainable development. By strengthening the connection between technical education and sustainability principles, the curriculum not only aligns more closely with SDG goals but also positions future civil engineers to lead in creating sustainable solutions within the profession

5. Conclusion

This paper has explored the innovative approach taken by the School of Civil Engineering at UiTM in embedding SDGs into the educational framework. Through a comprehensive curriculum mapping exercise, this study demonstrates the alignment of civil engineering subjects with key SDGs, particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 6 (Clean Water and Sanitation), and SDG 11 (Sustainable Cities and Communities). Integrating these goals into project-based learning, problem-solving assessments, and exams equips students with skills and knowledge essential for addressing sustainability challenges in their future careers.

The analysis reveals that while environmental and infrastructure-related SDGs are well-represented, social sustainability dimensions such as gender equality (SDG 5) and reducing inequalities (SDG 10) require further integration into the curriculum. This gap suggests that future curriculum development should aim for a more balanced approach, embedding both environmental and social sustainability in civil engineering education.

However, this study has several limitations. First, the methodology relies heavily on qualitative curriculum mapping and stakeholder consultations, which may introduce biases based on the perspectives of participating faculty and students. While stakeholder feedback provides valuable insights, it may not capture the views of all relevant parties or reflect the full diversity of professional expectations in the industry. Additionally, curriculum mapping was limited to certain SDGs deemed most relevant to civil engineering; as a result, the broader spectrum of SDGs may not have been fully considered, potentially overlooking interdisciplinary synergies.

Despite these constraints, this initiative represents a transformative step toward integrating sustainability into higher education. By incorporating service learning, enhancing assessment methods, and investing in faculty professional development, institutions can better equip future engineers with competencies needed to support the global agenda for sustainable development. As more academic institutions align their educational frameworks with global sustainability imperatives, the role of higher education in addressing the world's most pressing challenges becomes increasingly significant.

6. Future Recommendations

The findings of this study highlight the substantial progress made in embedding SDGs into civil engineering education at UiTM. However, several key areas present opportunities for further enhancing the integration of sustainability principles.

Broader SDG Coverage: Although SDG 9 (Industry, Innovation, Infrastructure), SDG 6 (Clean Water and Sanitation), and SDG 11 (Sustainable Cities and Communities) are well-integrated into the curriculum, other goals such as SDG 5 (Gender Equality) and SDG 10 (Reduced Inequalities) require greater attention. To address this, faculty should conduct workshops to identify opportunities for incorporating social sustainability content into existing courses. This could involve developing modules on equitable access to infrastructure and gender-sensitive design, ensuring that engineering students gain a more holistic view of sustainability.

Interdisciplinary Collaboration: Sustainability challenges often intersect multiple disciplines, making interdisciplinary collaboration vital. Future curriculum development should promote partnerships between engineering, environmental sciences, social sciences, and business faculties. Implementing joint projects where students from different disciplines work together on real-world sustainability challenges can provide a broader understanding of these issues and better prepare students for collaborative work in their professional careers.

Community Engagement and Service Learning: To strengthen the practical application of SDGs, it is essential to increase community-based learning initiatives. Establishing partnerships with local governments and non-profit organizations can facilitate service-learning projects that engage students in addressing local sustainability challenges. For instance, projects could focus on SDG themes such as poverty reduction (SDG 1) or sustainable cities (SDG 11), allowing students to gain hands-on experience while promoting sustainable development within the community.

Enhancing Assessment Methods: Current assessment methods heavily rely on project-based learning, which is beneficial for technical aspects of sustainability. However, there is a need to incorporate reflective assessments, such as case studies analysing real-world projects and the ethical implications of engineering decisions. These assessments will deepen students' critical thinking skills and encourage them to engage with the broader social and environmental responsibilities of their future work.

By implementing these specific strategies—expanding SDG coverage, fostering interdisciplinary collaboration, enhancing community engagement, and refining assessment methods—UiTM can continue to advance its mission of shaping future engineers equipped to address global sustainability challenges. Engaging stakeholders throughout this process will ensure that the curriculum remains relevant and impactful, ultimately preparing students to make meaningful contributions to sustainable development in their careers.

7. Co-Author Contribution

The authors affirmed that there is no conflict of interest in this article. Author1 carried out the field work, prepared the literature review and conclusion. Author2 overlooked the writeup of the whole article. Author3 wrote the introduction and research methodology. Author4 did the data entry and Author5 carried out the statistical analysis and interpretation of the results.

8. Acknowledgements

The authors would like to express their gratitude to the School of Civil Engineering, College of Engineering, Universiti Teknologi MARA for their support. Additionally, the authors extend their heartfelt appreciation to the respondents for their invaluable support throughout this research endeavour.

9. References

Barth, M., & Rieckmann, M. (2020). Education for Sustainable Development: Learning and Teaching in Transformative Ways. *Sustainability*, *12*(2), 487. https://doi.org/10.3390/su12020487

Burke, R. D., Antaya Dancz, C. L., Ketchman, K. J., Bilec, M. M., Boyer, T. H., Davidson, C., Landis, A. E., & Parrish, K. (2018). Faculty Perspectives on Sustainability Integration in Undergraduate Civil and Environmental Engineering Curriculum. Journal of Professional Issues in Engineering Education and Practice, 144(3). https://doi.org/10.1061/(ASCE)EI.1943-5541.0000373

Cebrián, G., Grace, M., & Humphris, D. (2019). Curricular integration of education for sustainability in higher education: Autoethnographies of transformation. *International Journal of Sustainability in Higher Education*, *20*(6), 1027–1043. https://doi.org/10.1108/IJSHE-04-2019-0141

Chau, K. W. (2007). Incorporation of Sustainability Concepts into a Civil Engineering Curriculum. https://doi.org/10.1061/ASCE1052-39282007133:3188

Leal Filho, W., Salvia, A. L., & Pretorius, R. W. (2020). Universities and Sustainable Communities: Meeting the Goals of the Agenda 2030. *Springer*. https://doi.org/10.1007/978-3-030-38932-0

Lozano, R., Merrill, M., Sammalisto, K., & Ceulemans, K. (2021). Connecting competences and pedagogical approaches for Sustainable Development in higher education: A literature review and framework proposal. *Sustainability*, *13*(4), 1765. https://doi.org/10.3390/su13041765

Mochizuki, Y., & Fadeeva, Z. (2018). Competences for sustainable development and sustainability: Significance and challenges for ESD. *International Journal of Sustainability in Higher Education*, *19*(1), 5–21. https://doi.org/10.1108/IJSHE-03-2017-0041

Nakad, M., Gardelle, L., & Abboud, R. J. (2024). A Systematic Review of the Different Methods Assessing Sustainability Integration in Engineering Curricula. In Sustainability (Switzerland) (Vol. 16, Issue 11). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/su16114549

Price, J. M., & Robinson, M. (2015). Developing Future Engineers: Case Study on the Incorporation of Sustainable Design in an Undergraduate Civil Engineering Curriculum. Journal of Water Resources Planning and Management, 141(12). https://doi.org/10.1061/(asce)wr.1943-5452.0000505

Sterling, S. (2019). Transformative learning and sustainability: Sketching the conceptual ground. *Learning and Teaching for a Sustainable Future*, *12*, 21–35.

Thürer, M., Tomašević, I., Stevenson, M., Qu, T., & Huisingh, D. (2018). A systematic review of the literature on integrating sustainability into engineering curricula. In Journal of Cleaner Production (Vol. 181, pp. 608–617). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2017.12.130

UNESCO. (2020). Education for sustainable development: A roadmap. *United Nations Educational, Scientific and Cultural Organization*. https://unesdoc.unesco.org/ark:/48223/pf0000374802

United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. https://sdgs.un.org/2030agenda

Watson, M. K., Asce, S. M., Noyes, C., & Rodgers, M. O. (2013). Student Perceptions of Sustainability Education in Civil and Environmental Engineering at the Georgia Institute of Technology. https://doi.org/10.1061/(ASCE)EI.1943-5541