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Engineering and Sustainability in Kuwait: Engagement, Knowledge, and Experience

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Abstract

Kuwait is one of the leading oil- and gas-producing countries in the Arab world and globally. Petroleum products account for nearly 50% of its gross domestic product (GDP) and approximately 95% of total exports and government revenues. Alongside this dominant hydrocarbon sector, the engineering and built environment industry makes a notable contribution to the national economy, representing 2% of GDP and 4.7% of the non-oil sector. Globally, these industries are known as main sources of environmental pollution, and they have traditionally been characterized by limited sustainability awareness and practice. However, in line with global developments and the strategic objectives of the New Kuwait 2035, engineers, professional societies, researchers, and construction firms in Kuwait are gradually recognizing the importance of environmental challenges and the necessity to advance sustainable practices. Thus, this paper assesses the levels of sustainability-related engagement, knowledge, and experience among practising engineers and engineering students, and estimates the extent to which their organizations are involved in promoting sustainability, with "organization" referring to the workplace organization for practising engineers and to the educational or training institution for students. An online survey was conducted to study the level of participants' knowledge of, engagement with, and experience in sustainability, as well as the initiatives adopted by their organizations to foster sustainability. The responses were analyzed in SPSS using descriptive and inferential statistics to identify patterns and draw conclusions. The results show that practising engineers and engineering students across a range of engineering sectors in Kuwait have positive levels of sustainability knowledge and attitudes. However, sustainability practices were rated as only moderate. This suggests that further effort is needed to close the gap between theory and practice by embedding sustainability more fully into both education and industry, thereby strengthening individual engineers' attitudes and improving organizations' sustainability practices.

Keywords: construction; engineering; engineering education; Kuwait; sustainability

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1. Introduction

The distinctive importance of sustainable development within the engineering and construction professions has been recognized by several task forces worldwide. Professional bodies and engineering companies have come to realize that sustainable development has multiple implications for their work, and the broader relationship between professionals and

society [1]. Sustainability awareness is particularly relevant for the engineering professions, due to the significant direct impacts of their activities on environmental, economic, and social dimensions of sustainability, and the long-term effects of the products (e.g., structures and devices) they build [2]. Engineers perform a vital role in the design, construction, and operation of infrastructure across a number of industries; therefore, their activities can contribute significantly to carbon emissions and wider environmental challenges [1]. In response to these concerns, several initiatives have been introduced to encourage the integration of sustainability into engineering practice. For example, the UK Engineering Council revised its professional registration requirements in 2004 to incorporate sustainability, while the Royal Institution of Chartered Surveyors introduced compulsory sustainability-related competencies for membership [3].

According to previous research work [4], the role of a mediator is essential in ensuring the long-term sustainability of natural resources and systems for future generations. This approach entails recognizing intrinsic worth of non-human nature and their interests and reconceptualizing human relationships with non-human entities, including the natural environment. It may be achieved by incorporating the interests of non-human natural actors into socio-technical networks. Such a shift permits engineers to move beyond the traditional Western modernist paradigm, which is characterized by a dualistic relationship in which culture is positioned as dominant over nature. To realize this, engineers must amend their roles in society and the economy as well as establish new models of engineering practice. Through such practice, engineers are able to function as mediating agents, cultivating a more balanced and sustainable relationship among technology, society, and the natural environment. Though, sustainable technological development cannot be achieved through engineering efforts alone. Although engineers play a central role in the design, development, and management of technological systems, their work is embedded within broader socioeconomic contexts shaped by economic growth, commercial interests, and societal and political expectations for continually increasing material standards of living. Subsequently, enhancing technological efficiency and decreasing environmental pollution, while necessary, are inadequate in themselves to tackle the complexity and scale of the contemporary ecological crisis. Nonetheless, engineers are uniquely positioned to suggest alternatives to dominant development paradigms and to foster the emergence of more sustainable patterns of consumption. By taking on a mediating role, engineers can help in directing society to a more sustainable future in which economic development and ecological sustainability are viewed as complementary rather than integrally conflicting objectives [4].

Kuwait's economy stays deeply dependent on the oil and gas sector, with petroleum products making up approximately half of national GDP and the immense majority of export incomes, thus underpinning extensive public expenditure [5]. Beside this economic backdrop, the national development plan, New Kuwait 2035, strives to advance the country's alignment with the United Nations Sustainable Development Goals (SDGs) by reducing dependence on fossil fuels, mitigating environmental pollution, and encouraging the adoption of innovative technologies to stimulate private-sector development. The engineering and construction environment sectors are mainly important to the achievement of these objectives, considering their substantial contribution to economic activity and their potential to expedite the transition towards a more sustainable and diversified economy [6]. In parallel, environmental sustainability has received increasing attention among professional bodies, researchers, engineers, and construction companies in Kuwait, reflecting a growing recognition of the importance of integrating sustainability principles into engineering practice and development activities. Despite the increasing recognition of sustainability among professional associations, researchers, engineers, and construction organizations in Kuwait, empirical evidence concerning sustainability knowledge, attitudes, engagement, and practi-

cal application between engineering students and practicing engineers stays limited. This contextual gap is particularly important given Kuwait's distinctive socioeconomic setting, characterized by an oil-dependent economy alongside increasing national commitments to sustainability and economic diversification. Furthermore, previous studies have often examined engineering students and practicing engineers separately, limiting understanding of how sustainability-related knowledge, engagement, and practice may differ between future and practicing professionals. Existing research has also tended to emphasize individual-level sustainability awareness and knowledge, with comparatively less attention given to the organizational context in which engineers operate and the extent to which organizations support and implement sustainable practices. This creates a substantial knowledge-practice gap, however it is uncertain whether individuals' positive sustainability knowledge and engagement are converted into effective sustainability practices within organizations.

In the context of this study, sustainability engagement refers to the degree to which engineering students and practicing engineers actively participate in, support, and advocate for sustainability-related activities and practices, and translate their sustainability knowledge and attitudes into actions that contribute to environmental improvement and sustainable outcomes within educational, professional, and organizational contexts. Accordingly, the study addresses the following research questions:

RQ1: What are the levels of sustainability knowledge, engagement, and practical experience among engineering students and practicing engineers in Kuwait?

RQ2: To what extent do sustainability knowledge, engagement, practical experience, and perceptions of organizational sustainability practices differ between engineering students and practicing engineers, across engineering disciplines, and across industry sectors?

RQ3: To what extent is individual sustainability knowledge, engagement, and practical experience associated with perceived organizational sustainability practices?

This study aims to examine the levels of sustainability knowledge and engagement among practising engineers and engineering students and to assess the extent to which their organizations promote and support sustainable practices in Kuwait. The part of engineers is critical to advancing the shift towards sustainability, especially in countries such as Kuwait, which, as a major oil producer, faces mounting pressure to adopt sustainable energy resources.

The study contributes empirical evidence on sustainability engagement, knowledge, and experience among engineering students and practicing engineers in Kuwait while examining how individual-level perceptions correspond with perceived organizational sustainability practices.

It is anticipated that the results of this study will deliver important information for educators, legislators, and stakeholders to institute appropriate strategies and regulatory frameworks to foster the integration of sustainable practices across Kuwait's engineering sector.

Furthermore, organizational move towards sustainable practices is essential for achieving national sustainability objectives. This study will generate useful insights into the extent to which organizations are committed to promoting sustainability and will highlight areas where improvement is needed. By examining the present status of sustainability practices within Kuwait's engineering profession, this investigation provides valuable information to support corporations in developing effective plans and guidelines for promoting and integrating sustainable practices.

1.1. Role of Engineers in Sustainability

Traditionally, the role of engineers has been to develop and build products based on designers' concepts and in accordance with client requirements. Their remit did not extend to assessing the sustainability of the design, nor to considering how their own work

might be conducted in the most sustainable manner possible. Previous research work [7], described that the engineering sector operates at the perimeter of these interconnected systems, inventing products through which society engages with the economy and infrastructure at the interface between society and the environment. Engineering activities profoundly affect the number of non-renewable resources expended and the value of the natural environment (environmental system), aside from exerting a direct and substantial influence on individuals through the services that underpin societal development and community well-being. Engineering activities require substantial financial resources while also generating significant economic value. From this perspective, the close alignment between engineering activities and the fundamental principles of sustainable development becomes evident, although these connections are not always fully recognized, even within the engineering profession itself.

Within the context of sustainable development, the built environment must be improved to satisfy fundamental human needs, including shelter, potable water supply, sanitation, and the infrastructure that reinforces social organization. The provision of these vital services inevitably affects the natural environment [8], and the rapid growth of the global population is escalating demand for societal and physical infrastructure, thereby heightening the imperative to convey it sustainably [7]. The infrastructure that underpins society and modern human life is supplied by engineers. Historically, civil engineering, and its less formalized antecedents, has instituted a fundamental element of human development [7].

The engineering profession faces a distinct challenge in addressing sustainability. Moving beyond ecological modernism and efficiency-driven approaches requires a more fundamental reconceptualization of engineering and technological impacts, particularly with respect to the interrelationships among humans, technology, and the natural environment. Furthermore, engineering decisions made during the design, construction, and manufacture of new technologies can have long-term implications for their use, performance, and lifecycle, as well as for the infrastructure in which they are integrated. The ethical implications of engineering practices and decisions have been extensively discussed among both engineers and philosophers. In addition to constituting a technical challenge, sustainability must also be understood as a moral concern [9].

As discussed previously, mediators can contribute to safeguarding the long-term sustainability of natural resources and ecosystems for future generations. By reconceptualizing the relationships between humans and nonhuman entities, they can also help to recognize the intrinsic value of nonhuman nature. Through the incorporation of the welfare of nonhuman natural actors into the networks that constitute socio-technical systems, engineers acting as mediators challenge the dualistic conception of culture as dominant over nature. Achieving this requires engineers to reconsider their roles within society and the economy and to develop new models of engineering practice.

Engineers develop, design, and manage technological systems within a context structured by economic growth, profit maximization, and steadily rising material standards of living. However, achieving sustainable technological development requires contributions that extend beyond the engineering profession alone [10]. The development of more efficient and less polluting technologies is, in itself, inadequate to resolve the ecological crisis. Engineers, however, occupy a unique position as intermediaries linking technological systems, society, and the natural environment, qualifying them to offer alternatives to prevailing development models and to foster more sustainable patterns of consumption [4,9].

1.2. Role of Engineering Organization in Sustainability

In search of enhanced social and environmental impact while satisfying financial viability, organizations are increasingly escalating their sustainability initiatives. Engi-

neers contribute to sustainability-oriented workplace cultures by planning and constructing projects that protect natural resources, guarantee economic efficiency, and boost environmental and community health. In terms of environmental, social, and economic issues, sustainable building is primarily concerned with the community's well-being [10]. In order to introduce sustainable construction into the construction industry, green buildings are viewed as a subset of sustainable construction [10].

Sustainable engineering involves the responsible and efficient use of resources in ways that preserve their availability for future generations while minimizing adverse environmental impacts. Achieving sustainability needs an interdisciplinary tactic and must not be regarded as the exclusive obligation of environmental engineers. Rather, sustainability principles ought to be integrated across all engineering disciplines to enhance quality of life and promote long-term societal well-being. Professional engineers accordingly play a substantial role in advancing sustainability. By reducing the utilization of natural resources and appreciating both environmental constraints and the long-term viability of resources, they pursue to promote the welfare, health, and safety of all [11].

Sustainable development defines engineering practice in both constructive and constraining ways. Engineers develop options and solutions intended to enrich societal benefit while curtailing environmental impact. Within the dominating legacy global economy, resources are being depleted, pollution is intensifying, population growth is accelerating, and ecosystems are being degraded, giving rise to several urgent challenges at both local and global scales. A purely environmental alignment is therefore insufficient, and engineers are progressively expected to integrate considerations of social justice and poverty alleviation into their work. Through the exchange of experience and best practices, engineers can steer change by leveraging the processes of globalization. The leadership and influence that engineers exert in promoting sustainability within their organizations must be appreciated [11].

Engineering has a central role to play in mitigating climate change through the advancement and implementation of sustainable technologies and infrastructure. Renewable energy technologies, including hydropower, solar, wind, and wave energy, can supply electricity with minimal or no direct carbon emissions, while green hydrogen offers a potential means of cost-effective energy storage. Besides, the development of climate-robust infrastructure may decrease vulnerability to natural hazards, such as cyclones and floods, thus bolstering the capacity of communities and infrastructure systems to adapt to changing climatic conditions. These contributions extend further than the conventional focus of sustainable engineering on decreasing greenhouse gas emissions and addressing wider environmental challenges. Additional established measures comprise carbon capture technologies, electricity generation from waste-derived biosolids, and the use of timber obtained from fast-growing forests in construction, all of which can contribute to more sustainable engineering practices once appropriately implemented [12].

Engineers could play a substantial role in preserving and protecting oceans, seas, and the marine species they support. Marine engineers work alongside scientists and practitioners from other engineering disciplines to address challenges such as fisheries depletion, ocean pollution, and the management of marine resources. Specifically, plastic pollution and climate change pose major threats to marine ecosystems and natural resources, such as the Great Barrier Reef, requiring the development of effective engineering solutions to mitigate these impacts. Furthermore, environmental engineers contribute to biodiversity conservation by promoting the responsible management of forest resources and implementing practices that minimize environmental degradation [12].

Agricultural monitoring, infrastructure development, and the assessment and forecasting of natural hazards, including earthquakes, are facilitated by innovative geospatial

technologies. Beyond facilitating the planning, evaluation, and negotiation of sustainable development initiatives, these technologies can assist Indigenous and disadvantaged communities in conserving and managing natural forests. Furthermore, Mapping of the forest cover and monitoring of the decline in animal populations can be achieved using sensor and drone technologies [12].

1.3. Efforts of Engineering Organizations in Kuwait to Promote Sustainability

The Middle East and North Africa (MENA) region faces a pressing need for sustainable approaches to the engineering and built-environment sectors [13]. As a region experiencing some of the world's most rapid population growth, its contemporary building sector has largely evolved from the mid-twentieth-century modernist American model, which emphasizes reinforced-concrete structures and road-oriented urban development. This model is often poorly aligned with the region's traditional socio-cultural characteristics and distinctive climatic conditions [14]. The entrenched status of the legacy paradigm, together with the comparatively lower upfront costs associated with familiar yet wasteful and unsustainable methods, has impeded the development and uptake of sustainable design and construction practices in the region [15]. Nevertheless, a failure to hasten the adoption of sustainability measures is likely to exacerbate the adverse effects of current practices, with serious long-term repercussions for environmental integrity, socio-economic development, and quality of life, and potentially for food security and political stability as well [16].

The adoption of sustainable construction practices across the MENA region is essential for achieving the Sustainable Development Goals (SDGs). Greenhouse gas emissions, for example, are not limited to a particular region or country, but have a global impact. Over the past 20 years, MENA region carbon dioxide emissions have increased by 114% net (44% per capita) [17]. The trend suggests the region will contribute a larger share of global greenhouse gas emissions in the next century, even though it presently accounts only 6% to world carbon dioxide emissions [18].

Kuwait records one of the highest per capita incomes globally; however, its economy remains heavily reliant on hydrocarbons, characterized by extensive social welfare expenditure, an overstaffed public sector, and a correspondingly underdeveloped private sector [19,20]. Recently, higher oil prices have promoted economic growth. Kuwait has roughly 10% of the world's confirmed oil reserves, and petroleum-related products constitute more than 50% of gross national product, 95% of export incomes, and 95% of government revenue [14].

The construction industry contributed approximately 2% to Kuwait's overall economy and 4.7% to its non-oil sector at the end of 2008 [6]. Subsequent to the oil sector, construction represented the country's second-largest source of investment [14]. Together with the private sector, Kuwait's building industry underpins both the nation's economic and military strength.

Kuwait-based professional organizations, researchers, and construction firms are increasingly concerned with environmental issues and sustainability. In Kuwait, sustainable projects remain mostly at the pioneering phase, reflecting the relatively early development of the country's green-building movement [14]. So far, under its Core and Shell rating system, the United States Green Building Council (USGBC) has awarded LEED Gold certification to only one construction project in Kuwait. However, after the financial crisis of 2009, the project was subsequently cancelled [14]. The limited adoption of sustainable construction practices in Kuwait may partially be ascribed to inadequate governmental support and the absence of appropriate policy incentives. Kuwaiti professionals in engineering design and construction accentuate the importance of government intervention in accelerating the acceptance of innovative design and construction approaches. This intervention, which is

aimed at encouraging the adoption of renewable technologies, processes, and sustainable products, may involve the introduction of updated standards and guidelines, along with financial incentives, including subsidies [15].

Kuwait, as one of the member states of the Gulf Cooperation Council (GCC), displays the lowest level of engagement in green building projects [14]. Yet, the government has not instituted an adequate framework for the implementation of green construction initiatives. For a long time, it has been contended that environmentally responsible practices ought to be embraced and implemented across Kuwait's business and governmental sectors. To increase awareness and foster the development and proliferation of green and sustainable buildings, the Kuwaiti construction sector should adopt a more proactive stance. Accordingly, the sector ought to be held responsible for its resource consumption, conservation practices, and ecological impacts. The government has, in fact, already undertaken several measures in this direction.

Approximately 40% of Kuwait's primary energy consumption is attributed to buildings [14]. Besides their significant energy requirements, buildings consume considerable quantities of water, including desalinated water whose production requires significant amounts of electricity generated from fossil fuels. Enhancing the sustainability of buildings could help reduce the intensive consumption of natural resources and mitigate the environmental impacts associated with large-scale construction activities, while also generating long-term economic benefits [21]. While sustainable construction practices offer considerable potential for energy savings, encouraging consumers to reduce their electricity consumption remains challenging in Kuwait. It is envisaged that government subsidies are, partly, responsible for this obstacle. It has been reported that these subsidies cover approximately 85% of the cost of electricity, thus reducing the financial incentives for consumers to conserve energy [14].

2. Research Design and Methods

The research design adopted in this study, which is described in details in subsequent sections, is illustrated in Figure 1. Several advantages are achieved by integrating the research design and methodology sections. These include improved coherence and clarity, enabling a more logical and comprehensive presentation of the study [22]. Besides, this approach reduces redundancy and repetition, thus enhancing conciseness and readability [23]. In addition, displaying the research design beside the methods employed provides a general understanding of their interrelationship and alignment with the study objectives [24]. It also enables a clearer explanation of the rationale underlying the methodological choices and a more comprehensive assessment of the study's strengths and limitations [25].

2.1. Data Acquisition Strategy and Method

Data on engineering professionals' and students' sustainability knowledge, engagement, experience, and perceptions of organizational sustainability practices were collected using an online questionnaire. The questionnaire was developed by adapting relevant items from previously validated sustainability and engineering survey instruments and tailoring them to the Kuwaiti engineering context [26–31]. The use of previously developed and validated measurement items provided an established theoretical and empirical basis for the survey instrument, thus strengthening its credibility and reducing the risk of developing items that were insufficiently aligned with the constructs under investigation. Since the survey was developed by adapting and contextualizing previous studies, this approach may reinforce and improve the validity and credibility of the survey. However, the adaptation of previously validated measures does not, by itself, establish validity in a new population or context. Therefore, the adapted questionnaire was further reviewed and

pilot tested to ensure the relevance, clarity, and appropriateness of the items for the Kuwaiti engineering context.

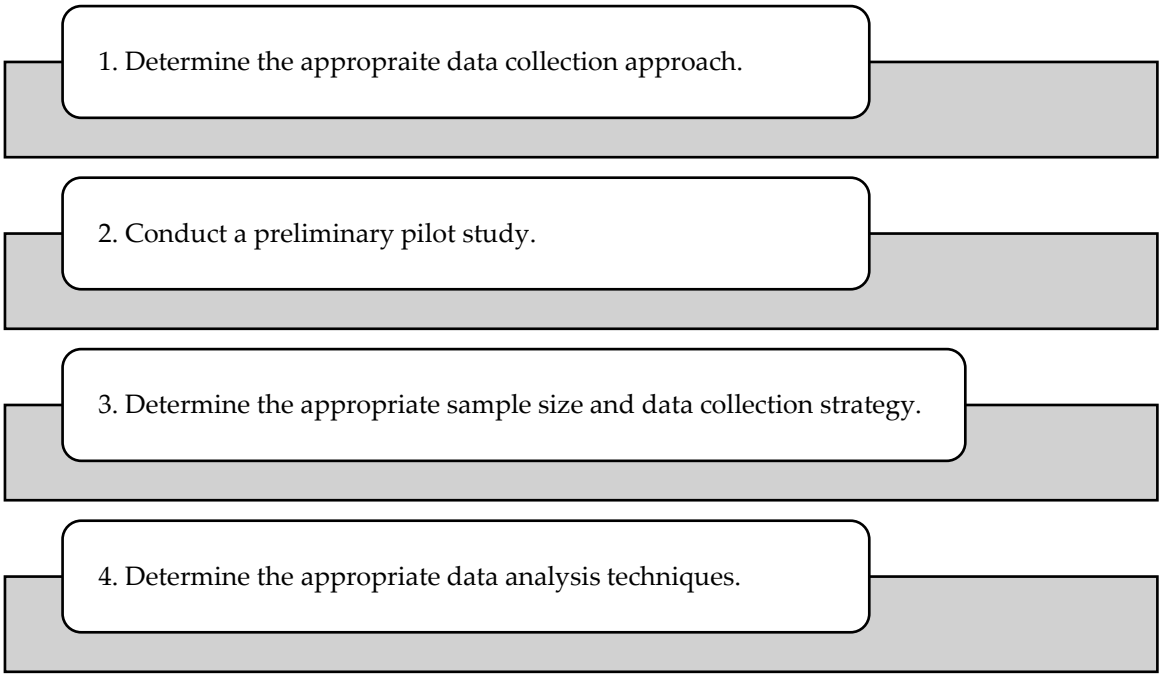


Figure 1. Design of research survey. Source: Author.

The online survey methodology and questionnaire design were developed in accordance with established methodological principles and best practices for web-based surveys, following the procedures previously outlined in [32]. Web-based survey tools bring a number of benefits as a method of gathering data [33,34]. To start with, they are easy to access and simple to use for both researchers and respondents, which makes it possible to engage a broad audience and raise response rates. Also, they may save money, since there is no need to print materials, send them out, or enter responses by hand. In addition, many of these tools come with built-in options for organizing and analyzing results, which streamlines the research workflow. Their flexibility in layout and customization further allows researchers to adapt questionnaires to the particular aims of a study. Lastly, since responses are collected digitally, storing and retrieving the data is straightforward and efficient. Briefly, online survey platforms give researchers data collection tools that are efficient, economical, and adaptable.

Sustainability engagement was conceptualized as the extent to which engineering students and practicing engineers actively participate in, apply, support, and promote sustainability-oriented practices within their academic or professional activities. The construct therefore extends beyond passive awareness or knowledge and captures respondents' active involvement in integrating sustainability considerations into engineering decision-making and practice. The sustainability engagement measure was developed by adapting and contextualizing the sustainability-integrated work and knowledge/skills dimensions based on previous research investigation [35]. Especially, the adaptation was based on the study's emphasis on the integration of environmental sustainability into engineering practice, together with related dimensions of leadership, societal and environmental impact, communication, lifelong learning, and innovation. Cronbach's alpha was used to assess internal consistency reliability; evidence of content/construct validity was established separately through pilot testing and adaptation from validated previous research instruments.

A pilot study was conducted to evaluate and refine the questionnaire and the proposed data-collection procedures prior to the administration of the main survey. The pilot was treated as a diagnostic stage of instrument development rather than simply as a preliminary administration of the questionnaire. Precise attention was given to respondents' understanding and interpretation of the questionnaire items, the clarity and appropriateness of the wording, the suitability of the response options, and the feasibility of questionnaire administration. The pilot also provided an opportunity to identify ambiguous or potentially problematic items and to make appropriate refinements before the full-scale survey. Moreover, preliminary internal-consistency analysis was undertaken for the relevant multi-item constructs. These pilot results were treated as preliminary diagnostic evidence and were not considered definitive evidence of the reliability or validity of the final survey instrument.

After pilot testing and subsequent refinement of the questionnaire, submission of incomplete or partially completed questionnaires was prevented due to the configuration of the final survey. Specifically, respondents were required to complete all mandatory items before the questionnaire could be submitted. Consequently, the final dataset comprised only fully completed and valid responses, thereby eliminating item-level missing data and ensuring a complete dataset for subsequent statistical analysis.

Ultimately, the final survey was administered to the target population, with the main objective of assessing their understanding of sustainability and the extent to which they apply it in practice, precisely concerning the incorporation of sustainable procedures within their respective engineering fields. To increase coverage of the study population, recruitment was deliberately conducted through multiple educational, professional, and social-media channels, with particular attention to reaching both engineering students and practicing engineers across different engineering disciplines and industry sectors. This multi-channel recruitment strategy was intended to increase the diversity of the respondent pool and reduce dependence on any single source of participants. The survey consisted of multiple items pertaining to sustainable technology measures:

Designs aimed at minimizing energy consumption and/or greenhouse gas emissions
Designs adhering to relevant environmental standards and regulatory requirements
Designs incorporating the 3R principles (renewable, recyclable, or recycled materials)
Designs that minimize material waste throughout the manufacturing process
Designs that utilize materials free from toxic substances
Designs that minimize the overall carbon footprint
Manufacturing that minimizes energy consumption and the use of natural resources
Manufacturing processes that minimize environmental pollution
Products designed for safe disposal or recycling at the end of their useful life
Products that need minimal packaging

The survey questions were designed to elicit responses concerning sustainability, focusing on either respondents' perspectives and attitudes or the actions undertaken by respondents and the organizations with which they are affiliated. The first set of questions addresses respondents' subjective perspectives, whereas the second set focuses on more objective, evidence-based, and factual information. Consequently, the instrument was designed to balance subjective perceptions against observable practices.

Likert-based surveys, as applied in the present investigation, present several advantages, including simplicity of administration, standardization, and the generation of measurable data [36]. Besides, they offer a flexible and non-intimidating response format that enables the measurement of a wide range of constructs [37].

2.2. Sampling and Recruitment

To recruit engineering students and practicing engineers in Kuwait, a non-probability, voluntary-response sampling approach was employed. The online questionnaire was disseminated through relevant social-media groups and professional and educational networks, including groups and networks associated with engineering students, practicing engineers, engineering professionals, academic institutions, and professional contacts. The invitation to participate contained a brief description of the study, its purpose, eligibility requirements, definition of sustainability, and a link to the online questionnaire. Participation was entirely voluntary, and respondents self-selected to participate after accessing the survey invitation. No individual was directly selected or assigned to participate, and no probability-based sampling frame was available from which respondents could be randomly selected. This approach was considered appropriate for reaching the two target groups—engineering students and practicing engineers—who are geographically dispersed across Kuwait and are readily accessible through online professional and educational networks. Dissemination through multiple channels was also intended to widen participant coverage across engineering disciplines and employment sectors and to reduce reliance on a single recruitment source. The use of professional and educational networks was particularly relevant because the study sought responses from individuals with engineering education or professional experience, while social-media dissemination facilitated wider access to eligible participants.

Since participation depended on individuals' exposure to the survey invitation and their willingness to respond, the resulting sample should be regarded as a non-probability sample rather than a statistically representative probability sample of all engineers and engineering students in Kuwait. Voluntary online recruitment may introduce self-selection and coverage bias because individuals who are more interested in sustainability, more active on social media, or more engaged with professional and educational networks may have been more likely to participate. Such limitations are inherent in non-probability online surveys. However, the multi-channel recruitment strategy employed in the present survey broadened access to the target population and enhanced the diversity of potential respondents. By reducing reliance on any single network or participant group, this approach limited the likelihood of systematic over-representation of individuals with a particular interest in sustainability or greater online engagement, thereby minimizing the potential for self-selection and coverage bias.

2.3. Sample Size Calculation

Based on an estimated population of 40,709 engineers in Kuwait, as reported by *Al-Qabas* newspaper [38], the required sample size was determined to be 381 respondents. This calculation was based on a 95% confidence level, a 5% margin of error, a Z-score of 1.96, and an assumed population proportion (p) of 50%. The sample size was calculated using the formula proposed by Fox et al. (2009) [39]:

$$Sample\ Size = N \times \frac{\frac{Z^2 \times p \times (1-p)}{e^2}}{N - 1 + \frac{Z^2 \times p \times (1-p)}{e^2}} \quad (1)$$

where (N) denotes the population size, (Z) represents the Z-score corresponding to the selected confidence level, (e) denotes the margin of error, and (p) represents the assumed population proportion

2.4. Participant Recruitment

Delivering online surveys through social media groups dedicated to practicing engineers and engineering students has been shown to be an effective and efficient means of data collection [40,41]. Social media platforms provide extensive reach and ease of access,

enabling participants to respond to the survey with minimal delay. Moreover, by drawing on established online communities, researchers can target a population with relevant professional or academic interests, which is likely to improve both the response rate and the relevance of the data obtained.

Besides, the utilization of social media groups can reduce reliance on conventional survey distribution methods, such as paper-based questionnaires and email invitations, which may require considerable time and financial resources. Social media platforms enable surveys to be disseminated rapidly to a broad audience at minimal cost, thereby providing a practical and cost-effective approach for researchers operating under resource constraints [40].

2.5. Results and Analysis

Likert-scale survey data can be analyzed using statistical software packages such as SPSS version 26 [42]. In this study, several analytical methods were employed to interpret and summarize the collected data, as described below.

2.6. Statistical Methods

Descriptive statistical measures, including means, standard deviations, frequencies, percentages, and weighted scores were utilized to address the research objectives of the study. The scores were calculated according to the following criteria:

$$Length\ of\ period = \frac{Upper\ bound - lower\ bound}{Number\ of\ levels} = \frac{5-1}{3} = 1.33 \quad (2)$$

Accordingly, three levels, namely, low (1.00–2.33), moderate (2.34–3.67), and high (3.68–5.00), were used to classify the score ranges.

The internal consistency and reliability of the research instrument were assessed by Cronbach's alpha coefficient, while the statistical significance of the hypothesized relationships was evaluated by the independent-samples *t*-test. These statistical procedures are described in detail in the following sections.

2.7. Study Sample Reliability

For a questionnaire to be considered reliable, a Cronbach's alpha of at least 0.60 is needed, showing that the items measure the intended constructs and that the instrument is consistent and dependable [43]. The results shown in Table 1 show that all Cronbach's alpha coefficients exceed 0.60, representing an acceptable level of internal consistency and reliability for the study instrument.

Table 1. Research instrument reliability scores.

Section Title	Cronbach's Alpha
Knowledge of and experience of certain sustainable technologies and practices	0.88
Organizational adoption of certain sustainable technologies and practices	0.83

Source: Author.

2.8. Principal Characteristics

The required sample size was determined a priori using the finite-population sample-size formula, based on a 95% confidence level, a 5% margin of error, and maximum population variability ($p = 0.50$). The calculation yielded an ideal sample of 381 respondents. A total of 350 complete and usable responses were ultimately obtained, representing 91.9% of

the initially calculated target sample. Although the achieved sample was slightly below the calculated minimum, the shortfall of 31 respondents represents a relatively modest reduction in the planned sample size. Under a simple-random-sampling framework, the achieved sample corresponds to an approximate theoretical precision of ±5.2 percentage points at the 95% confidence level, compared with ±5.0 percentage points for the originally calculated sample. The pre-specified 95% confidence level was therefore retained rather than being retrospectively reduced to accommodate the achieved sample.

The final sample comprised 213 engineering students (60.9%) and 137 practicing engineers (39.1%), providing substantial representation of both principal respondent groups and supporting the comparative analyses undertaken in the study. The inclusion of engineering students was important because they represent the future engineering workforce and will increasingly contribute to engineering decisions with environmental, economic, and social sustainability implications. Including both students and practicing engineers also enabled comparison between the educational and professional stages of the engineering pathway, providing insight into potential differences in sustainability knowledge, engagement, and experience and helping to identify possible gaps between sustainability education and professional practice.

The higher representation of students may reflect their greater accessibility through university networks and online platforms, whereas practicing engineers may have had fewer opportunities to participate because of professional commitments. This difference in group representation constitutes a potential limitation of the voluntary-response, non-probability sampling approach, as differences in accessibility and response propensity may have influenced the composition of the sample. Given this sampling approach, the calculated precision should be regarded as a theoretical benchmark rather than a formal estimate of sampling error. Accordingly, sample adequacy was assessed in relation to the study objectives, the representation of the two respondent groups, and the planned statistical analyses. Overall, the achieved sample was considered adequate for addressing the research questions and conducting the intended comparative analyses.

As shown in Table 2 and illustrated in Figures 2 and 3, most participants were engineering students (60.9%, $n = 213$), whereas the remaining 39.1% ($n = 137$) were practising engineers. The largest group encompassed specialists in the *building and architecture* sector (34.0%, $n = 119$), while the majority of respondents were associated with many civil engineering specializations (70.6%, $n = 247$).

Table 2. Principal information.

Specialty		N	%
Respondents group	Students	213	60.9
	Engineers	137	39.1
Academic discipline/ qualification	Architectural	7	2.0
	Chemical	35	10.0
	Civil	247	70.6
	Electrical & Electronic	34	9.7
	Environmental	7	2.0
	Mechanical	20	5.7

Table 2. *Cont*.

	Specialty	N	%
Industrial or training sector	Architecture & building	119	34.0
	Aviation	7	2.0
	Design & technological advancement	28	8.0
	Electricity & energy systems	21	6.0
	Food & beverage	7	2.0
	Public services	28	8.0
	Materials manufacturing	7	2.0
	Gas & oil	42	12.0
	Others	91	26.0
	Total	350	100.0

Source: Author.

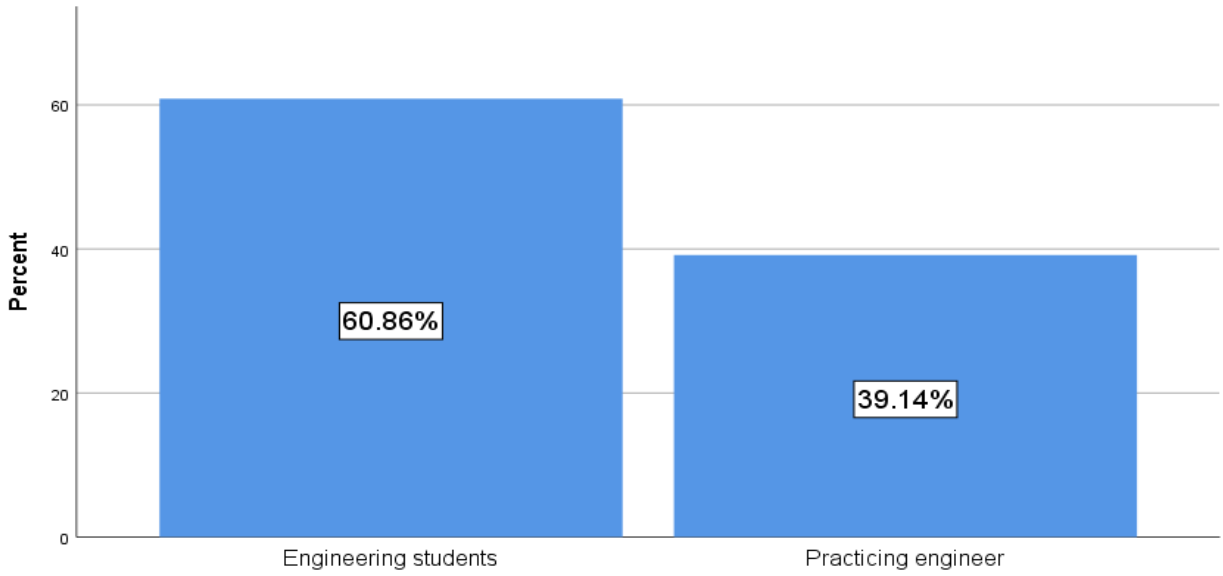


Figure 2. Participants' distribution: students and practitioners. Source: Author.

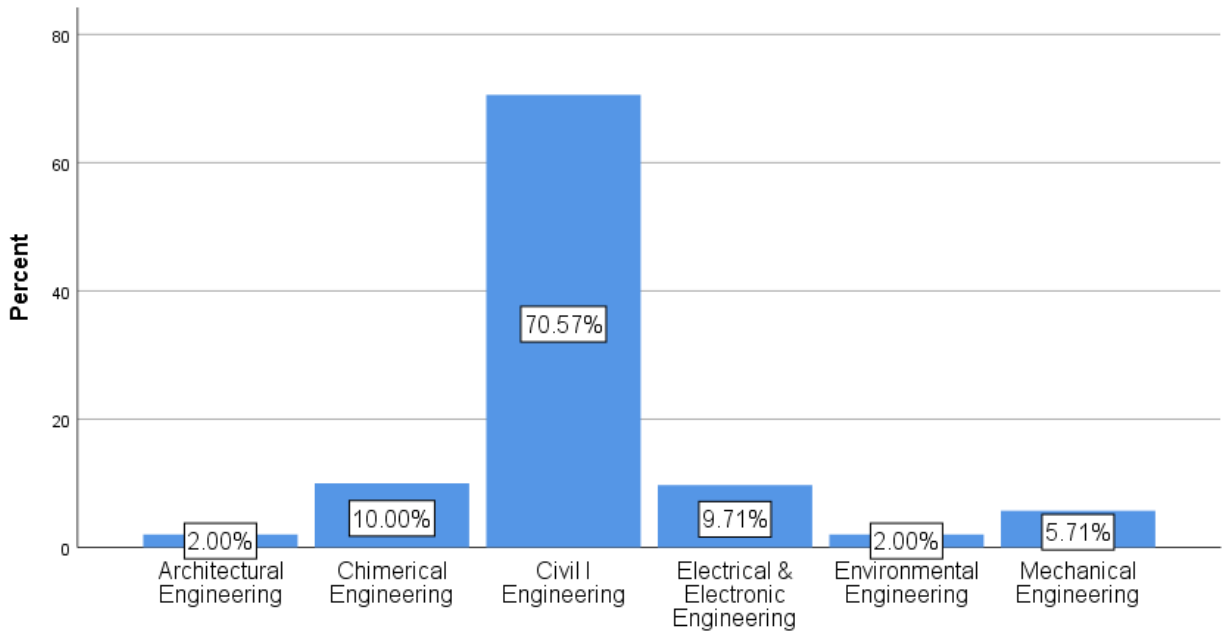


Figure 3. Participants' distribution by engineering field.

2.9. Practising Engineers

The statements evaluating practicing engineers' attitudes towards sustainability received moderate mean scores, ranging from 3.00 to 3.40, as shown in Table 3. Amid practising engineers, the highest mean score was noted for knowledge and/or experience of designs that conform to applicable environmental standards and regulatory requirements.

Table 3. Practising engineers' attitudes toward certain sustainable technologies and measures.

	Mean	SD	Degree
I possess knowledge of and/or experience in developing designs that conform to applicable environmental standards and regulatory requirements.	3.40	0743	Moderate
I possess knowledge of and/or experience in developing designs that enhance energy efficiency and reduce associated emissions.	3.39	1.087	Moderate
I possess knowledge of and/or experience in manufacturing and engineering practices aimed at minimizing energy consumption and the use of natural resources.	3.39	1.031	Moderate
I possess knowledge of and/or experience with products designed to facilitate safe disposal at the end of their useful life.	3.33	0.979	Moderate
I possess knowledge of and/or experience with designs that reduce material waste.	3.28	0.905	Moderate
I possess knowledge of and/or experience with designs that incorporate non-toxic materials.	3.28	1.288	Moderate
I possess knowledge of and/or experience with products designed to minimize packaging.	3.24	1.004	Moderate
I possess knowledge of and/or experience with manufacturing or engineering processes that minimize environmental pollution.	3.23	1.208	Moderate
I possess knowledge of and/or experience with designs incorporating 3R materials.	3.15	1.281	Moderate
I possess knowledge of and/or experience with designs aimed at reducing carbon footprints.	3.00	1.111	Moderate
Average	3.26	0807	Moderate

Source: Author.

2.10. Engineering Students

Engineering students' attitudes toward various sustainability technologies and measures ranged from moderately to highly favorable. It can be seen from Table 4 that the items measuring attitudes towards sustainability received moderate mean scores, ranging from 3.15 to 3.66, with the highest-rated item among engineering students being knowledge of and/or experience with designs incorporating 3R (reduce, reuse, recycle) materials. Nonetheless, the element evaluating knowledge and/or experience with designs that reduce material waste received a high rating, with a mean score of 3.72.

Table 4. Engineering students' attitudes towards certain sustainability technologies and practices.

	Mean	SD	Degree
I possess knowledge of and/or experience with designs that reduce material waste.	3.72	1.155	High
I possess knowledge of and/or experience with designs incorporating 3R materials.	3.66	0.879	Moderate
I possess knowledge of and/or experience in manufacturing and engineering practices aimed at minimizing energy consumption and the use of natural resources.	3.56	1.198	Moderate
I possess knowledge of and/or experience with designs that incorporate non-toxic materials.	3.55	1.052	Moderate
I possess knowledge of and/or experience with designs aimed at reducing carbon footprints.	3.53	1.114	Moderate
I possess knowledge of and/or experience in developing designs that conform to applicable environmental standards and regulatory requirements.	3.49	1.089	Moderate
I possess knowledge of and/or experience with products designed to minimize packaging.	3.44	1.202	Moderate
I possess knowledge of and/or experience with manufacturing or engineering processes that minimize environmental pollution.	3.34	0.911	Moderate

Table 4. *Cont.*

	Mean	SD	Degree
I possess knowledge of and/or experience with manufacturing or engineering processes that minimize environmental pollution	3.18	1.231	Moderate
I possess knowledge of and/or experience with products designed to facilitate safe disposal at the end of their useful life.	3.15	1.099	Moderate
Average	3.46	0.771	Moderate

Source: Author.

2.11. Engineering Organizations' Attitudes and Practices Regarding Sustainability

Tables 5–7 present the sustainable technologies most frequently adopted or implemented by the participants' respective organizations. The mean scores show relatively well-established organizational practices, mainly with respect to the use of products requiring minimal packaging (3.59) and the adoption of 3R principles in organizational designs and measures (3.53). Among the organizations employing professional engineers, the most dominant sustainable practices were the adoption of 3R principles in the design and use of materials (3.38) and the use of products needing minimal packaging (3.38). In contrast, among organizations associated with engineering students, the most prevalent sustainable practices were the use of products that can be safely disposed of (3.85) and products requiring minimal packaging (3.72).

Table 5. Use and opinions on selected sustainable technologies and measures (All).

All			
	Mean	**SD**	**Degree**
My organization utilizes products with minimal packaging	3.59	1.085	Moderate
My organization adopts designs and materials based on the 3R principles.	3.53	1.099	Moderate
My organization utilizes products designed for safe end-of-life disposal	3.51	1.211	Moderate
My organization adopts energy- and/or resource-efficient manufacturing or engineering practices.	3.44	0.990	Moderate
My organization adopts low-pollution manufacturing and engineering processes.	3.40	1.300	Moderate
My organization adopts low-carbon footprints designs and measures.	3.40	1.024	Moderate
My organization adopts designs and measures that comply with relevant environmental standards and guidelines.	3.38	0.990	Moderate
My organization adopts designs and measures that minimize material waste.	3.32	1.133	Moderate
My organization adopts energy-efficient and low-emission designs and measures.	3.29	1.095	Moderate
My organization adopts designs and measures using non-toxic materials.	3.07	1.054	Moderate
Average	3.39	0.825	Moderate

Source: Author.

Table 6. Use and opinions on selected sustainable technologies and measures (Engineers).

Practising Engineers			
	Mean	**SD**	**Degree**
My organization utilizes products with minimal packaging	3.38	1.037	Moderate
My organization adopts designs and materials based on the 3R principles.	3.38	1.037	Moderate
My organization utilizes products designed for safe end-of-life disposal	2.99	1.328	Moderate
My organization adopts energy- and/or resource-efficient manufacturing or engineering practices.	3.34	1.038	Moderate
My organization adopts low-pollution manufacturing and engineering processes.	3.04	1.137	Moderate
My organization adopts low-carbon footprints designs and measures.	3.01	0.978	Moderate

Table 6. *Cont*.

Practising Engineers			
	Mean	**SD**	**Degree**
My organization adopts designs and measures that comply with relevant environmental standards and regulations.	3.21	0.886	Moderate
My organization adopts designs and measures that minimize material waste.	3.20	1.294	Moderate
My organization adopts energy-efficient and low-emission designs and measures.	2.98	1.101	Moderate
My organization adopts designs and measures using non-toxic materials.	2.85	1.040	Moderate
Average	3.14	0.788	Moderate

Source: Author.

Table 7. Use and opinions on selected sustainable technologies and measures (Students).

Engineering Students			
	Mean	**SD**	**Degree**
My organization utilizes products with minimal packaging	3.72	1.097	High
My organization adopts designs and materials based on the 3R principles.	3.62	1.128	Moderate
My organization utilizes products designed for safe end-of-life disposal	3.85	0.995	High
My organization adopts energy- and/or resource-efficient manufacturing or engineering practices.	3.51	0.955	Moderate
My organization adopts low-pollution manufacturing and engineering processes.	3.63	1.349	Moderate
My organization adopts low-carbon footprints designs and measures.	3.65	0.978	Moderate
My organization adopts designs and measures that comply with relevant environmental standards and guidelines.	3.48	1.040	Moderate
My organization adopts designs and measures that minimize material waste.	3.40	1.012	Moderate
My organization adopts energy-efficient and low-emission designs and measures.	3.50	1.044	Moderate
My organization adopts designs and measures using non-toxic materials.	3.22	1.042	Moderate
Average	3.56	0.808	Moderate

Source: Author.

3. Hypotheses Testing

Testing the first hypothesis: No statistically significant differences were noticed in engineers' attitudes and activities towards sustainability at the significance level of $\alpha \leq 0.05$ across diverse engineering fields of study or qualification.

An independent sample *t*-test was conducted to test the first hypothesis. Table 8 shows that the T value was significant at $(\alpha \leq 0.05)$. Therefore, it is concluded that statistically significant differences exist in the attitudes and actions of engineering towards sustainability at the significance level of $\alpha \leq 0.05$ which is attributed to engineer type variable. With engineering students exhibiting more positive attitudes than practising engineers.

Table 8. Independent-samples T-test for hypothesis 1.

Respondents	N	Mean	SD	T	Df	Sig. (2-Tailed)
Engineer	137	3.26	0.807	−2.3491	348	0.021 *
Students	213	3.46	0.771			

* Significant at $(\alpha \leq 0.05)$. Source: Author.

Testing the second hypothesis: No statistically significant differences were noticed in engineers' attitudes and activities towards sustainability at the significance level of $\alpha \leq 0.05$ across diverse engineering fields of study or qualification.

An independent sample *t*-test was conducted to test the second hypothesis. Table 9 shows that the T value was significant at ($\alpha \leq 0.05$). Accordingly, it is concluded that statistically significant differences exist in the attitudes and actions of engineering corporations towards sustainability at the significance level of $\alpha \leq 0.05$ that is ascribed to the engineer type variable. Specifically, the attitudes of engineering students' corporations were higher than those of practising engineers.

Table 9. Independent-samples T-test for hypothesis 2.

Respondents	N	Mean	SD	T	df	Sig. (2-Tailed)
Engineers	137	3.14	0.789	−4.783	348	0.000 *
Students	213	3.56	0.808			

* Significant at ($\alpha \leq 0.05$). Source: Author.

Testing the third hypothesis: No statistically significant differences were noticed in engineers' attitudes and activities towards sustainability at the significance level of $\alpha \leq 0.05$ across diverse engineering fields of study or qualification.

A one-way ANOVA test was conducted to test the third hypothesis. As illustrated in Table 10, the f value was significant at ($\alpha \leq 0.05$), so it is concluded that there are differences in the attitudes and actions of engineering towards sustainability at the level of significance ($\alpha \leq 0.05$) ascribable to engineering discipline and academic qualification. From the results presented in Table 11, it is noted that higher attitudes among specialists in electrical & electronic engineering than among those specializing in civil and mechanical engineering.

Table 10. One-way ANOVA test for hypothesis 3.

Engineering Sector	N	Mean	SD	df	F	Sig.
Civil	247	3.32	0.843			
Mechanical	20	3.00	0.086			
Chemical	35	3.42	0.633			
Environmental	7	3.79	0.279	5	5.268	0.000 *
Electrical & electronic	34	3.93	0.628			
Architectural	7	3.40	0.191			
Total	350	3.38	0.790			

* Significant at ($\alpha \leq 0.05$). Source: Author.

Table 11. Scheffee test for hypothesis 3.

		Mean Difference (I–J)
Electrical & electronic engineering	Civil engineering	0.60753 *
	Mechanical engineering	0.92647 *

* Significant at $p \leq 0.05$. Source: Author.

Testing the fourth hypothesis: No statistically significant differences were noticed in engineers' attitudes and activities towards sustainability at the significance level of $\alpha \leq 0.05$ across diverse engineering fields of study or qualification.

A one-way ANOVA test was conducted to test the fourth hypothesis. As illustrated in Table 12, the f value was significant at ($\alpha \leq 0.05$), so it is concluded that there are differences in the attitudes and actions of engineering corporations towards sustainability at the level of significance ($\alpha \leq 0.05$) related to engineering discipline and academic qualification. The results presented in Table 13 indicate that the level of awareness was higher

among *electrical & electronic engineering* specialists than among those of *civil engineering* and *mechanical engineering*.

Table 12. One-way ANOVA test for hypothesis 4.

Engineering Sector	N	Mean	SD	df	F	Sig.
Civil	247	3.33	0.879	5	4.181	0.001 *
Mechanical	20	3.01	0.141			
Chemical	35	3.42	0.531			
Environmental	7	3.91	0.318			
Electrical & electronic	34	3.86	0.830			
Architectural	7	3.69	0.292			
Total	350	3.39	0.825			

* Significant at ($\alpha \leq 0.05$). Source: Author.

Table 13. Scheffee test for hypothesis 4.

		Mean Difference (I–J)
Electrical & electronic engineering	Civil engineering	0.52228 *
	Mechanical engineering	0.84588 *

* Significant at $p \leq 0.05$. Source: Author.

Testing the fifth hypothesis: No statistically significant differences were noticed in engineers' attitudes and activities towards sustainability at the significance level of $\alpha \leq 0.05$ across diverse engineering fields of study or qualification.

A one-way ANOVA test was conducted to test the fifth hypothesis. As illustrated in Table 14, the f value was significant at ($\alpha \leq 0.05$), so it is concluded that there are differences in the attitudes and actions of engineering towards sustainability at the level of significance ($\alpha \leq 0.05$) ascribable to industry of work or training. The results presented in Table 15 indicate that the level of awareness was lower among workers in *material production* than among those employed in *electricity & energy*, *public services*, and *oil & gas* sectors.

Table 14. One-way ANOVA test for hypothesis 5.

Industrial or Training Sector	N	Mean	SD	df	F	Sig.
Architecture & building	119	3.14	1.003	8	7.778	0.000 *
Aviation	7	3.10	0.461			
Design & technological advancement	28	3.00	0.322			
Electricity & energy systems	21	3.87	0.859			
Food & beverage	7	3.50	0.323			
Public services	28	3.75	0.700			
Materials manufacturing	7	2.50	0.667			
Gas & oil	42	3.78	0.654			
Others	91	3.50	0.431			
Total	350	3.38	0.789			

* Significant at ($\alpha \leq 0.05$). Source: Author.

Table 15. Scheffee test for hypothesis 5.

		Mean Difference (I–J)
Material manufacturing	Electricity & energy systems	−1.36667 *
	Public services	−1.25000 *
	Gas & oil	−1.28333 *

* Significant at $p \leq 0.05$. Source: Author.

Testing the sixth hypothesis: No statistically significant differences were noticed in engineers' attitudes and activities towards sustainability at the significance level of $\alpha \leq 0.05$ across diverse engineering fields of study or qualification.

A one-way ANOVA test was conducted to test the sixth hypothesis. As depicted in Table 16, the f value was significant at $(\alpha \leq 0.05)$, so it is concluded that there are differences in the attitudes and actions of engineering corporations towards sustainability at the level of significance $(\alpha \leq 0.05)$ ascribable to industry of work or training. The results presented in Table 17 indicate that awareness was lower among organizations specializing in *design & technology development* than among those operating in the *electricity and energy and oil & gas* sectors.

Table 16. One-way ANOVA test for hypothesis 6.

Industrial or Training Sector	N	Mean	SD	df	F	Sig.
Architecture & building	119	3.44	0.978	8	5.640	0.000 *
Aviation	7	3.10	0.324			
Design & technological advancement	28	2.83	0.480			
Electricity & energy systems	21	3.83	1.105			
Food & beverage	7	3.40	0.422			
Public services	28	2.95	0.924			
Materials manufacturing	7	2.70	0.000			
Gas & oil	42	3.72	0.691			
Others	91	3.47	0.514			
Total	350	3.39	0.822			

* Significant at $(\alpha \leq 0.05)$. Source: Author.

Table 17. Scheffee test for hypothesis 6.

		Mean Difference (I–J)
Design & technological advancement	Electricity & energy systems	−1.00833 *
	Gas & oil	−0.87500 *

* Significant at $p \leq 0.05$. Source: Author.

4. Discussion

The results show a generally positive level of sustainability knowledge, experience, and attitudes among engineering students and practicing engineers in Kuwait, but only a moderate level of reported organizational sustainability practice. Individual scores were 3.46 for students and 3.26 for practicing engineers, compared with 3.39 for organizational 684 practices. This trend indicates a potential gap between individual sustainability competence and its translation into organizational practice. It is therefore important for future studies to investigate the underlying causes of this gap in greater detail, which could inform the development of more targeted and effective interventions.

The student–engineer comparison reinforces the above interpretation. Students expressed considerably higher sustainability attitudes and actions (3.46 vs. 3.26; $p = 0.021$) and significantly higher perceptions of organizational sustainability practices (3.56 vs. 3.14; $p < 0.001$). Whereas this difference may echo more recent exposure to sustainability education among students, the cross-sectional design does not permit causal interpretation. At the organizational level, practices linked to minimized packaging, 3R designs/materials, and safe disposal received the highest ratings, whereas non-toxic materials, energy/emission reduction, and material-waste reduction received lower ratings.

Substantial variations were also observed across engineering disciplines and industry sectors. Individual sustainability attitudes and actions differed by engineering field ($F = 5.268$, $p < 0.001$) and industry sector ($F = 7.778$, $p < 0.001$), while organizational practices also differed by field ($F = 4.181$, $p = 0.001$) and sector ($F = 5.640$, $p < 0.001$). The results revealed that sustainability engagement is non-uniform across professional contexts. However, the causes of these differences were not directly examined and should therefore be investigated in future research.

The main findings of the present study are consistent with several previous research studies conducted in various countries [24,29,35,44]. For example, a study surveyed mechanical engineers and students in the USA [24]. Where it was concluded that there appears to be a strong emphasis on the implementation of sustainability concepts, practices and measures in engineering, by both practising engineers and engineering organizations. The principal findings of this study indicated that nearly two-thirds of professional engineers were involved with sustainable products and processes, and over 50% of students were engaged in sustainable design during their studies. Another study was conducted in Sweden, which reported the existence of a gap between competences acquired by engineering students and competences desired by some Swedish companies [44]. This study concluded that 35% of alumni asserted they encounter sustainability issues at least occasionally in their work, but that only 50% of them feel they have adequate competences to take decisions from a sustainability viewpoint. A more recent similar study explores the relationship between sustainability awareness, pro-environmental behavior, and environmental attitudes among engineering students at one of Saudi Arabia universities [29]. This study analyzed responses from only 81 participants, it was concluded that while students retain moderate sustainability awareness, their engagement in eco-friendly actions stays limited, despite declaring positive environmental attitudes. The main findings of this investigation confirmed the persistence of the attitude–behavior gap.

Overall, the findings of our study are consistent with those presented in previous similar studies and show several quantitative similarities.

4.1. Policy and Practical Implication

The primary implication is that individual sustainability competence requires to be systematically translated into organizational practice. The moderate organizational scores, despite generally positive individual responses, show that awareness and knowledge alone may not ensure implementation. Organizations should therefore embed sustainability objectives, responsibilities, and measurable indicators within engineering projects, procurement, operational procedures, and performance management.

This organizational priority should be complemented by systematic integration of sustainability competencies into engineering curricula and continuing professional development, particularly through practical application, systems thinking, resource efficiency, climate resilience, and sustainable design. Stronger university–industry–government collaboration and a national framework for engineering sustainability competencies could provide greater consistency between education, professional development, and organizational practice.

4.2. Limitations

The results of this study are subject to the limitation that it focuses exclusively on Kuwait, which may limit the external validity of the results. Besides, the findings should be interpreted in light of the study's methodological limitations. The voluntary, non-probability sampling approach limits statistical generalizability, and the sample was somewhat unbalanced, comprising 60.9% students and 39.1% practicing engineers. Several engineering

and industry subgroups were also small, limiting the robustness and generalizability of subgroup comparisons. Although 350 responses were obtained against an a priori target of 381, the calculated precision should be regarded only as a theoretical benchmark because probability sampling was not used. Rather than independently verified sustainability performance, the study relied on self-reported data and perceived organizational practices. Accordingly, the findings should be interpreted as evidence of reported sustainability knowledge, engagement, and organizational practices within the surveyed sample. Future research should employ larger, more diverse, and better-balanced samples and, where feasible, integrate survey measures with objective organizational indicators and longitudinal evidence.

5. Conclusions

A questionnaire-based survey was administered to the target population to examine their levels of engagement, knowledge, and experience pertaining to sustainability. In addition, the study sought to estimate the extent to which their affiliated organizations are engaged in advancing sustainability. The statistical analysis of the main data showed an increasing awareness of environmental and sustainability issues amongst engineers, engineering students, professional bodies, researchers, and construction firms in Kuwait. The results of this study indicated a positive level of sustainability-related knowledge and attitudes among engineering students and practising engineers across various engineering sectors in Kuwait. In addition, the results revealed a substantial shift towards sustainable practices in engineering organizations. However, the overall assessment of these practices was moderate, indicating a need for further initiatives to bridge the discrepancy between individual engineers' attitudes and organizational sustainability practices. When interpreting the findings of this study, some limitations should be acknowledged. The results are based on responses acquired from participants during the study period and are subject to the limitations related to the relatively constrained sample size and the reliance on self-reported data from practising engineers and engineering students. Consequently, the generalizability of the findings may be limited. Additional research involving larger and more varied samples is therefore recommended to offer a more comprehensive understanding of sustainability-related knowledge, engagement, and experience among engineers and engineering students in Kuwait. Future studies could also employ complementary research methodologies to capture a wider range of viewpoints and strengthen the robustness and validity of the results.

Despite the above-mentioned limitations, the study provides valuable findings that are likely to benefit many stokeholds, such as educational institutions, engineering organizations, government bodies and policy makers in advancing the goals of sustainable development.

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