

ASSESSING SUSTAINABILITY IN KUWAIT'S HIGHER EDUCATION INSTITUTIONS' ENGINEERING CURRICULA

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ABSTRACT

As engineering is a discipline that is the center of most of the United Nations Sustainable Development Goals, engineering higher education institutions must play a significant role in promoting sustainable livelihoods. This paper aims at assessing the inclusion of sustainability concepts in Kuwait's higher education engineering curricula. It presents the results of a sustainability survey which evaluates the current state of sustainability education in engineering higher education institutions; faculty members' experiences in integrating sustainability principles into their courses; and faculty members' views on the importance of sustainability in engineering curricula. The survey results show that sustainability concepts are mainly introduced as portions of fundamental courses such as introduction to engineering, graduation projects, research projects, or through extra-curricular activities such as conferences, seminars, and workshops while a clear framework governing the delivery and assessment of such concepts at the program level is still not well established.

KEYWORDS

Engineering, education, sustainability, sustainable development goals, CDIO standards: 1-3, 5, 11-12.

INTRODUCTION

The unprecedented demand for natural resources in the last century had resulted in an adverse impact on the environment, societies, and economies around the globe. The United Nations (UN) General Assembly adopted 17 Sustainable Development Goals (SDGs) in September 2015 to promote sustainable development across the Globe (United Nations, 2015). This was a very ambitious effort to place goal setting at the center of global policy and governance to drive sustainability (Biermann et al., 2017; Kanie et al., 2017).

Governments and industries across the world have since used the UN SDGs as a basis for various policies, procedures, and practices, making it imperative that the future work force is aware of the sustainable practices to drive the future development agenda. Kuwait's 2035 vision adapts the UN SDGs 2030 agenda to the unique Kuwaiti economic, social, and environmental conditions to transform Kuwait into a financial and trade hub regionally and internationally and becoming more attractive to investors (General Secretariat of the Supreme Council for Planning and Development of Kuwait, 2020). The pillars of the National Development Plan (2035 Vision) are: sustainable diversified economy; effective civil service; sustainable living environment; developed infrastructure; high quality healthcare; creative human capital; and global positioning (Ministry of Foreign Affairs, State of Kuwait, n.d.).

As governments and industries across the world reconfigure their development strategies to align with UN SDGs, it is imperative that the future work force is aware of the sustainable practices to drive the future development agenda. Hence, education at all levels needs to play a significant role in promoting sustainable livelihoods. (Quelhas et al., 2019) defines education for sustainable development as the education that aims at preparing individuals to deal with economic, social, and environmental problems that threaten sustainability. This education needs to go beyond the knowledge and understanding of environmental and social issues, to affect attitudes, change behaviors, and promote competencies needed to shape a sustainable future (UNESCO Representation in Brazil, 2017). To drive real change, the students need to go beyond increased awareness of sustainable practices and change their attitudes and behaviors to support sustainable practices.

Studies conducted at the beginning of the new millennia suggested that engineering students' knowledge of sustainability practices was not satisfactory with significant knowledge gaps in various areas. Since then, studies were conducted to promote education for sustainable development. Rose et al. (2015) stated that students' awareness of sustainable practices was improved by embedding sustainability into a first-year engineering curriculum through a deliberative and dynamic renewal process that brought together internal and external stakeholders through a structured sequence of facilitated workshops and meetings. Various curriculum renewal processes around the world have achieved similar outcomes with respect to increasing students' awareness of sustainability practices (Bjornberg & Skogh, 2015; Byrne et al., 2013; Colombo & Alves, 2017).

The Conceive, Design, Implement, and Operate (CDIO) community also played a key role in innovating novel approaches to incorporate sustainability into higher education curricula, Miñano-Rubio et al. (2016) provided a comprehensive methodology to integrate sustainability in CDIO projects. Malmqvist et al. (2019) discussed development ideas for the CDIO standards and suggested optional standards, one of them is related to sustainability. Cheah et al. (2022) discussed how to best deliver education for sustainable development for transformational learning.

In alignment with the international UN objectives for education for sustainable development (UNESCO Representation in Brazil, 2017) as well as the requirements of the country-specific vision (New Kuwait 2035), and as a first step towards the development of pedagogical strategies in Kuwait's engineering higher education institutions to graduate engineers who are assets for the achievement of the worldwide sustainable development goals, this paper investigates the inclusion of sustainability concepts in Kuwait's higher education engineering curricula. Whereas its first part presents the survey questionnaire and methodology used to collect data, its second part provides the survey results, and its last part discusses the major outcomes and conclusions drawn from the data analysis. This is aligned with CDIO standard 12 which highlights the importance of reviewing engineering programs to take decisions about a program and its plans for continuous improvement.

SURVEY QUESTIONNAIRE

To assess sustainability inclusion in engineering curricula in Kuwait, a questionnaire was developed and adapted from the Sustainability Assessment Questionnaire for Colleges and Universities designed by the Association of University Leaders for a Sustainable Future (AULSF, 2009). This reference questionnaire was tailored and shortened to fit the context of Kuwait and the particularity of its Higher Education Institutions (HEIs) while keeping the focus on the inclusion of sustainability in engineering curricula.

The developed questionnaire underwent two stages of review before being publicly published. In the first stage, an initial draft was validated by three subject matter experts who provided relevant and constructive feedback. Some comments were related to the length and clarity of the questionnaire which were addressed by combining questions and easing online navigation. It was also suggested to include discipline specific examples from the Middle East and North Africa (MENA) region. The second review stage consisted of a pilot study to ensure the validity and readability of the questionnaire. The questionnaire was shared online with 12 faculty members from various universities in Kuwait. Whereas most of the participants were excited about the topic and assured us of the clarity of questions, the majority had concerns regarding revealing the name of their institution. Accordingly, it was decided to remove the question related to the name of the institution to assure the participants about the anonymity of their responses.

The final version of the questionnaire included five sections. The first section introduces the participants to the subject and confirms the anonymity of the questionnaire. The second section included an explanatory video to introduce the participants to the research topic using a visually aided method which is usually more preferred than explanatory texts. Section 3 aims to collect demographic data such as age, gender, position, and whether the participant is involved in teaching an engineering program or not. All questions in section 3 were multiple choice questions where the user selects one choice.

Section 4 of the final questionnaire consists of 14 questions aimed at recording perceptions towards the current level of integration between sustainability concepts and the participant's institution's curricula. It assesses multiple dimensions including (1) the currently offered engineering curriculum in the participant's educational institution, (2) research and scholarships, operations, (3) faculty, staff development, and rewards, and (4) administration, mission and planning. Section 4 questions were of different types including multiple choice, checkboxes, short and long answer open-ended questions, and scale-based questions. Finally, section 5 included only one open ended question and aims at collecting general

feedback about the participant's perceptions related to Sustainability in Kuwait's Higher Education Institutions' Curricula.

The questionnaire was shared using multiple direct and indirect, formal and informal channels. Many responses were collected on multiple occasions such as conferences, academia gatherings, and social media. Meetings with random faculty members from various universities in Kuwait were conducted on several occasions to explain the survey objectives and motivate them to fill in the survey objectively with the main aim of increasing the response rate and ensuring most public and private universities in Kuwait are represented in the responses. In addition, official letters and emails were sent to Public and Private Universities in Kuwait through their official channels requesting to disseminate the questionnaire to all educational institutions and colleges offering one or more engineering program. Moreover, for quick access, a quick response (QR) code was generated for easy sharing.

SURVEY RESULTS AND ANALYSIS

The population under investigation in this research is the set of all faculty employed in private and public Kuwaiti higher education institutions which yields to a population of around 2950 persons. This estimated number was obtained from counting the faculty members listed on the various universities' websites and other secondary resources. Considering the extensive and diverse nature of this population, a simple random sampling method was deemed most suitable for the research design, as it enables the random selection of individuals possessing pertinent attributes that are crucial to achieving the study's objectives. The best sample size is estimated accordingly based on the population size and confidence level selected. Considering a margin of error of 10%, the minimum sample size required from the targeted population is 94.

As with any survey, this study may be subject to limitations such as response bias, insufficient depth in capturing attitudes, and variations in cultural and contextual perspectives. However, these challenges were mitigated through the careful design of the questionnaire and the involvement of academics from diverse cultural backgrounds, disciplines, and universities.

Data collection was open for a period of four months starting from October 2023 through January 2024 which yielded a collection of 106 responses. Numerical data collected was analyzed using Google Forms® and Microsoft Excel®. Open ended questions were analyzed using the qualitative data software NVivo®. Within the context of this paper which focuses on analyzing the inclusion of sustainability in engineering curricula in Kuwait, the results of only section 3 (demographics) and seven out of the 14 questions of section 4 are presented and discussed. The selected questions are listed in the Appendix.

Demographic Results

The results of section 3 of the survey show that most of the respondents are from the age category 20 to 29 (34%) followed by the category 40 to 49 (31.1%) then the category 30 to 39 (26.4%) and the least are above 50 years (8.5%). Gender wise, the majority are male participants with 72.6% while 27.4% are females. Moreover, 98.1% of the participants are academics who are involved in teaching/delivering courses from an engineering program curriculum. The previous figures are compatible with the demographics of the overall faculty members' population in Kuwait which includes master's and PhD holders. Being mostly faculty members involved in teaching engineering programs (98.1%) provides validation for the participants' responses to the questions of sections 4 and 5 of the survey.

Sustainability in Kuwait's HEI's Engineering Curricula

The first question of section 4 of the survey asks respondents to indicate the extent to which their institution offers courses which address topics related to sustainability. Almost 37.7% of the participants expressed that the offering of sustainability related courses is of great deal at their institutions, 36.8% revealed that their institutions offer a little sustainability within their courses and 19.8% ranked their institution as offering quite a bit of sustainability topics within its courses. The rest were not sure about whether sustainability is offered or expressed that sustainability is not covered at all. Figure 1 shows the distribution of responses.

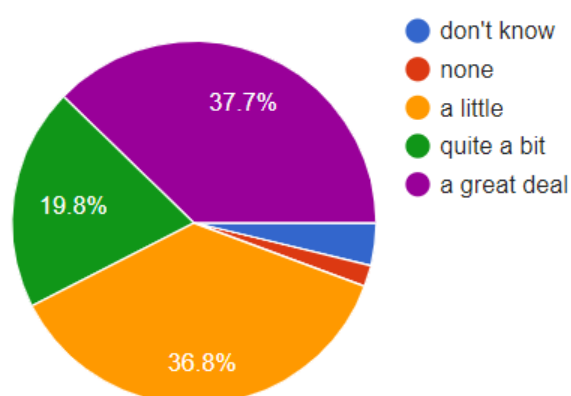


Figure 1. Distribution of responses to the question: Indicate the extent to which your institution offers courses related to sustainability.

An open-ended follow-up question asked participants to fill in the name and code of the courses(s) in which sustainability topics are taught in their institution. Figure 2 shows the occurrence percentage of course titles out of 78 total extracted words. Analyzing the answers shows that most of the mentioned courses are “supporting courses” (e.g., general engineering, graduation projects, etc.) (38.46%), “ethics” (25.64%), and “environment” (19.23%). Moreover, going over the responses, most of the responses mention one course. On the other hand, the course codes provided were of different encoding which validates that the survey data represents various universities in Kuwait.

Another open-ended follow-up question asked the participants: “What courses do you believe are essential to educate about sustainability and are not being taught in your institution?”. Figure 3 shows the recurrent words’ percentage out of 110 extracted words. Interestingly, courses which are considered as fundamental to sustainable development such as “sustainability”, “energy”, and “renewable” acquired the highest occurrence percentages which indicate a lack of fundamental sustainability concepts in the participants’ engineering curricula.

It is here worth mentioning that Figure 2 and Figure 3 present the results of two inverse questions (sustainability related courses taught vs. not taught in the participant’s institution). Whereas the first question (courses taught) led to 78 extracted words, the second one led to more extracted words (110 words) which indicate that participants are more aware of sustainability related courses not taught in their institution compared to those taught. Moreover, the occurrence of words in these two figures are reversed in the sense that words with the highest occurrence percentage in one figure appear in the lower range in the other one and vice-versa (e.g. “sustainability” occurred $38.46\% \times 110 = 42$ times in the list of courses not taught in the institution versus $3.85\% \times 78 = 3$ times in the list of courses taught in the institution). This provides a validation for the results.

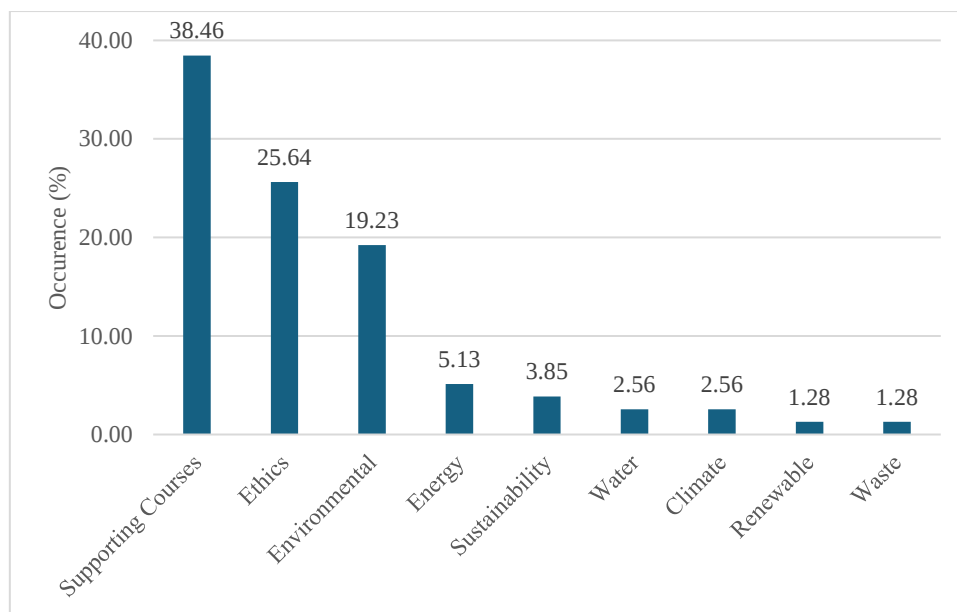


Figure 2. Occurrence of course titles in responses to the question: List any courses you are aware of in which sustainability related topics are taught in your institution

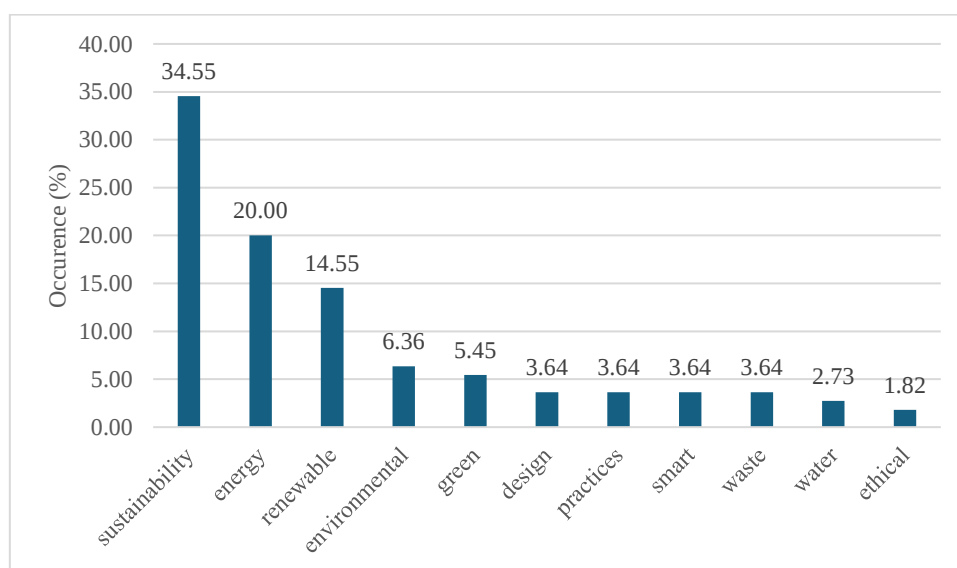


Figure 3. Occurrence of stated courses in responses to the question: What courses do you believe are essential to educate about sustainability and are not being taught in your institution?

One additional question in Section 4 asked the participants: “Do you believe undergraduates are required to take a course(s) on issues related to the environment or sustainability?”. Participants almost unanimously (98.1%) responded with a “yes” to this question. This question was followed by the following open-ended question: “Justify your response to the previous question and please explain why you believe undergraduates are or are not required to take a course(s) on issues related to the environment or sustainability?”. Table 1 shows the recurrent words’ frequency and their percentages in the answers to this question after analyzing them. The answers were mostly within the context of “Important” (32.9%), “Knowledge” (21.1%), “Future” (12.3%), “Environment” (10.5%), and “Issues” (10.1%).

Looking at the results of the five questions discussed above, one may conclude that engineering faculty members who participated in the survey believe almost unanimously that students must be exposed to courses related to the environment or sustainability due to their importance to the future, environment, and the world in general. As for the engineering curricula they deliver, the participants revealed that there are some sustainability topics being covered mostly as part of introductory courses or graduation projects; however, sustainability is not incorporated across the whole curriculum since most participants mentioned none, one, or at most two courses. Moreover, it is evident that some curricula are still not incorporating fundamental discipline-based sustainability courses such as renewable and green energy.

Table 1. Occurrence of stated reasons in responses to the question: Justify your response to the previous question and please explain why you believe undergraduates are or are not required to take a course(s) on issues related to the environment or sustainability?

Word	Count	Occurrence Percentage (%)	Similar words
Important	75	32.89	demand, need, required, requirement, requirements, requiring, mandatory, basic, crucial, essential, importance, important
Knowledge	48	21.05	know, knowledge, learn, learning, aware, awareness, understand, understanding, study, take, taking, teaching
Future	28	12.28	future
Environmental	24	10.53	environmental, environmentally, environment
Issues	23	10.09	issues, problem, problems
World	16	7.02	global, globally, human, humanities, world, worldwide
Practices	14	6.14	practices, practicing, skills, use, used, using
Sum	228	100.00	

Established Structures Related to Sustainability

One question of Section 4 in the survey enquired whether the participant's institution established multidisciplinary and interdisciplinary structures (such as an institute or center) for research, education, and policy development on sustainability issues. Most participants (62.3%) declared that their institution has such structures, while 22.6% mentioned that such structures haven't been established yet and 15.1% were unaware whether such structures exist in their institution or not.

A follow-up open-ended question asked the participants to elaborate more about the established structures (for research, education, and policy development on sustainability issues) in their institution. 63.2% of participants who answered "yes" to the previous question described the established structure in its second part. Most answers were related to support and collaboration (45.10%), funds (29.41%), and seminars, conferences and workshops (19.61%). Table 2 shows the words' frequency and their occurrence percentages in the answers for this question. Interestingly, there is no significant indications about well-established structures or centers that governs the implementation of sustainability concepts in the Kuwaiti HEIs and most of the answers are related to indirect support through

encouragements, funds, seminars, conferences, etc. With the absence of such structures, the incorporation of sustainability in the curricula would remain at a low scale, uncontrolled, unassessed, and non-monitored which limits its development pace and potential to match the national and international standards of education for sustainable development.

Table 2. Occurrence of stated structures in responses to the question: Please explain by describing the institute or center that was established by your institution for research, education and policy development on sustainability issues

Word	Count	Occurrence Percentage (%)	Similar words
Support & Collaboration	23	45.10	collaborates, collaborating, collaboration, assist, encourages, help, support, supports, serves
Funds	15	29.41	funding, funds, support, supports
Seminars/ Conferences	10	19.61	seminars, conferences, courses, forms, webpage, documents, reports
Planning	3	5.88	planning, programs, projects
Sum	51	100.00	

CONCLUSION

In this paper, the critical role of engineering higher education institutions in Kuwait in advancing sustainability to serve the Country's National Development Plan (2035 Vision) is investigated. The findings reveal that while sustainability concepts are present in the engineering curricula of the faculty members who participated in the study, they are often fragmented and lack a cohesive framework for integration and assessment. Faculty members recognize the importance of incorporating sustainability into engineering education and have made efforts to introduce these principles through various courses and extracurricular activities. However, significant challenges remain, including a lack of internal structures or centers governing a comprehensive sustainability education.

To enhance the effectiveness of sustainability integration in engineering curricula, it is essential for Kuwait's higher education institutions to develop a clear and unified framework that outlines the delivery and assessment of sustainability concepts across all programs. This would not only equip future engineers with the necessary skills to address global challenges but also align educational practices with the United Nations Sustainable Development Goals. Moving forward, collaborative efforts among faculty, curriculum developers, and policymakers will be crucial in fostering an educational environment that prioritizes sustainability, ultimately contributing to a more sustainable future for Kuwait and beyond.

Among other approaches to incorporate sustainability in engineering curricula, a Conceive, Design, Implement, and Operate (CDIO) program is certainly a strong option. A CDIO program ensures engineering students pass through all stages of product development and in turn, when properly implemented, helps students develop a holistic understanding of the environmental, social, and economic impacts of engineering solutions. This is particularly emphasized in CDIO standards 1, 2, 3, 5, and 11 focusing on sustainability inclusion in each of the conceive, design, implement, and operate stages; active, integrated and student-centered learning which are essential in an education for sustainable development; as well as the importance of continuously assessing sustainability related students' knowledge, competencies, and skills to promote sustainability attitudes in engineering students.

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REFERENCES

- Association of University Leaders for a Sustainable Future (AULSF). (2009). *Sustainability assessment questionnaire (SAQ) for colleges and universities*. Retrieved from <https://ulsf.org/wp-content/uploads/2015/06/SAQforHigherEd09.pdf>
- Biermann, F., Kanie, N., & Kim, R. E. (2017). Global governance by goal-setting: The novel approach of the UN Sustainable Development Goals. *Current Opinion in Environmental Sustainability*, 26, 26-31.
- Bjornberg, K. E., & Skogh, I. (2015). Integrating social sustainability in engineering education at the KTH Royal Institute of Technology. *International Journal of Sustainability in Higher Education*, 16(5), 639–649.
- Byrne, E., Desha, C., Fitzpatrick, J., & Hargroves, K. (2013). Exploring sustainability themes in engineering accreditation and curricula. *International Journal of Sustainability in Higher Education*, 14(4), 384–403.
- Cheah, S.-M., Lim, L. Y., & Chao, Y. C. (2022). *CDIO for Education for Sustainable Development Using Common Core Curriculum*. Proceedings of the 18th International CDIO Conference, Reykjavik University, Reykjavik, Iceland, June 13-15, 2022.
- Colombo, C. R., & Alves, A. C. (2017). Sustainability in engineering programs in a Portuguese public university. *Journal of Production*, 27.
- General Secretariat of the Supreme Council for Planning and Development of Kuwait. (2020). *Kuwait National Development Plan*. Retrieved from <http://www.newkuwait.gov.kw/plan.aspx>
- Johan Malmqvist, Maria Knutson Wedel, Ulrika Lundqvist, Kristina Edström, Anders Rosén, Thomas Fruergaard Astrup, Martin Vigild, Peter Munkebo Hussman, Audum Grom, Reidar Lyng, Svante Gunnarsson, Helene Leong and Aldert Kamp. *Towards CDIO Standards 3.0*. Proceedings of the 15th International CDIO Conference, Aarhus, Denmark, June 25-27, 2019.
- Kanie, N., Bernstein, S., Biermann, F., & Haas, P. M. (2017). Introduction: Global governance through goal setting. In *Governing through goals: Sustainable development goals as governance innovation* (pp. 1-28). MIT Press.
- Miñano-Rubio, R., Moreno Romero, A., Lumbreras, J., Uruburu, Á., Carrasco-Gallego, R., & Borge, R. (2016). *Designing a Comprehensive Methodology to Integrate Sustainability Issues in CDIO Projects*. Proceedings of the 12th International CDIO Conference Turku, Finland, June 12-16, 2016.
- Ministry of Foreign Affairs, State of Kuwait. (n.d.). *Kuwait Vision 2035 New Kuwait*. Retrieved from <https://www.mofa.gov.kw/en/pages/kuwait-vision-2035>
- Quelhas, O. L. G., Lima, G. B. A., Ludolf, N. V. E., Meiriño, M. J., Abreu, C., Anholon, R., Neto, J. V., & Rodrigues, L. S. G. (2019). Engineering education and the development of competencies for sustainability. *International Journal of Sustainability in Higher Education*, 20(4), 614-629.
- Rose, G., Ryan, K., & Desha, C. (2015). Implementing a holistic process for embedding sustainability: A case study in first-year engineering, Monash University, Australia. *Journal of Cleaner Production*, 106, 229–238.
- UNESCO Representation in Brazil. (2017). *Education for Sustainable Development: Learning Objectives*. Retrieved from <http://unesdoc.unesco.org/images/0024/002474/247444e.pdf>
- United Nations. (2015, September 25). *Transforming our world: The 2030 Agenda for Sustainable Development* [Resolution adopted by the General Assembly]. Retrieved from <https://sdgs.un.org/2030agenda>

BIOGRAPHICAL INFORMATION

Hassan Salti is an Associate Professor and the Head of Electrical and Electronics Engineering Department at the College of Engineering of the Australian University, Kuwait. In addition to his technical engineering research interests, he is currently involved in the restructuring of engineering curricula as well as internal and external audits and accreditations such as Engineers Australia and ABET. He is also member of the CDIO committee at the Australian University.

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APPENDIX – SURVEY QUESTIONS

Demographics

Q1. What is your age? – *20-29, 30-39, 40-49, Above 50.*

Q2. What is your gender? – *Female, Male.*

Q3. What is your position? – *Academic, Non-Academic*

Q4. Are you currently teaching or involved in an Engineering Curriculum? – *Yes, No.*

Assessing Sustainability in Kuwait's HEI's: Selected Questions

Q1.a. Indicate the extent to which your institution offers courses which address topics related to sustainability. (Such topics could include globalization and sustainable development; environmental policy and management; etc.) – *don't know, none, a little, quite a bit, a great deal.*

Q1.b. Please list any courses you are aware of in which such topics are taught in your institution. Please list the name of the course along with its code. Type N/A if not applicable.

Q2. What courses do you believe are essential to educate about sustainability and are NOT being taught in your institution?

Q3a. Do you believe undergraduates are required to take a course(s) on issues related to the environment or sustainability? – *Yes, No.*

Q3b. Justify your response to the previous question and please explain why do you believe undergraduates are or are not required to take a course(s) on issues related to the environment or sustainability?

Q4.a. Have your institution established multidisciplinary and interdisciplinary structures (such as an institute or center) for research, education and policy development on sustainability issues? – *Yes, No, Don't know.*

Q4.b. If your answer to the previous question is YES, please explain by describing the institute or center. If your answer is NO, type N/A for not applicable.