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Perceptions of Higher Education Instructors on Education for Sustainable Development towards STEM Education in UAE

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Abstract This study aims to investigate the perceptions of higher education instructors in universities across the United Arab Emirates (UAE) regarding education for sustainable development (ESD) within science, technology, engineering, and mathematics (STEM) education. It focuses on three key constructs: knowledge, skills, and attitudes. Several independent variables were also considered, including gender, educational program, educational level, years of service, and the institution's location. The study adopted a descriptive approach and gathered data through a cross-sectional survey. A cohort of 200 participants took part in an e-education survey that focused on ESD knowledge, skills, and attitudes towards STEM education. We employed various analytical methods, including descriptive analyses, analyses of variance, and t-tests. The study revealed that instructors across STEM education showed high attitudes towards ESD, particularly in terms ofn-STEM instructors had lower perceptions and highlighted students' ESD knowledge deficiencies. Skills and knowledge. HEI instructors had similar perceptions, while male instructors exhibited greater understanding compared to females. Non-STEM instructors had lower perceptions and highlighted student deficiencies in ESD knowledge. Engineering instructors emphasized mathematical thinking for sustainable development. Experience played a role, with veteran instructors advocating for national prioritization of STEM and ESD integration.

Keywords: Higher Education Instructors, STEM education, ESD, Sustainability

INTRODUCTION

Human activities significantly influence contemporary ecological changes, impacting both present and future welfare as well as social and economic stability (Carroll, 2020). This interaction between humans and the environment forms a complex system, presenting challenges for achieving sustainability (Leicht, Heiss, and Byun, 2018). Education plays a pivotal role in addressing these challenges, equipping the younger generation with the necessary skills to tackle socio-economic issues (Howells, 2018). Education for Sustainable Development (ESD) emerges as a crucial tool in this endeavour, aiming to foster changes in attitude, knowledge, skills, and values, thereby promoting a more sustainable society for all (Kioupi and Voulvoulis, 2019).

ESD addresses current and future environmental challenges through an integrated approach to economic, environmental, and social dimensions (Kanie and Biermann, 2017). It encompasses learning content, outcomes, the learning environment, and pedagogy (Leicht, Heiss, and Byun, 2018). ESD enables students to comprehend changes, anticipate the future, and collaborate on solving present and future societal issues (Bellanca, 2010; Trilling and Fadel, 2009), advocating for a multidisciplinary approach to address interconnected sustainability challenges (Shaohong et al., 2015). To use ESD effectively, we need to move towards learner-centered approaches and multidisciplinary frameworks (UNESCO, 2020; Parry and Metzger, 2023) and get everyone involved in promoting sustainability (Brusca, Labrador, and Larran, 2018).

Educational institutions, particularly in higher education, have gradually integrated sustainable development, which is crucial for societal transformation (Barth and Rieckmann, 2012; Ferrer-Balas, Buckland, and de Mingo, 2009). Universities play a crucial role in adopting a systemic approach to address societal challenges and influence policymakers (Paletta et al., 2019). Higher education also plays disciplinary and interdisciplinary roles in resolving social and environmental problems encountered by graduates (Barth and Timm, 2011). The significance of education for sustainable development spans across tertiary, primary, and secondary education, offering distinct contributions by preparing teachers and training students to adopt sustainable attitudes and practices (Vladimirova and Le Blanc, 2015; Badea et al., 2020).

In global educational policy and reforms, STEM education for sustainable development is prominent, emphasising the combination of science and mathematics expertise with technology and engineering (Chesky and Wolfmeyer, 2015). This multidisciplinary approach fosters self-direction, problem-solving, teamwork, and project management skills (Stehle and Peters-Burton, 2019), promoting creativity by addressing real-world issues through innovative solutions (Gomez and Albrecht, 2013; Margot and Kettler, 2019). STEM education equips students to address sustainability problems like environmental pollution and resource depletion, fostering innovation and responsibility (Nguyen and Tran, 2020; Tanenbaum, 2016).

Therefore, we propose the following research questions to explore higher education instructors' perspectives on sustainable development and STEM education in UAE universities:

1. What are the higher education instructors' perceptions of education for sustainable development and towards STEM education in UAE universities?
2. Are there any demographic disparities between higher education instructors' perceptions of education for sustainable development and STEM education in UAE universities?

It is crucial to align educational objectives with the thematic intentions of sustainable development (SD) and education for sustainable development (ESD), emphasising a focus on student competencies (Nan-Zhao, 2005; Delors, 2001). UNESCO's four pillars of Education for the Twenty-First Century underscore the importance of integrating ESD into educational practices, promoting learning to know, do, live, and be (UNESCO 2017). Sustainability competency, encompassing cognitive abilities, functional skills, and ethical principles applicable in real-world contexts, highlights the need for common frameworks and innovative teaching strategies (Stibbe 2009; Barth and Rieckmann 2016).

In higher education, there is a growing emphasis on STEM education to enhance the number and diversity of graduates, with academic practices playing a pivotal role in improving students' perceptions and skills in both ESD and STEM education (Borrego and Henderson 2014; Henderson et al. 2017).

This study is important because it looks at how higher education teachers in the UAE feel about combining ESD and STEM education. It directly answers research questions about the role of academia in developing students' knowledge, skills, and abilities in these areas (Al-Naqbi and Alshannag 2018). By focusing on instructors, who are instrumental in shaping educational practices and curriculum development, this study provides valuable insights into how these educators perceive and approach these critical educational paradigms. Additionally, by examining potential demographic differences among instructors, such as gender, educational background, and teaching experience, the research offers a nuanced understanding of how various factors may influence instructors' perceptions of ESD and STEM education.

Anderson's (1990) amended Bloom's Taxonomy guides the study, emphasising higher-order thinking skills. Educational learning styles recognise Knowledge, Skills, and Attitudes (KSA) as key domains (Maqsood et al., 2003). ESD promotes critical thinking, collaboration, and problem-solving (Tilbury & Wortman, 2004). STEM education emphasises innovation and problem-solving (Cooper & Heaverlo, 2013). The study's conceptual framework highlights three main domains: knowledge, skills, and attitude (KSA), integrating critical thinking, creativity, and collaboration (Braus and Wood, 1993; Markusen, 2006; Wu et al., 2019). Effective teaching fosters innovative and creative approaches (Kirschner, 2001; Scager et al., 2016).

The 2030 Agenda for Sustainable Development and UAE Higher Education Institutions' Contribution to a Sustainable World

Higher education institutions globally play a pivotal role in advancing sustainability efforts (Corcoran, Walker & Wals, 2004; Bizerril et al., 2018). Since the Talloires declaration in 1990, universities have increasingly integrated sustainability principles into their curriculum and campus practices (UNESCO, 2020). They educate future professionals on sustainability issues, fostering a mindset crucial for addressing global challenges (Kassel, Rimanoczy & Mitchell, 2016). Concepts like "systems thinking" are emphasised to understand sustainability's multidimensional nature (UNESCAP, 2015).

In the UAE, aligning with global sustainability agendas is paramount to achieving national development objectives (UAE Vision 2021; UAE Centennial Vision 2071; Wyman, 2019). The UAE has committed to the UN's Sustainable Development Goals (SDGs) and established a National Committee to implement them (NCSDG 2017).

Youth empowerment initiatives and partnerships with various sectors drive sustainable development efforts, as demonstrated by Expo 2020 (Karolak, 2021; Expo 2020 Dubai Sustainably Report 2020).

To effectively contribute to sustainability, higher education institutions must incorporate it into core courses and employ participatory learning methods (Figueiró & Raufflet, 2015; Mintz & Tal, 2013). Communication strategies tailored to different student demographics enhance effectiveness (Lertpratchya et al., 2017). Interdisciplinary research and partnerships are essential for addressing sustainability challenges comprehensively (Annan-Diab & Molinari, 2017). Therefore, the collaboration between the 2030 Agenda for Sustainable Development and UAE higher education institutions signifies a significant step towards achieving a more sustainable world, both locally and globally.

STEM Education and Sustainable Development: Bridging the Gap for a Sustainable Future

In recent years, the intersection of STEM (science, technology, engineering, and mathematics) education and sustainable development has gained increasing attention in school and university settings (DeCoito, 2015). This emphasis stems from recognising STEM education as foundational for promoting sustainable development by equipping future generations with essential skills (Pahnke, O'Donnell, and Bascopé, 2019). With global leaders committing to achieving the Sustainable Development Goals (SDGs) by 2030, the urgency to address sustainability challenges grows daily (UNESCO, 2018). People view STEM education as crucial for addressing these challenges and equipping individuals for a world that is changing rapidly (Khadri, 2022).

At the heart of this discourse lies the need for STEM education to evolve towards a more future-oriented and sustainability-focused approach (Schratz and Symeonidis, 2018). This includes integrating sustainability principles into the curriculum and adopting innovative teaching methodologies that foster interdisciplinary learning (Del Cerro Velazquez and Lozano Rivas, 2020). Additionally, educators must cultivate anticipatory competencies in students, enabling them to envision and create sustainable futures (Del Cerro Velazquez and Lozano Rivas, 2020).

The integration of sustainability into STEM education extends beyond theoretical knowledge to practical application and societal engagement (Dotson et al., 2020). Institutions of higher education play a pivotal role in this process, serving as catalysts for social change and sustainable development (Shepherd, 2015). However, this transformation requires a shift in educational paradigms towards holistic, values-driven, and locally relevant approaches (Winter, Sterling, and Cotton, 2015). It necessitates changes not only in curriculum content, but also in teaching methods and assessment practices (Leifler and Dahlin, 2020).

Efforts to integrate sustainability into STEM education face challenges, including the need for interdisciplinary collaboration and the adaptation of teaching practices (Redman, 2013). Nevertheless, there is a growing recognition of the potential of STEM fields to contribute to sustainable development through innovation and problem-solving (Gamage, Ekanayake, and Dehideniya, 2022). Higher education institutions have a responsibility to lead this transition by equipping students with the knowledge, skills, and mindset needed to address sustainability challenges (Zizka, McGunagle, and Clark, 2019).

Therefore, STEM disciplines play a crucial role in addressing global sustainability concerns, strengthening the intricate link between STEM education and sustainable development (Hamilton and Pfaff, 2014). By embracing a more holistic and future-oriented approach to education, institutions can empower students to become agents of change and contribute to a more sustainable world (Franco et al., 2019). Through collaborative efforts and innovative pedagogies, STEM education can bridge the gap between theory and practice, paving the way for a sustainable future for all.

2. MATERIALS AND METHODS

The study employed a descriptive methodology, utilising a cross-sectional survey to collect data from a predetermined population at a single point in time. We collected the perception of Higher Education Institutions (HEIs) instructors in the UAE using a developed Attitude, Knowledge, and Application (AKA) questionnaire (Wahono & Chang, 2019), which included items guided by the STEM Education Quality Framework (STEM, 2011). The instructors' questionnaire, known as the Knowledge, Skills, and Attitude Questionnaire (KSAQ), aimed to gather data on the instructors' knowledge, skills, and attitudes (KSA) regarding sustainable development (SD) and education for sustainable development (ESD) in STEM education. The questionnaire comprised three parts, each meticulously crafted to ensure coherence with the study's core aspects.

The first part of the questionnaire, labeled "closed-form items," collected demographic information about the instructors, including gender, the program they teach, their education level, total years of teaching experience, and the location of their institutions.

The second section of the questionnaire for HEI instructors encompassed three domains, consisting of thirty-eight questions covering STEM Knowledge (SK), STEM Skill (SS), STEM Attitude (SA), and Education for Sustainable Development Attitude (ESDA). We further divided STEM skills into subdomains, which included Science-Engineering (SS-SE), Science-Mathematics (SS-SM), Science-Technology (SS-ST), Science-Technology-Mathematics (SS-STM), Science-Technology-Engineering (SS-STE), Science-Engineering-Mathematics (SS-SEM), and Science-Technology-Engineering-Mathematics (SS-STEM). We used a five-point Likert scale to assess HEIs instructors' perceptions of education for sustainable development towards STEM education (5 = strongly agree, 4 = agree, 3 = neutral (neither agree nor disagree), 2 = disagree, and 1 = strongly disagree).

We distributed an e-questionnaire link to nine different institutions across the seven emirates of the UAE. It targeted HEIs instructors responsible for teaching general science, technology, engineering, and mathematics courses. The convenience sample for this study comprised a total of 200 instructors.

We conducted inferential statistics, specifically a one-sample t-test, using SPSS version 23 to determine if there was a statistically significant difference between the sample mean and a known population mean of the knowledge, skills, and attitudes reported by HEIs instructors (Muijs, 2011). We analysed differences in demographic variables among HEIs instructors, including gender, emirate, educational programme, education level, and years of service, using t-tests and e-way A ANOVA. Additionally, we employed two-sample t-tests to assess differences between male and female HEI instructors, and used a one-way ANOVA to compare mean results among groups based on various factors such as emirate, educational programme, education level, and years of experience.

We used descriptive statistics to analyse quantitative data from HEI instructors' questionnaires, which provided information on frequency, mean, standard deviation, and percentages of responses (Johnson & Christensen 2014). This analysis aimed to describe, summarise, and make sense of the collected data.

The study's questionnaire is available for reference in the appendix at the end of the manuscript.

3. RESULTS AND DISCUSSION

Descriptive Analysis and Normality

Table (1) shows descriptive statistics for all observed items in instructors' questionnaire. Hair et al. (2019) and Bryman (2012) argued that data is considered to be normal if skewness is between -2 to +2 and kurtosis is between -7 to +7. In this study, the highest and lowest skewness values were -1.255 and 1.001, respectively, while the kurtosis values ranged between -0.681 and 4.028. Therefore, the skewness and kurtosis values met the normal distribution criteria and were useful parameters in all statistical analysis.

Table 1: Descriptive Statistics and Normality for HEIs Instructors' Questionnaire (N=200)

	Frequencies (%)					Descriptive Statistics				
Scale Item	**SD**	**D**	**N**	**A**	**SA**	**M**	**Md**	**Std.D**	**Sku**	**Kurt**
Overall	**(.10)**	**(1.49)**	**(15.59)**	**(64.12)**	**(18.69)**	**4.00**	**4.00**	**.535**	**-.391**	**1.085**
Knowledge	**9 (.22)**	**119 (2.97)**	**761 (18.99)**	**2464 (61.48)**	**655 (16.34)**	**3.91**	**4.00**	**.524**	**-.552**	**2.494**
K_01	1 (.20)	3 (.60)	29 (5.79)	341 (68.06)	127 (25.35)	4.18	4.00	.568	-.458	2.506
K_02	1 (.20)	61 (12.18)	113 (22.55)	280 (55.89)	46 (9.18)	3.62	4.00	.823	-.594	-.126
K_03	2 (.40)	31 (6.19)	166 (33.13)	261 (52.10)	41 (8.18)	3.61	4.00	.741	-.399	.233
K_04	1 (.20)	4 (.80)	114 (22.75)	316 (63.07)	66 (13.17)	3.88	4.00	.629	-.292	.741
K_05	1 (.20)	4 (.80)	83 (16.57)	307 (61.28)	106 (21.16)	4.02	4.00	.654	-.369	.729
K_06	1 (.20)	5 (1.00)	84 (16.77)	326 (65.07)	85 (16.97)	3.98	4.00	.629	-.418	1.181
K_07	1 (.20)	6 (1.20)	76 (15.17)	322 (64.27)	96 (19.16)	4.01	4.00	.640	-.468	1.214
K_08	1 (.20)	5 (1.00)	96 (19.16)	311 (62.08)	88 (17.56)	3.96	4.00	.651	-.351	.746
Attitude	**4 (.10)**	**43 (1.07)**	**585 (14.60)**	**2591 (64.65)**	**785 (19.59)**	**4.03**	**4.00**	**.580**	**-.302**	**.889**
A_09	-	9 (1.80)	84 (16.77)	317 (63.27)	91 (18.16)	3.98	4.00	.649	-.375	.558
A_10	-	5 (1.00)	73 (14.57)	330 (65.87)	93 (18.56)	4.02	4.00	.610	-.276	.618
A_11	1 (.20)	4 (.80)	72 (14.37)	328 (65.47)	96 (19.16)	4.03	4.00	.621	-.420	1.309
A_12	1 (.20)	5 (1.00)	76 (15.17)	323 (64.47)	96 (19.16)	4.01	4.00	.634	-.437	1.193
A_13	1 (.20)	5 (1.00)	68 (13.57)	328 (65.47)	99 (19.76)	4.04	4.00	.625	-.469	1.420
A_14	1 (.20)	6 (1.20)	69 (13.77)	320 (63.87)	105 (20.96)	4.04	4.00	.642	-.493	1.266
A_15	-	5 (1.00)	72 (14.37)	324 (64.67)	100 (19.96)	4.04	4.00	.619	-.277	.509
A_16	-	4 (.80)	71 (14.17)	321 (64.07)	105 (20.96)	4.05	4.00	.617	-.237	.360
Skills	**1 (.02)**	**40 (.73)**	**763 (13.85)**	**3619 (65.67)**	**1088 (19.74)**	**4.04**	**4.00**	**.570**	**-.204**	**.680**
S_17	-	3 (.60)	69 (13.77)	322 (64.27)	107 (21.36)	4.06	4.00	.610	-.193	.275
S_18	-	4 (.80)	70 (13.97)	329 (65.67)	98 (19.56)	4.04	4.00	.605	-.235	.516
S_19	-	3 (.60)	65 (12.97)	330 (65.87)	103 (20.56)	4.06	4.00	.597	-.191	.446
S_20	-	5 (1.00)	65 (12.97)	330 (65.87)	101 (20.16)	4.05	4.00	.608	-.294	.690
S_21	-	5 (1.00)	74 (14.77)	321 (64.07)	101 (20.16)	4.03	4.00	.624	-.272	.437
S_22	-	3 (.60)	70 (13.97)	331 (66.07)	97 (19.36)	4.04	4.00	.597	-.184	.433
S_23	-	4 (.80)	72 (14.37)	330 (65.87)	95 (18.96)	4.03	4.00	.604	-.231	.521
S_24	-	3 (.60)	66 (13.17)	337 (67.27)	95 (18.96)	4.05	4.00	.586	-.186	.581
S_25	-	4 (.80)	69 (13.77)	329 (65.67)	99 (19.76)	4.04	4.00	.605	-.237	.524
S_26	-	3 (.60)	67 (13.37)	336 (67.07)	95 (18.96)	4.04	4.00	.588	-.186	.553
S_27	1 (.20)	3 (.60)	76 (15.17)	324 (64.67)	97 (19.36)	4.02	4.00	.622	-.366	1.102

Note: *SD=Strongly Disagree, D=Disagree, N= Neither agree nor disagree, A=Agree, SA=Strongly Agree, M=Mean, Md=Median, Std.D=Standard Deviation, Sku=Skewness, Kurt=Kurtosis*

Table (1) offers a comprehensive view of the frequencies and descriptive statistics within three distinct clusters: knowledge, attitude, and skills. In the knowledge cluster, the data demonstrated a strong consensus, with a high percentage of respondents agreeing with the statements, mirrored by a mean (M) of 4.22 and low standard deviation (Std.D). The attitude cluster likewise indicated an overwhelming agreement, with 72.50% of respondents strongly agreeing, substantiated by a mean (M) of 4.16 and low Std.D. The skills cluster presented a similar pattern of consensus, with 75.88% strongly agreeing, a mean (M) of 4.20, and a low Std.D. Notably, the skewness and kurtosis values for all clusters fell within the acceptable range, signifying distribution properties approximating normality. These findings underscore the robustness and reliability of the data within these domains, enhancing the credibility of the study's outcomes and ensuring that the data can be confidently employed in further analysis and interpretation.

Results of Demographic Data Analysis

Table 2: Demographic Summary of HEIs Instructors (N=200)

Demographic Variables	Frequency (%)
Gender	
Female	109 (54.5)
Male	91 (45.5)
Educational Program	
Computer Science	48 (24.0)
Engineering	81 (40.5)
General Science	34 (17.0)
Mathematics	21 (10.5)
Others	16 (8.0)
Educational Level	
Bachelor	7 (3.5)
Master	69 (34.5)
Doctorate	7 (3.5)
PhD	117 (58.5)
Years of Service	
Less than 2 years	10 (5.0)
2-5 years	30 (15.0)
5-10 years	45 (22.5)
10 years	46 (23.0)
More than 10 years	69 (34.5)
Institution's Location	
Abu Dhabi	17 (8.5)
Ajman	26 (13.0)
Dubai	46 (23.0)
Fujairah	31 (15.5)
Ras al Khaimah	22 (11.0)
Sharjah	52 (26.0)
Umm Al Quwain	6 (3.0)

Graphical Representation

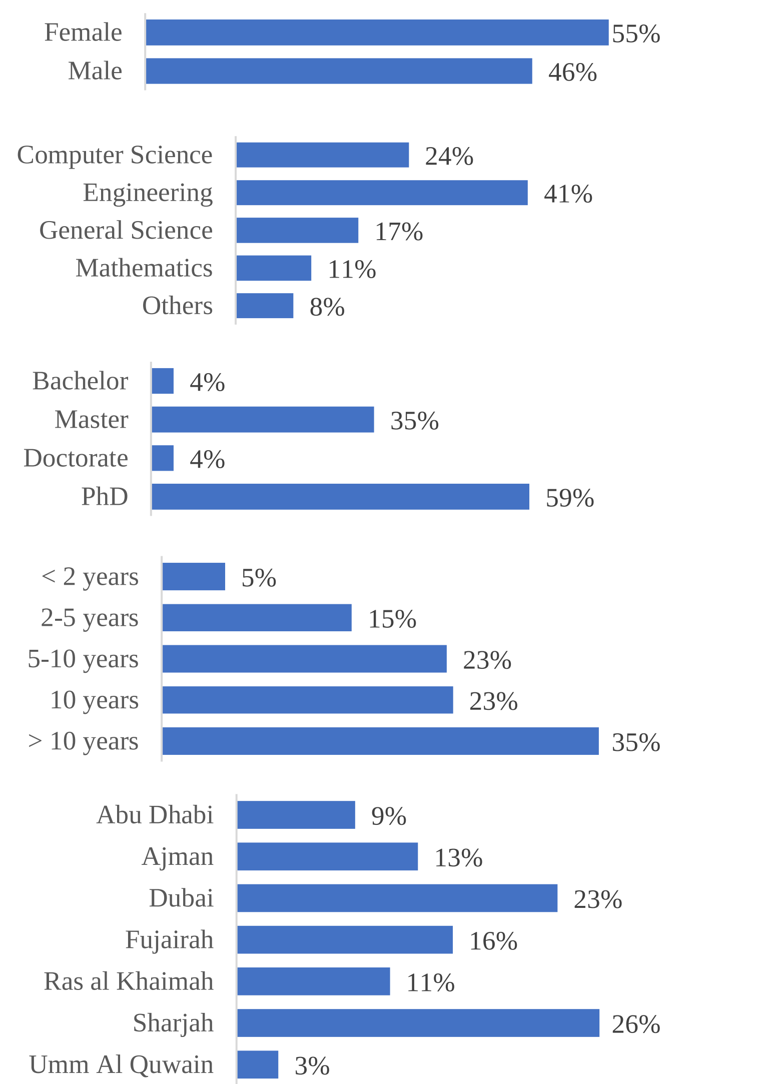

Table 2 presents the frequencies and percentages for the various demographic categories of the 200 participating instructors. The majority of participants were females, represented by 54.5%, while 45.5% were males. Engineering accounted for 40.5% of their educational program, followed by computer science at 24.0%, general science at 17.0%, and mathematics at 10.5%. The majority of participants (58.5%) were PhD holders, while 34.5% were master's holders. The majority (57.5%) had at least 10 years of experience. The largest proportion of instructors came from Sharjah (26.0%) and Dubai (23.0%).

Inferential Analysis

We conduct statistical tests in this section to measure how higher education instructors in the UAE perceive ESD's approach to STEM education. We also measure these perceptions across the various demographic categories of the participating instructors. We employ a one-sample t test to gauge the degree to which instructors' perceptions are accurate. We use an independent-samples t test to gauge the instructors' perceptions of both female and male groups. We use a one-way ANOVA to measure instructors' perceptions across groups of educational programmes, educational level, years of service, and the institution's location.

Instructors' Perceptions

We conducted a one-sample t test to determine whether there is a significant difference between the instructors' perceptions and the hypothesised mean (M = 4.00). We determined the hypothesised mean as an approximation of the grand mean (M = 4.09) for the total responses.

The results indicated a significant difference between the overall grand mean (M = 4.09, SD = 0.359) and the test value of 4.00 [t (199) = 3.465, p = 0.001]. The mean difference value of 0.088 suggests a significant difference between the overall grand mean and the hypothesised mean of 4.00, indicating a high level of agreement (R% = 81.76%). The knowledge test showed that the mean score (M = 3.78, SD = 0.493) was much lower than the expected mean of 4.00 [t (199) = -6.281, p < 0.001], with a mean difference of -0.219, which means that there was a moderately high level of agreement; R% = 75.62%. But the test showed that the attitude mean score (M = 4.21, SD = 0.431) was much higher than the expected mean score of 4.00 [t(199) = 6.967, p < 0.001], with a mean difference of 0.213, which means that there was a high level of agreement; R% = 84.25%. On the test, the skills mean score (M = 4.17, SD = 0.401) was much higher than the expected value of 4.00 [t (199) = 6.071, p < 0.001], and the mean difference was 0.172, which means there was a high level of agreement (R% = 83.44%).

Based on R%, we can conclude that attitude leads the scale, with the highest R% of 84.25%, followed by skills at 83.44%, and knowledge at 75.62%. The skills subscales had very similar R% values, ranging between 83.07% (for SS-SM) and 83.98% (for SS-SE), and their mean scores were significantly higher than the hypothesized value of 4.00, p < 0.001.

On the item level, knowledge items K_01 and K_09, all attitude items, and all skills items had a significantly higher mean score than the hypothesised value of 4.00, p < 0.01. Knowledge items K_02, K_03, K_04, K_06, K_07, and K_08 had mean scores significantly lower than the hypothesised value of 4.00, p < 0.001. On the other hand, there was no significant difference between the hypothesised value of 4.00 and the mean scores of K_05 and ST_28.

The results of the t-tests provide valuable insights into the perceptions of instructors regarding the three constructs. In the overall assessment, instructors exhibited a significant level of agreement, with the grand mean surpassing the hypothesised mean of 4.00 by a mean difference of 0.088, representing an impressive 81.76% relative agreement.

Delving deeper into the sub-scales, the results indicated substantial discrepancies. The 'Knowledge' sub-scale displayed a significant deviation from the hypothesised mean, with a mean difference of -0.219 and 75.62% relative agreement. This suggests a less favorable perception among instructors about their knowledge of the construct. Interestingly, when analysing individual items, it is found that components K_01 demonstrated the highest relative agreement (84.40%), while K_03 showed the lowest (67.20%), signifying the varying degrees of agreement within this sub-scale.

Conversely, the 'Attitude' sub-scale revealed a significantly more positive perception, with a mean difference of 0.213 and an impressive 84.25% relative agreement. The high level of agreement was consistent across all items within this sub-scale, indicating a consistently positive attitude towards the construct.

The 'Skills' sub-scale also demonstrated a significant positive deviation from the hypothesised mean, with a mean difference of 0.172 and an overall relative agreement of 83.44%. More research showed that the relative agreement percentages for the Skills sub-scales (SE, SM, ST, STM, STEM, and SEM) are very close to each other, ranging from 83.07% to 85.00%. This means that people have the same positive opinion about all of these sub-scales.

Furthermore, item-level analysis revealed that some items within the 'Knowledge' sub-scale had significantly lower agreement, particularly K_03, K_07, and K_08, suggesting specific areas for improvement. Conversely, all 'Attitude' and 'Skills' items exhibited a high level of agreement, emphasising the consistent positive perceptions across these items.

In summary, the findings suggest that instructors perceive the construct with varying degrees of favorability across different sub-scales, with 'Attitude' showing the highest agreement, followed by 'Skills,' and 'Knowledge.' Top of Form

The perceptions of instructors across different demographic groups are influenced by gender differences.

We conducted an independent-sample t test to determine if females and males' perceptions of education for sustainable development towards STEM education in the UAE significantly differ. The test indicated that there was no significant difference between females and males in their perceptions [t (198) = -1.372, p = 0.172]. However, there were significant gender differences in knowledge [t (198) = -2.877, p = 0.004], where males had higher mean scores (M = 3.89, SD = 0.451) than females (M = 3.69, SD = 0.510).

On the item level, males had significantly higher mean scores than females in K_02, K_03, K_04, K_07, and K_08, which are all measuring knowledge; p < 0.05. In addition, the mean score for ST_28 was significantly higher in the males' group than the females' [t (198) = -1.996, p = 0.047].

Instructors' Perceptions According to the Educational Programme Differences

We conducted a one-way ANOVA to determine the effect of educational programmes (computer science, engineering, general science, mathematics, and others) on instructors' perceptions. The results of the test of homogeneity of variances (Levene's test) indicate that when the significance values of the Levene's test statistic fall below 0.05, we report the Walch statistic instead of F. Overall, the one-way ANOVA results showed no statistically significant difference in instructors' perceptions between educational programme groups (F F (4, 195) = 2.116, p = 0.080 > 05). We conducted a one-way ANOVA to assess the impact of different educational programs (computer science, engineering, general science, mathematics, and others) on instructors' perceptions, and found no statistically significant difference among these program groups. The F (4, 195) statistic yielded a value of 2.116 with a corresponding p-value of 0.080, which is greater than the typical significance level of 0.05. Consequently, we cannot reject the null hypothesis, which posits no significant differences in instructors' perceptions based on the chosen educational programme. These findings suggest that the type of educational programme the instructors have undergone does not significantly influence their perceptions, as the p-value does not provide sufficient evidence to support this claim. However, at the main scale level, there is a statistically significant difference in instructors' knowledge between educational program groups: W (4, 59.642) = 3.805, p = 0.008 < 0.01. According to post-hoc multiple comparison analysis, instructors with other educational programs had a significantly lower mean score than those in computer science, engineering, and general science educational ograms (p < p <). We found no statistically significant difference in the attitudes and skills of instructors across educational programme groups (p > 0.05).

At the item level, there was a statistically significant difference between educational program groups in K_02, K_03, K_04, and K_07, which measure knowledge, p < 0.05. SM_23 showed a statistically significant difference between educational programme groups in skills, with a p-value of less than 0.05.

Instructors' Perceptions According to the Years of Service Differences

We conducted a one-way ANOVA to determine the effect of years of service (less than 2 years, 2–5 years, 5–10 years, 10 years, and more than 10 years) on instructors' perceptions. Overall, the result of the one-way ANOVA shows that there is no statistically significant difference in instructors' perceptions between years of service groups (F (4, 195) = 2.203, p = 0.070 > 0.05). However, on the main scale level, there is a statistically significant difference in instructors' attitudes between years of service groups: W (4, 50.383) = 3.386, p = 0.016 < 0.05. Post-hoc multiple comparison tests reveal that instructors with more than 10 years of experience have significantly higher mean scores for attitude than instructors with 10 years of experience (p = 0.023).

Instructors' Perceptions of the Institution's Location Differences

We conducted a one-way ANOVA to investigate the impact of the location of HE Institutions (Abu Dhabi, Ajman, Dubai, Fujairah, Ras al Khaimah, Sharjah, and Umm al Quwain) on the instructors' perceptions of ESD towards STEM education. Overall, the result of the one-way ANOVA shows that there is no statistically significant difference in instructors' perceptions between institution locations (F (6, 193) = 1.382, p = 0.224 > 0.05). Furthermore, on the main scale level, i.e., knowledge, attitude, and skills, there is no statistically significant difference in instructors' perceptions between institution locations. At the item level, there is a statistically significant difference in K_05 and A_14 between institution locations (p < 0.05). The post hoc multiple comparisons analysis reveals that instructors in Abu Dhabi and Dubai have a higher mean score of K_05 than instructors in Ajman (p < 0.05).

4. CONCLUSION

Based on the extensive investigation of instructors' perceptions regarding Education for Sustainable Development (ESD) and STEM education in UAE higher education institutions (HEIs), several significant insights have emerged. These insights provide a comprehensive understanding of the current landscape and offer valuable implications for educational practices and policies.

Firstly, instructors across different demographic groups, including gender, educational programmes, years of service, and institution locations, exhibit a generally positive attitude towards the integration of ESD and STEM education. This positive attitude underscores the recognition of the importance of sustainability principles in higher education and the belief in the transformative potential of STEM education in fostering sustainable development.

While there might be subtle variations in the perceptions of male and female instructors, the overall consensus on the importance of ESD and STEM integration remains strong across genders. However, further research could delve into potential gender-specific approaches to teaching ESD and STEM, ensuring inclusivity and addressing any disparities in perception or implementation.

Instructors from diverse educational programmes, spanning science, engineering, mathematics, and technology, share a common understanding of the value of integrating ESD and STEM. This suggests a cross-disciplinary recognition of the relevance of sustainability principles in educational practices. Tailoring professional development opportunities and curriculum enhancements to suit specific programme requirements could further amplify the integration efforts.

Instructors with varying years of service demonstrate a consistent acknowledgment of the importance of ESD and STEM integration, albeit with potential differences in their levels of experience and expertise. Leveraging the expertise of seasoned educators while fostering mentorship opportunities for newer faculty members could facilitate knowledge exchange and capacity building across generations of instructors.

Instructors from different institutional locations within the UAE showcase a shared commitment to promoting ESD and STEM education. However, regional contexts and resources may influence the implementation strategies and priorities. Tailoring initiatives to address localised sustainability challenges and leveraging regional strengths could optimise the impact of integration efforts.

In conclusion, the positive attitudes, foundational knowledge, and diverse skill sets among UAE HEI instructors underscore a promising trajectory towards advancing ESD and STEM education. By leveraging these insights and addressing demographic variations through targeted interventions and inclusive practices, UAE higher education institutions can play a pivotal role in nurturing a generation of environmentally conscious and socially responsible leaders and innovators poised to tackle complex global challenges.

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Appendix

The Higher Education Instructors' Questionnaire

Section 1: Instructors' Demographic Information

Gender	Male		Female				
Educational Programme	Engineering	General Science	Mathematics	Computer Science	Others		
Educational level	Diploma	Bachelor	Master	Doctorate	PhD		
Years of service	More than 10 years	10 years	5-10 years	2-5 years	Less than 2 years		
Institution's Location	Abu Dhabi	Dubai	Sharjah	Ajman	Fujairah	Umm Al Quwain	Ras al Khaimah

Section 2:

Please use the following key to indicate the degree to which you agree or disagree with each of the following statements:

(5) SA: Strongly agree	(4) A: Agree	(3) N: Neither agree nor disagree	(2)D: Disagree	(1) DA: Strongly disagree

STEM and ESD Knowledge		5	4	3	2	1
How do you describe the knowledge towards STEM and ESD?		SA	A	N	D	DA
1-	My students know the term STEM					
2-	My students know the term ESD					
3-	My students know the difference between sustainability, sustainable development, and ESD					
4-	My students are aware that STEM and ESD can be integrated					
5-	My students know that STEM is a combination of integrated science, technology, engineering and math or a combination of no less than two of those disciplines.					
6-	I have enough knowledge about the pros and cons of integrated STEM					
7-	I have enough knowledge about the pros and cons of integrated STEM and ESD					
8-	I know STEM Education is essential for SD.					
9-	STEM and ESD are essential to enhance my knowledge of the economic requirements					
STEM and ESD Attitude		5	4	3	2	1
How do you describe the Attitude towards STEM and ESD?		SA	A	N	D	DA
10-	More values are gained if scientific, technological, engineering, and mathematical approaches are integrated in teaching ESD in the classroom					
11-	ESD and STEM should be taken as a national priority in communities.					
12-	ESD and STEM should be taken as a national priority in universities.					
13-	By integrating ESD and STEM education, males and females should have equal opportunities to all kinds of employment.					
14-	By integrating ESD and STEM, the present generation would ensure that the next generation can live in communities that are as healthy as the existing communities today					
15-	Every learner should have a positive attitude towards ESD and STEM					
16-	By exposing the learner to the universal challenges of sustainability, there would be more interest towards STEM education.					

17-	ESD and STEM help learners protect natural resources					
STEM and ESD Skills Science-Engineering (SS-SE)		5	4	3	2	1
How do you describe the skills towards STEM and ESD?		SA	A	N	D	DA
18-	My students' skills in science towards ESD would be enhanced by STEM disciplines					
19-	Integrating science with engineering may enhance the students' ESD skills					
20-	Science and engineering promote designing skills towards ESD					
21-	Questions or assignments related to ESD promotes the students' ability to design and create a concept or model in the form of project tasks					
STEM and ESD Skills Science-Mathematics (SS-SM)		5	4	4	2	1
How do you describe the skills towards STEM and ESD?		SA	A	N	D	DA
22-	Science learning that produces data always leads students to be analysed by using simple statistics to comprehend the SD					
23-	Students think carefully with mathematical thinking to make a decision about SD problems					
24-	Collecting observational data on a science class in the form of numbers (quantitative data) promotes your SD skills					
STEM and ESD Skills Science- Technology (SS-ST)		5	4	3	2	1
How do you describe the skills towards STEM and ESD?		SA	A	N	D	DA
25-	Teaching a science subject with a variety of electronic tools promotes more skills towards finding solutions for energy preservation					
26-	Activities involving simple technology, or a particular procedure, would promote skills towards ESD subjects					
27-	Using a variety of learning platforms enhances STEM skills and reduces the SD as the cost of such platforms requires more expenditures to utilize them by the universities					
28-	Technology means the internet usage only, so SD skills toward the community issues will not be resolved without the internet.					
STEM and ESD Skills Science-Technology-Mathematics (SS-STM)		5	4	3	2	1
How do you describe the skills towards STEM and ESD?		SA	A	N	D	DA
29-	In ESD classes, students' learning skills will be enhanced by using a technological tool to mathematically analyze data from observations (ex: use calculator, computer, mobile phone, ect)					
30-	In ESD classes, students are often invited to use all possible technologies to collect data on learning in the science classroom (ex: using a thermometer and using mathematical computation to make a decision)					
31-	Explaining lessons about complex calculations in the science classroom and showing it by Power Point or other learning technologies will promote students' skills in finding the solutions of SD issues, and would make the students more competent in dealing with the SD issues in communities.					
STEM and ESD Skills Science-Technology-Engineering Mathematics (SS-STEM)		5	4	3	2	1
How do you describe the skills towards STEM and ESD?		SA	A	N	D	DA

32-	Students' skills towards SD issues are enhanced because your lessons often combine, by many ways, the technology, design-engineering, and mathematics approaches into a single learning topic of science					
33-	In your ESD course, you ask the students to prepare or to bring simple materials to design a particular model together to search for information through websites, or following a particular procedure to produce something and calculate the appropriate form (maximum length, breadth ideal, etc. for the design); therefore, you acknowledged that their learning skills are developed in that course					
34-	In the ESD courses, you train the students by using mathematical thinking, design of planning, and also technological assistance to solve various problems in decision making on science learning. By doing this, your students are more skilled to deal with the SD issues.					
35-	In the ESD course, your students' science skills are enhanced through using technology, engineering, and mathematical context simultaneously					
STEM and ESD Skills **Science-Engineering-Mathematic (SS-SEM)**		5	4	3	2	1
How do you describe the skills towards STEM and ESD?		SA	A	N	D	DA
36-	If the students use or recycle the goods around, they will be more competent in figuring out the SD issues. This is more useful and economically valuable, especially for the learning process of science					
37-	The students' learning or practicum, skills of ESD are often promoted by the use of analysis of profitability, graphics, and spatial ability of space, especially in engineering or creating a particular model or academic product.					
38--	Students' skills in ESD or STEM courses are promoted when they rely on their competency and there is an element of mathematical calculation in the process of practice					