Salud, Ciencia y Tecnología - Serie de Conferencias. 2024; 3:.1142
doi: 10.56294/sctconf2024.1142

Category: STEM (Science, Technology, Engineering and Mathematics)

ORIGINAL

Examining a knowledgeable experience and learning orientation about environmental sustainability among the engineering students of the UAE

Examinando una experiencia conocedora y una orientación de aprendizaje sobre la sostenibilidad ambiental entre los estudiantes de ingeniería de los Emiratos Árabes Unidos

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Cite as: Abudaqa M, Ab-Samat H. Examining a knowledgeable experience and learning orientation about environmental sustainability among the engineering students of the UAE. Salud, Ciencia y Tecnología - Serie de Conferencias. 2024;3:.1142. https://doi.org/10.56294/sctconf2024.1142

Submitted: 21-02-2024 **Revised:** 12-05-2024 **Accepted:** 26-08-2024 **Published:** 27-08-2024

Editor: Dr. William Castillo-González

ABSTRACT

Introduction: the heavy reliance on fossil fuels for energy poses a significant threat to sustainable development. Addressing this issue is crucial, with higher education institutions playing a vital role in promoting environmental sustainability.
Objective: this study explores the perceptions and learning orientations of engineering students in the UAE regarding renewable energy, eco-innovations, and environmental literacy.
Method: a survey was conducted among 275 engineering students from various higher education institutions in the UAE, assessing their confidence in renewable energy knowledge and eco-innovations.
Results: only 5 % of students had high or very high confidence in their renewable energy knowledge, compared to 14 % and 18 % for eco-innovations. No significant difference was found between male and female students in their awareness of these topics. The constructs' reliability and validity were confirmed, and environmental literacy significantly influenced students' learning orientation.
Conclusions: enhancing knowledge and coursework on renewable energy, eco-innovations, and environmental literacy is essential for fostering learning orientation among engineering students. Active involvement from students, faculty, and governmental officials, especially the Ministry of Education, is crucial for creating an effective learning environment.

Keywords: Environmental Literacy; Renewable Energy; Learning Orientation; Eco-Innovations; UAE.

RESUMEN

Introducción: la gran dependencia de los combustibles fósiles para la energía representa una amenaza significativa para el desarrollo sostenible. Abordar este problema es crucial, y las instituciones de educación superior desempeñan un papel vital en la promoción de la sostenibilidad ambiental.
Objetivo: este estudio explora las percepciones y orientaciones de aprendizaje de los estudiantes de ingeniería en los Emiratos Árabes Unidos con respecto a la energía renovable, las ecoinnovaciones y la alfabetización ambiental.
Método: se realizó una encuesta entre 275 estudiantes de ingeniería de diversas instituciones de educación superior en los Emiratos Árabes Unidos, evaluando su confianza en el conocimiento de la energía renovable y las ecoinnovaciones.
Resultados: solo el 5 % de los estudiantes tenía una alta o muy alta confianza en su conocimiento sobre energía renovable, en comparación con el 14 % y el 18 % para las ecoinnovaciones. No se encontraron diferencias significativas entre estudiantes masculinos y femeninos en su conocimiento de estos temas.

Se confirmó la fiabilidad y validez de los constructos, y la alfabetización ambiental influyó significativamente en la orientación de aprendizaje de los estudiantes.
Conclusiones: mejorar el conocimiento y los cursos sobre energía renovable, ecoinnovaciones y alfabetización ambiental es esencial para fomentar la orientación de aprendizaje entre los estudiantes de ingeniería. La participación activa de los estudiantes, el profesorado y los funcionarios gubernamentales, especialmente el Ministerio de Educación, es crucial para crear un entorno de aprendizaje efectivo.

Palabras clave: Alfabetización Ambiental; Energía Renovable; Orientación de Aprendizaje; Ecoinnovaciones; Emiratos Árabes Unidos.

INTRODUCTION

Today, one of the most pressing problems faced by the global economy is climate change, which is indeed a major threat to the environment, global organizations, and humankind.[1] To tackle such ecological concerns, policymakers, governmental decision-makers, environmental activists, and researchers play a critical role in combating challenges with long-term consequences. Likewise, education for sustainable development (SDV) has gained little attention in the past due to a lack of awareness and understanding among various stakeholders linked with higher education. However, with increasing ecological threats in the form of energy consumption from fossil fuels and the slow development of ecological innovations, policymakers have shown keen interest in developing and promoting learning orientation among students at higher educational institutions. Specifically, energy is accepted as one of the most powerful needs in the 21st century, driving all global economies where industrialization and related activities are directly connected with the availability and utilization of energy.[2] Despite its significance as a major need in the contemporary world, almost 80 % of global energy consumption comes from fossil fuels, which directly release toxic gases into the environment.[3]

Moreover, environmental concerns are not only determined through global warming but also air pollution, water pollution, ozone depletion, forest destruction, and the emissions of radioactive substances into the natural climate, which are very crucial.[4] Along with these damaging effects caused by traditional energy sources, another adverse outcome from these energy sources is depletion, which is much faster than the regeneration rate, creating a gigantic need for better alternatives with minimal or no damaging outcomes on nature. Such type of energy is called renewable energy, which is based on running water, wind, sunlight, and similar sources.[5]

In addition, compared to the past, a growing interest has been observed among different community members regarding eco-innovations and related technologies. In this regard, the United Nations has made utmost efforts to combat climate change by developing a set of sustainable development goals known as SDGs.[6] SDG7 mainly deals with promoting renewable energy and energy efficiency, asserting the need to ensure reliable, sustainable, and modern energy for all. However, without considering ecological innovations, the dream of clean and green energy toward achieving environmental and sustainable objectives is not possible. The extent to which such innovations have been investigated in the existing literature, specifically in higher education, is yet to be explored.

Since the United Nations Conference on Environment and Development held in 1992, education for sustainable development has gained accelerated significance with a target of growing environmentally literate citizens. Moreover, over the past couple of decades, the Nations Decade for environmental education was announced during 2005-2014.[7] Titles like environmental attitude and behavior have been integrated into both formal and informal syllabi around the globe after Rio, transforming environmental education into education for sustainable development.[8] However, the rate of such education and literacy is slower, specifically in higher education, where the potential impact of such education is highly significant in both curriculum and pedagogical contexts.

Based on the above arguments, this study contributes in several manners. Firstly, it fills the literature gap by exploring both knowledgeable experiences about renewable energy and eco-innovations among engineering students in the UAE. A detailed investigation of the current literature makes it evident that such experiences among engineering students in the UAE are yet to be explored. Secondly, based on the existing literature gap, this research further examines the impact of environmental literacy on the learning orientation among engineering students in higher education in the UAE. Thirdly, a range of policy implications have been suggested based on the empirical findings to boost learning orientation, environmental literacy, and similar knowledge in higher education.

The rest of the paper is organized as follows. Section 2 covers the review of the literature. Section 3 reflects the research methods and data analysis techniques. Section 4 covers the results and discussion. The last section concludes the study with policy implications and limitations for future studies.

https://doi.org/10.56294/sctconf2024.1142

Literature review

Overview of Students' Perception and Knowledge of Renewable Energy

The literature work in the field of students' learning perception and knowledge related to renewable energy and ecological innovations is quite limited, where the greatest part of the earlier studies chiefly focuses on the linkage between environmental sustainability, energy sources, environmental regulations, and sustainable development practices. For this reason, the limited available studies have been reviewed regarding the attitude and learning horizons of the students from the contexts of environmental literacy, learning orientation, and experiences related to the student's confidence regarding clean energy and eco-innovations. One of the focal points in the related literature covers the student's knowledge about the perception and preferences of different energy sources, which infers that students both at schools and universities have a sufficient grasp of various forms of energy while expressing their preferences. However, this phenomenon is not the same in different economies.

Comparative Analysis Across Different Economies

Turkish university students are supportive of clean energy sources but are more knowledgeable about wind energy, bioenergy, solar energy, and geothermal energy.[9] Additionally, these students were observed with less knowledge related to biomass and hydraulic energy.[9]

Another study conducted by Çakirlar A et al.[10] aimed to examine the awareness scale about renewable energy specifically for students at secondary schools. Considering the semi-structured interview approach, two sample groups have been chosen for data collection. A sample of 30 students was explored for qualitative analysis, whereas 600 secondary students were analyzed for quantitative techniques. The empirical findings show that there is an intermediate level of awareness among the students related to renewable energy knowledge. Moreover, a significant correlation exists between cognitive and affective awareness. However, a sufficient difference was also observed between the participants in terms of field of study, source of information, grade level, and awareness related to green energy sources.

Eshiemogie et al.[11] take the sample from Nigerian universities to explore the trends in knowledge and perception related to renewable energy. The authors claim that not much is known about the knowledge and level of understanding among students at higher educational institutions in Nigeria. A quantitative data analysis was conducted. The study findings reveal some mixed outcomes. For example, it is observed that 98 % of the respondents confirm that they have heard about renewable energy, out of which 24 % are highly confident about their understanding related to clean energy. Moreover, over 90 % of respondents at higher education institutions want clean energy to be added to their curriculum.

Apart from the knowledgeable perception related to renewable energy, some scholars also explore the development of relevant skills in terms of innovation-based projects. For instance, Ripoll et al.[12] claim that students, specifically in the field of chemical engineering, need to be more familiar with highly technical skills. Considering such an issue, the authors explore the teaching innovation experience in the Biochemical engineering course. The authors suggest that there is a need to overcome the difficulties faced by the students through innovative projects. It is inferred that through new and improved technology methodology, a positive impact on student attitudes and learning outcomes would be achieved.

Students' Awareness of Sustainable Development

Considering students' awareness of sustainable development, Azapagic et al.[13] surveyed different universities in various developed economies while collecting a sample of 3 134 respondents. The key objectives were to explore the knowledge status among the students in terms of sustainable development, knowledge gaps, and best approaches to educate the students, specifically in the engineering field. The results of the survey state that the overall level of knowledge is not satisfactory; hence, various gaps exist. However, one of the key points to consider is that students believe that sustainable development is an important phenomenon to be considered. Besides, it is further suggested that teaching sustainability could also develop interest among the students while ensuring their commitment to practicing sustainable development engineering as a profession.

Gaps in Current Literature and Future Research Directions

On the basis of the above review, relevant research work has mainly focused on topics like knowledge and understanding related to renewable energy and sustainable development. However, the existing work has yet to be found covering the trends in renewable energy and eco-innovation knowledge among engineering students, specifically in the region of UAE. Moreover, the literature is also silent in exploring the role of environmental literacy towards learning orientation among the students in higher education for which this research has been carried out. Figure 1 covers the research framework along with the research hypotheses as tested through structural equation modeling.

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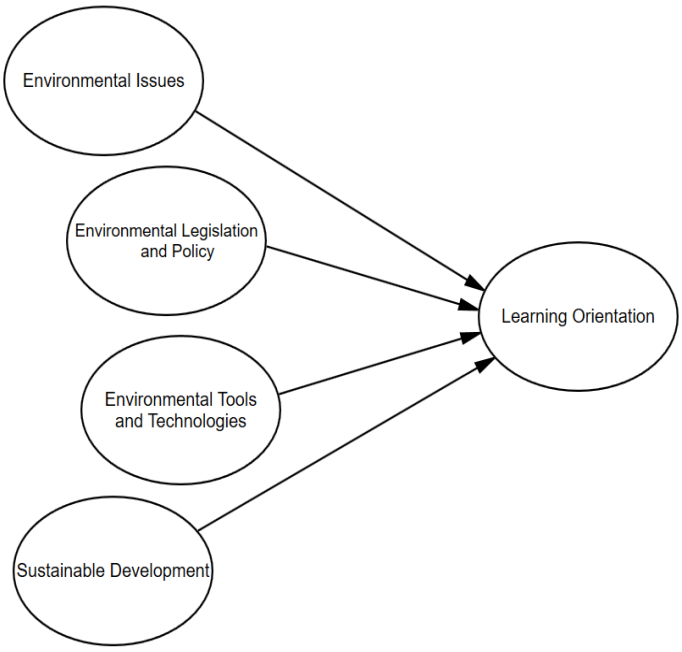

Figure 1. Research Framework

H1: environmental literacy, though environmental issues, significantly determines the learning orientation.

H2: environmental literacy, though environmental legislation and policy, significantly determines the learning orientation.

H3: environmental literacy through environmental tools and technologies significantly determines the learning orientation.

H4: environmental literacy through sustainable development significantly determines the learning orientation.

METHOD

Table 1. Description of the Survey Items

Survey Items	Scale	Source
What is your Level of Confidence about the Knowledge Related to Knowable Energy?	Very Low=1 5=Very High	Eshiemogie et al.[11]
What is your Level of Confidence about the Knowledge Related to Ecological Innovations?	Very Low=1 5=Very High	Eshiemogie et al.[11]
Have you ever heard about Renewable Energy and Ecological Innovations?	Yes=1, 2=No	Eshiemogie et al.[11]
How do you rate your knowledge of the following topics		
Environmental Issues	Scale	Source
Acid rain	Not heard of=1, Know a lot=5	Azapagic et al.[13]
Air pollution		
Biodiversity		
Climate Change		
Global Warming		
Ecosystems		
Solid waste		
Environmental Legislation, Policy	Scale	Source
The Florence Convention	Not heard of=1, Know a lot=5	Azapagic et al.[13]
ISO 14001		
Kyoto Protocol		
Montreal Protocol		
Intergovernmental Panel on Climate Change		
Environmental Tools and Technologies	Scale	Source

https://doi.org/10.56294/sctconf2024.1142

Clean Technology	Not heard of=1, Know a lot=5	Azapagic et al.[13]
Clean-up Technology		
Eco-Labelling		
Fuel-Cells		
Industrial Ecology		
Waste Minimization		
Sustainable Development	Scale	Source
Sustainable development—definition and the concept	Not heard of=1, Know a lot=5	Azapagic et al.[13]
Components of sustainable development		
Approaches to sustainable development		
Population growth		
Earth's carrying capacity		
Sustainable development—definition and the concept		
Learning Orientation	Scale	Source
I look at most of the additional readings suggested by the lecturer.	Strongly disagree=1, strongly agree=5	Jeffrey (2009)
I make sure I clearly understand the assessment requirements early in the course.		
I usually set out to understand thoroughly the meaning of what I am asked to read.		
It is important to me to do really well in my studies, so I make study a top priority		

The outcomes presented under this study consist of part of the broader research conducted in UAE aimed at discovering the knowledgeable perception about renewable energy and eco-innovations among engineering students. Moreover, it further explores the impact of environmental literacy on the learning orientation among engineering students. A questionnaire has been developed (table 1) covering the measuring scale and key items for each of the variables. Moreover, demographic factors like gender, relative department, and year of engineering were also added to the questionnaire. Once the questionnaire was developed, the data collection procedure was started and completed over four weeks by different engineering departments in both public and private universities of UAE. A sample of 315 questionnaires was received; however, out of which 275 responses were observed as valid with no missing responses. As per the suggestion of Delice et al.[9] it is believed that the minimum sample size for the quantitative analysis should be at least 30, where a sample size of above 250 is considered as bigger. Therefore, this study has taken the size of 275 responses as good enough for conducting the data analysis. The collected data was analyzed through SPSS-22 and Smart PLS version 3.3.9. Demographic analysis has been conducted through frequency distribution, whereas both the measurement model and structural model were subsequently applied.

RESULTS

Demographic Analysis

Table 2 shows the gender distribution of the respondents. Claiming that out of a total of 275 respondents, most of the respondents (80,72 %) were males who participated in the survey. In contrast, only 53 females, covering a percentage share of 19,28 %, contributed to the online survey questionnaire. This shows that the participation of female students in engineering is comparatively far lower than that of male members, showing a big gender imbalance in the engineering field. However, to combat this issue, it is paramount for female students to be encouraged enough to actively participate in the engineering programs among different universities in the UAE. The departmental distribution indicates that out of a total of 275 respondents, 64 belong to chemical engineering, 78 belong to machinal engineering, 26 belong to industrial/production engineering, 32 belong to agriculture engineering, and 75 links to other engineering field. It shows that the majority of the respondents came from machinal engineering, covering a % score of 28,36 % out of 100, where the second position in terms of respondents' participation is linked with chemical engineering, followed by agricultural engineering and other categories respectively. The distribution of the respondents in terms of year of engineering has also been reported in table 2, where 23 % from chemical engineering, 28 % from mechanical engineering, 9,45 % from Industrial/Production Engineering, and 11,34 % from Agriculture Engineering. Besides, the rest of the respondents belong to other engineering schools/departments. Figure 2-4 provides the graphical distributions for the demographic factors.

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Table 2. Demographics of the Respondents

Categories	Frequency	%
Gender		
Male	222	80,72
Female	53	19,28
Total	275	100
Relevant Department		
Chemical Engineering	64	23,27
Machinal Engineering	78	28,36
Industrial/Production Engineering	26	9,45
Agriculture Engineering	32	11,64
Others	75	27,28
Total	275	100
Year of Engineering		
Ist-4th Year	185	67,27
5th-Final Year	90	32,73
Total	275	100

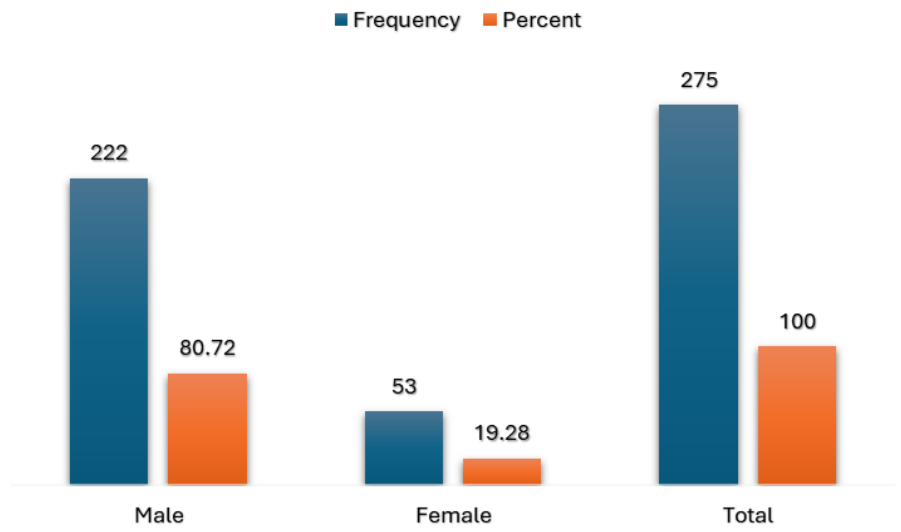

Figure 2. Gender Distribution

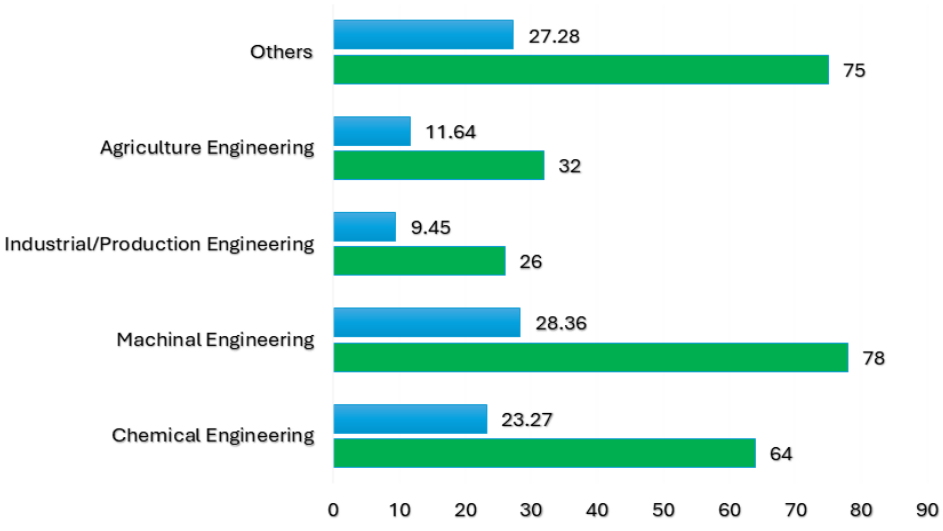

Figure 3. Departmental Distribution

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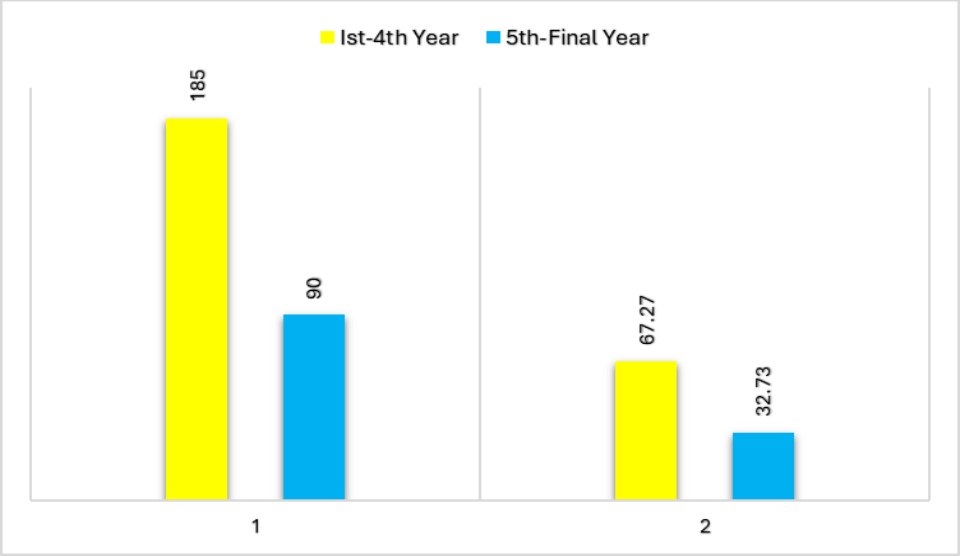

Figure 4. Year of Engineering

Confidence Over Renewable Energy Knowledge

Considering the confidence in renewable energy knowledge, 9,09 % of students are reporting a very low confidence covering, whereas 13,09 % are saying that they have a low confidence in their knowledge related to renewable energy. Moreover, the frequency distribution under table 3 reports that 68 % of students have an average level of confidence in renewable energy knowledge. This means that the majority of the respondents in the current study have an average level of renewable energy knowledge, which indeed could have been a better sign. However, on the other side, only 15 and 12 students had a high and very high level of confidence in their knowledge related to clean energy. Figure 3 covers the pie-distribution of the respondents covering the confidence in knowledge related to renewable energy.

Table 3. Confidence Over Renewable Energy Knowledge

Categories	Frequency	%
Very Low	25	9,09
Low	36	13,09
Average	187	68
High	15	5,45
Very High	12	4,37
Total	275	100

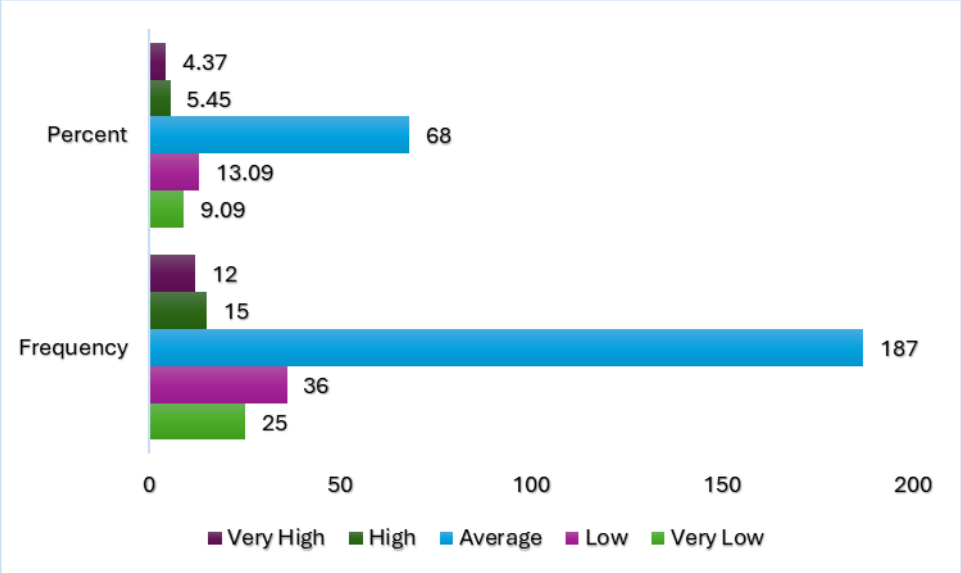

Figure 5. Confidence Over Renewable Energy Knowledge

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In addition, table 4 reports that 182 respondents out of 275 claim that they have heard about renewable energy and ecological innovations, whereas only 93 states that they have yet to hear about renewable energy. This means that although some of the respondents have low confidence in the renewable energy knowledge, the majority of the respondents have yet to hear about the clan energy. This fact is aligned with the empirical findings of Wang and Guo (2021) who claim that most individuals have a basic understanding of the energy crisis and ecological problems.

Table 4. Heard About Renewable Energy

Categories	Frequency	%
Yes	182	66,18
No	93	33,82
Total	275	100

Confidence Over Ecological Innovations

Table 5 covers the respondents' views regarding their confidence related to the ecological innovations for which frequency distributions are provided. The results show that out of a total respondent of 275, only 40 respondents had high confidence in ecological innovations, covering a percentage share of 14,55 %, whereas those having very high confidence over ecological innovations were only 50 in number, representing the total share of 18,18 % the overall sample. However, on the other side, the findings show that a total of 39 respondents had low confidence in the ecological innovations and related knowledge. In contrast, 45 members have very low confidence, respectively. Besides, the average level of confidence is represented by only 101 members. These findings provide some alarming situations where the current engineering students need more confidence in their desired knowledge of the ecological innovations for which some strategic policies and immediate steps are required. Figure 6 covers this distribution.

Table 5. Confident About Ecological Innovations

Categories	Frequency	%
Very Low	45	16,36
Low	39	14,18
Average	101	36,73
High	40	14,55
Very High	50	18,18
Total	275	100

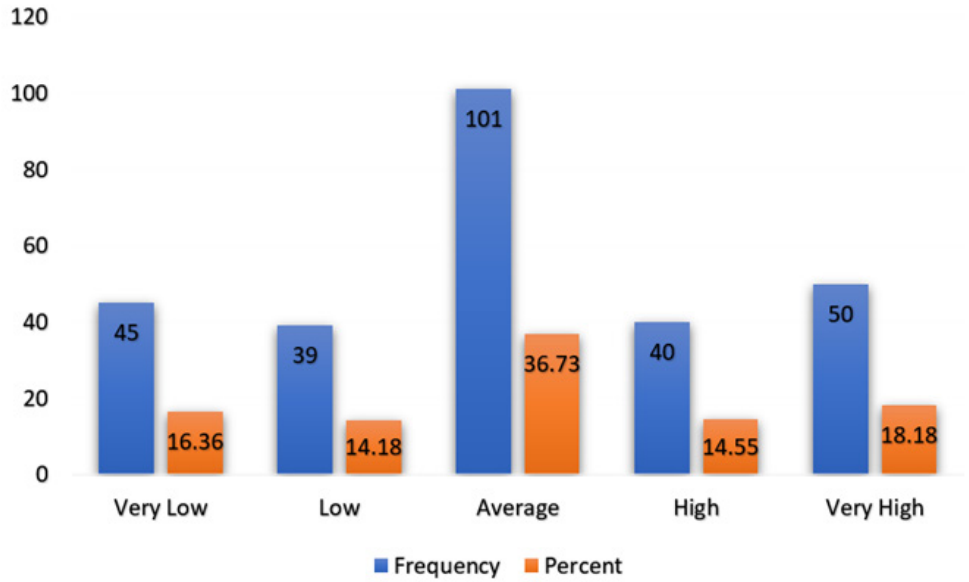

Figure 6. Distribution of the Confidence about Ecological Innovations

t-Test: Two-Sample Assuming Equal Variances for REN Knowledge

Table 6 reflects the awareness of renewable energy and EINO among engineering students based on their relative gender by assuming equal variance. The findings assume the following hypotheses:

H0: there is no significant difference between male and female students in terms of Awareness of renewable energy, assuming equal variance.

Ha: there is a significant difference between male and female students in terms of Awareness of renewable energy, assuming equal variance.

As per the findings under table 5, the results show that the p-value for the stated test is 0,535 which is above the 0,05 % level of significance. This indicates that the H0 is accepted, which indicates that there is no significant difference between male and female students in their relative awareness of the RE knowledge.

Table 6. Awareness of renewable energy by gender assuming equal variance

Descriptions	Variable 1	Variable 2
Mean	3,234	3,014
Variance	1,198	0,501
Observations	222	53
Pooled Variance	1,119	
Hypothesized Mean Difference	0	
df	71	
t Stat	0,622	
P(T<=t)	0,535	
t Critical	1,993	

t-Test: Two-Sample Assuming Equal Variances for EINO Knowledge

The study further investigates whether there is any significant difference between the two genders for the ecological innovation knowledge based on the equal variance of the two samples. For this purpose, the following null and alternative hypotheses have been established.

H0: there is no significant difference between male and female students in terms of Awareness/knowledge of ecological innovations, assuming equal variance.

Hb: there is a significant difference between male and female students in terms of Awareness/knowledge about ecological innovations, assuming equal variance.

Table 7 reports that the p-value is 0,770 with a t-critical of 1,99. As the stated p-value is above the 0,05 % level of significance, therefore, it is inferred that there is no significant difference between male and female students in terms of Awareness/knowledge of ecological innovations assuming equal variance, hence H0 is not rejected.

Table 7. t-Test: Two-Sample Assuming Equal Variances For EINO Knowledge

Descriptions	Variable 1	Variable 2
Mean	3	2,888889
Variance	1,174	0,861111
Observations	222	53
Pooled Variance	1,1392	
Hypothesized Mean Difference	0	
Df	71	
t Stat	0,292	
P(T<=t)	0,770	
t Critical	1,993	

Impact of Environmental Literacy on Learning Orientation

Measurement Model

Lastly, the current study investigates the role of environmental literacy on the learning orientation (LO) among engineering students in UAE. For this purpose, initially, the findings through Smart PLS version 3.3.9 have been presented under the title of “measurement model”. Table 8 provides the output for the constructs’

reliability and validity through alpha, rho_A, composite reliability, and average variance extracted or AVE, respectively. Existing literature states that for checking the reliability of every single construct, it is important that Cronbach's Alpha values should be above 0,70 (Ahmad & Ahmad, 2018; Calefato et al., 2008; Chen & Huang, 2007). As per the findings, the value of alpha for ELP, ENI, ETT, LRO, and SDV has been observed as 0,781, 0,912, 0,819, 0,775, and 0,914, respectively. These values are clearly indicating that the measurement of the latent constructs through relative items is reliable by all means.

Additionally, the composite reliability (CR) is another measure to examine the construct reliability for which the threshold level is observed as between 0,60 to 0,70. Moreover, in some cases, the CR values higher than 0,70 are preferable (Hair Jr et al., 2021). As per the results under table 7, the values of CR for the study variables are 0,850, 0,929, 0,879, 0,858, and 0,936. Finally, the term average variance extracted (AVE) reflects how much variance is linked to a relative latent construct. In this regard, a minimum acceptable level of 0,50 for AVE has been determined by researchers like Hair et al. (2021). The variables entitled ELP, ENI, ETT, LRO, and SDV achieve the AVE scores as 0,531, 0,586, 0,647, 0,604, and 0,745, accordingly. These values are reasonably above the minimum acceptable score of 0,50.

Table 8. Construct Reliability and Validity

Variables	Cronbach's Alpha	rho_A	CR	AVE
ELP	0,781	0,780	0,850	0,531
ENI	0,912	0,942	0,929	0,686
ETT	0,819	0,816	0,879	0,647
LRO	0,775	0,771	0,858	0,604
SDV	0,914	0,915	0,936	0,745

Note: ELP; environmental legislation and policy, ENI' environmental issues; ETT; environmental tools and technologies, LRO; learning orientation, SDV; sustainable development.

In the subsequent step, the findings for the discriminant validity through Fornell-Larcker criterion, loadings and cross-loadings, and HTMT ratio have been presented (table 9). The Fornell-Larcker Criterion help to explore the degree of shared variance among the latent constructs (Fornell and Larcker, 1981). Table 9 shows both diagonal and off-diagonal values for the latent variables. The criteria of Fornell-Larcker indicate that the square root of AVE for the latent construct must be greater than the correlation of that construct with latent variables. Therefore, it is inferred that the relative correlation of the study variables is relatively lower than the square roots (as shown under diagonal series).

Table 9. Fornell-Larcker Criterion

Variables	ELP	ENI	ETT	LRO	SDV
ELP	0,728				
ENI	0,212	0,828			
ETT	0,633	0,389	0,804		
LRO	0,650	0,188	0,632	0,777	
SDV	0,676	0,164	0,480	0,539	0,863

Note: ELP; environmental legislation and policy, ENI' environmental issues; ETT; environmental tools and technologies, LRO; learning orientation, SDV; sustainable development.

Table 10. Heterotrait-Monotrait Ratio (HTMT)

Variables	ELP	ENI	ETT	LRO	SDV
ELP	---				
ENI	0,222	---			
ETT	0,731	0,435	---		
LRO	0,611	0,205	0,739	---	
SDV	0,833	0,165	0,569	0,626	---

Note: ELP; environmental legislation and policy, ENI' environmental issues; ETT; environmental tools and technologies, LRO; learning orientation, SDV; sustainable development.

https://doi.org/10.56294/sctconf2024.1142

The results in table 10 show that HTM ratio between the study variables is lower than one where the highest score is 0,833 between ELP and SDV. Figure 7 reflects the output for the measurement model where the loadings have been covered through relative items of the latent variables.

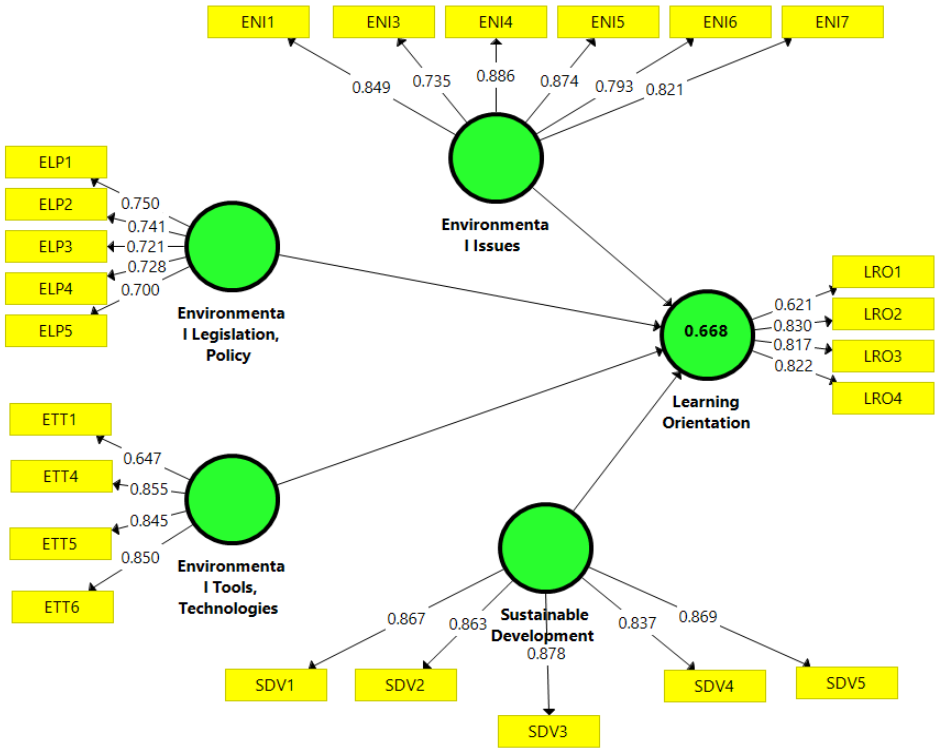

Figure 7. Measurement Model Output with Loadings

Structural Model

For checking the relationship between the study variables, the structural model output has been presented under table 11. It shows that there is a negative and insignificant impact of ENI on the learning orientation among the engineering students of different universities in UAE. More specifically, the value of standard deviation for the coefficient of ENI is 0,039 with the T-value of 1,053. This t-value is relatively lower than the threshold level of 1,96 in order to claim that there is a significant impact of ENI on LRO among the engineering students. As the T-value is relatively lower than 1,96; therefore, the p-value is also observed as insignificant even at 10 %. These findings claim that there is no significant impact of ENI on LRO, hence the study hypotheses entitled H1 is not supported. In this regard, one possible reason for this negatively insignificant association engineering students are not well aware about the environmental issues which may subsequently determine their learning orientation on significant grounds. Such relationship further suggests that there is a need to develop some more knowledgeable understanding among the engineering students regarding environmental issues in terms of acid rain, air pollution, biodiversity, climate change, depletion of natural resources, global warming, ozone depletion, solid waste, and many other others.

On the other side, the findings through path coefficients further reveal that the coefficient for the environmental legislation and policy in determining the learning orientation among the engineering students in different universities of UAE is positively significant. More specifically, it shows that a 1 % change in the value of ELP is causing an upward shift of 0,680 % in the learning orientation among the engineering students which is indeed a good sign. Additionally, the value of standard deviation for the coefficient of ELP to LRO is 0,058, with the t-value of 11 779. Finally, the p-value is observed as highly significant at 1 %, confirming that there is a significant and positive impact of climate literacy in terms of environmental legislation and policies towards increasing the learning orientation among the engineering students. Considering the earlier work, Azapagic et al.[13] conducted an international survey to explore the knowledge of engineering students regarding sustainable development and ecological issues along with the knowledge gaps. Their overall findings suggest that the overall knowledge level of the engineering students is not satisfactory, and a gap exist. As the coefficient for the ELP to LRO is positively significant; therefore, H2 is supported, which indicates that there is a significant impact of ELP on LRO among the engineering students in UAE.

https://doi.org/10.56294/sctconf2024.1142

Moreover, the findings under table 6 show that the coefficient for the environmental tools and technologies is 0,229, indicating a positive impact on LRO among the engineering students. More specifically, the value of standard deviation for the ETT to LRO is 0,047 which further provides the t-value of 4,828, and p-value as 0,000, significant at 1 %. This means that there is a significant and positive impact of ETT on the learning orientation among the engineering students in UAE. This is because environmental technologies like clean and clean up technology, design for environment, eco-labelling, industrial ecology, and similar renewable energy technologies are good source in dealing with the ecological pollution along with increasing more awareness and learning among the engineering students, specifically from the context of UAE. Therefore, H3 is supported and accepted accordingly.

Finally, table 6 reveals that the path coefficient for the relationship between sustainable development (SDV) and learning orientation is 0,230, indicating that there is a positive association between both. More specifically, it shows that keeping all the other factors as constant, a 1 % change in the value of environmental literacy through sustainable development causes an upward shift of 23,0 % in the learning orientation among the engineering students in UAE. The value of the standard deviation for this coefficient is 0,047, with the T-value of 4,893. As the p-value is 0,000, which is highly significant at 1 %; therefore, this research claims that there is a significant and positive impact of sustainable development on the learning orientation among the engineering students in UAE.

Table 11. Path Coefficients

Directions	Coefficients	SD	T-Values	P Values
ENI -> LRO	-0,041	0,039	1,053	0,292
ELP -> LRO	0,680	0,058	11,779	0,000
ETT -> LRO	0,229	0,047	4,828	0,000
SDV -> LRO	0,230	0,047	4,893	0,000

Note: ELP; environmental legislation and policy, ENI' environmental issues; ETT; environmental tools and technologies, LRO; learning orientation, SDV; sustainable development.

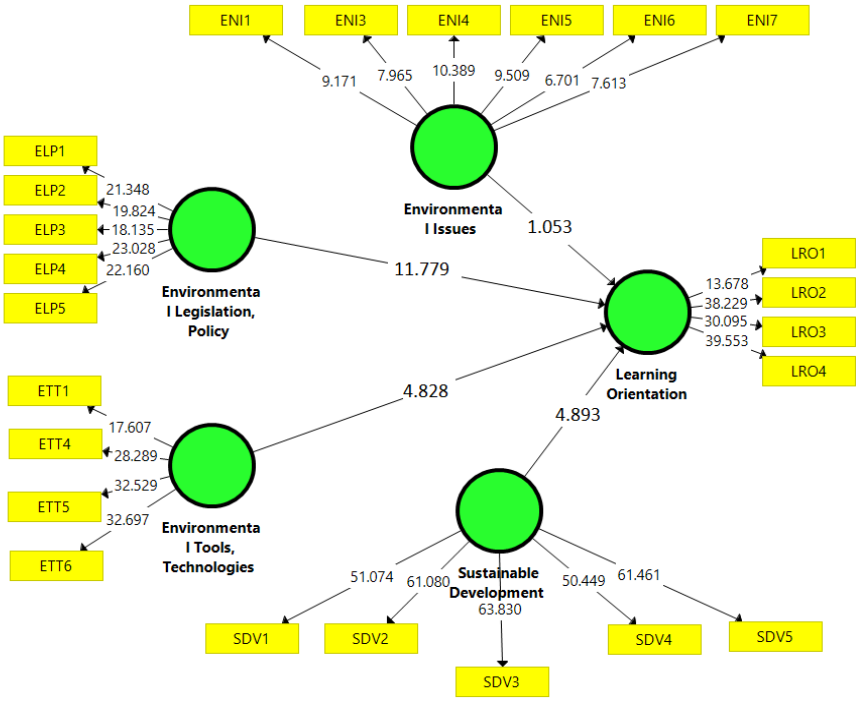

Figure 8. Structural Model Output

DISCUSSION

As per the findings above, it is found that among various engineering departments for the top engineering universities in UAE, most of the male students have got enrolled whereas, only few female students have been participated in the survey questionnaire. This would indicate that majority of the students who are interested in the engineering field belongs to male category which clearly indicates a gender imbalance.

For this reason, it is stated that university management and governmental officials need to promote the engineering degree courses among the female students. For this purpose, the relative authorities need to conduct seminars, public lectures, incentives while appointing the female heads of department.[14] Moreover, some financial incentives like offering scholarships to the female students for their enrollment can also provide some outstanding results in the coming time.

Moreover, the departmental distribution of the targeted respondents reflects that most of the students who have participated in the survey questionnaire belonged to machinal engineering, followed by the chemical engineering and industrial engineering. For this purpose, one key suggestion is to encourage the participation from the other engineering departments in the future studies while investigating the trends as linked with the renewable energy and ecological innovations. On the other side, the other engineering fields also need to be encouraged accordingly. Additionally, most of the contributions in the survey came from the final year students covering a percentage share of 57,5 %.

In addition, one of the crucial points as observed through survey questionnaire is that there were only 20 % (approximately) students having their high & very high confidence about the renewable energy knowledge. However, 79,5 % reflect their concerns related to average (68,5 %), low (2,7 %), and very low (8,2 %) knowledge of renewable energy. This clearly indicates the key gap as observed, with the engineering students who are currently enrolled in different universities here in UAE. For this purpose, one possible solution is to significantly focus on the key contents as being established by the relative engineering students to boost the students' knowledge related to renewable energy. For this purpose, there is a strong need to revise the current engineering curriculum for the UAE universities.

Additionally, for effective and efficient results in increasing the clean energy literacy among engineering students, the revised model of curriculum should also encompass various teaching modes. For example, the revised curriculum should not only cover the conventional teaching models like lecture-based modes of teaching but also involve acting learning exercises like hands-on laboratory practices, group discussions and projects, and industry-related internships, respectively. Such practices will boost the active learning horizons of engineering students along with their critical thinking and general academic performance as compared to conventional learning modes like lecture-based teaching.[15]

Moreover, the results also provide evidence that the current status related to ecological innovations among the students of various engineering departments has provided some mixed results. For example, only 16,4 % and 2,7 % of respondents claim that they have a high and very high confidence about their relative knowledge of ecological innovations, which is indeed a problematic sign. However, 61,6 % claim that they have a low confident about ecological innovations, whereas 5,5 % responded that they have a very low confident as linked with the relative knowledge of ecological innovations. These facts have clearly indicated the immediate need and significance of introducing that curriculum through which students can enhance their body of knowledge as linked with the Ecological innovations too.

The promotion of RE and EINO education among engineering students in UAE may provide a variety of benefits, for which following are the key highlights.

First, developing and promoting RE and EINO education among the engineering students may provide a first step in building engineers towards sustainable future. More specifically, with the rapid and dramatic changes as incurred in the RE and eco-system, developed nations like UAE would need to train and position their young engineers to be able to reasonably handle the evolving future for jobs, specifically in the renewable energy and ecological innovation sector effectively and efficiently.

Second, it is believed that innovation is normally borne out of the curiosity and interest. In this regard, if RE and ecological innovations would be added in the engineering curriculum, students will be more involved in the RE and EINO activities and likely to detect lapses in RE and EINO research, hence may open new path for the unprecedented innovations.

Third, asides from the fact that opening up the learning climate for the students while adding the RE and EINO in their educational curriculum could increase their awareness about the stated field, introducing young students with both RE and EINO could also make them more aware about environmental sustainability. This is because when engineering students will be more aware about both the clean energy and green innovations, they began to develop a sense of responsibility for their immediate environment and wellbeing of the world at large.

Fourth, with the involvement of both teachers and students in RE and EINO research projects a learning relationship will be established between them. Generally, such relationship helps in improving the quality of education. In this regard, with the improvement in the learning climate, engineering students could be more knowledgeable in both RE and EINO field.

CONCLUSIONS

In light of environmental challenges, it's crucial to enhance students' understanding of renewable energy and ecological innovations, especially among engineering students in the UAE. This study identified gaps in

knowledge, with only 5,45 % of respondents confident in their understanding of renewable energy. No significant gender differences were found in awareness levels.

To address these gaps, we recommend introducing courses on renewable energy and ecological innovations in engineering curricula. This should begin in the first year, building foundational knowledge for future learning. Additionally, integrating government policies and regulations into the curriculum will prepare students for industry challenges and entrepreneurial ventures.

Enhancing environmental literacy through targeted courses can improve learning orientation and support the UAE's transition to a net-zero carbon economy. Collaboration between the Ministry of Education and industry is essential for developing a practical roadmap and securing necessary funding.

Limitations include focusing solely on engineering students and not considering graduates' knowledge. Future research should explore these areas in other regions.

BIBLIOGRAPHIC REFERENCES

1. Kamran, H. W., Rafiq, M., Abudaqa, A., & Amin, A. (2024). Interconnecting sustainable development goals 7 and 13: the role of renewable energy innovations towards combating the climate change. Environmental Technology, 45(17), 3439–3455. https://doi.org/10.1080/09593330.2023.2216903

2. Eshiemogie SO, Ighalo JO, Banji TI. Knowledge, perception and awareness of renewable energy by engineering students in Nigeria: A need for the undergraduate engineering program adjustment. Cleaner Eng Technol. 2022a;6:100388. doi: https://doi.org/10.1016/j.clet.2021.100388.

3. Ighalo JO, Adeniyi AG. Adsorption of pollutants by plant bark derived adsorbents: An empirical review. J Water Process Eng. 2020;35:101228. doi: https://doi.org/10.1016/j.jwpe.2020.101228.

4. Adelodun B, Ajibade FO, Ighalo JO, Odey G, Ibrahim RG, Kareem KY, Choi KS. Assessment of socioeconomic inequality based on virus-contaminated water usage in developing countries: A review. Environ Res. 2021;192:110309. doi: https://doi.org/10.1016/j.envres.2020.110309.

5. Karasmanaki E, Tsantopoulos G. Exploring future scientists' awareness about and attitudes towards renewable energy sources. Energy Policy. 2019;131:111-119. doi: https://doi.org/10.1016/j.enpol.2019.04.032.

6. Pandey A, Asif M. Assessment of energy and environmental sustainability in South Asia in the perspective of the Sustainable Development Goals. Renew Sust Energ Rev. 2022;165:112492. doi: https://doi.org/10.1016/j.rser.2022.112492.

7. Teksoz G, Sahin E, Tekkaya-Oztekin C. Modeling Environmental Literacy of University Students. J Sci Educ Technol. 2012;21(1):157-166. doi:10.1007/s10956-011-9294-3.

8. Maurer M, Bogner FX. Modelling environmental literacy with environmental knowledge, values and (reported) behaviour. Stud Educ Eval. 2020;65:100863. doi: https://doi.org/10.1016/j.stueduc.2020.100863.

9. Karatepe Y, Neşe SV, Keçebaş A, Yumurtacı M. The levels of awareness about the renewable energy sources of university students in Turkey. Renewable Energy. 2012;44:174-179. doi:10.1016/j.renene.2012.01.099

10. Çakirlar Altuntaş E, Turan SL. Awareness of secondary school students about renewable energy sources. Renewable Energy. 2018;116:741-748. doi:10.1016/j.renene.2017.09.034

11. Eshiemogie SO, Ighalo JO, Banji TI. Knowledge, perception and awareness of renewable energy by engineering students in Nigeria: A need for the undergraduate engineering program adjustment. Cleaner Engineering Technology. 2022;6:100388. doi:10.1016/j.clet.2021.100388

12. Ripoll V, Godino-Ojer M, Calzada J. Development of engineering skills in students of biotechnology: Innovation project "From laboratory to industry". Education for Chemical Engineers. 2023;43:37-49. doi:10.1016/j.ece.2023.01.006

13. Azapagic A, Perdan S, Shallcross D. How much do engineering students know about sustainable development? The findings of an international survey and possible implications for the engineering curriculum. European journal of engineering education. 2005;30(1):1-19.

14. stasAlDhaheri H, Hilmi MF, Abudaqa A, Alzahmi RA, Ahmed G. The relationship between HRM practices, innovation, and employee productivity in UAE public sector: a structural equation modelling approach. International Journal of Process Management and Benchmarking. 2023;13(2):157-176. doi: 10.1504/IJPMB.2021.10039111

15. Abudaqa, A., Alzahmi, R. A., Hilmi, M. F., & Almujaini, H. (2023). IMPACT OF JOB SECURITY, CAREER ADVANCEMENT AND EMPLOYEE PARTICIPATION ON EMPLOYEE ENGAGEMENT IN OIL AND GAS INDUSTRY, UAE. Universidad y Sociedad, 15(3), 26-36.

FINANCING

The authors did not receive financing for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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