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THE ROLE OF GREEN TECHNOLOGY IN ACHIEVING SUSTAINABLE DEVELOPMENT IN E-LEARNING AT SAUDI UNIVERSITIES

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ABSTRACT

***Background:** This study investigates the role of green technology in promoting sustainable development through e-learning at Imam Abdulrahman Bin Faisal University, Saudi Arabia. It addresses the contributions of green technology to environmental awareness, quality of education, and green infrastructure. **Methods:** A descriptive-analytical approach was employed, surveying 217 faculty members from various disciplines to explore their perceptions of green technology's role and the challenges faced in its implementation. **Results:** The study revealed a high level of awareness among faculty regarding the role of green technology in sustainability. However, significant challenges were identified, including technical, financial, and cultural barriers. Gender, college type, and academic rank influenced perceptions of these challenges. **Conclusions:** The findings suggest that targeted strategies are needed to overcome the barriers to integrating green technologies in higher education. The study highlights the importance of institutional support in fostering the adoption of green technologies to promote sustainable practices.*

KEYWORDS: Green Technology, Sustainable Development, Higher Education, Faculty Perceptions, Gender Differences, Academic Rank, Institutional Challenges.

1. INTRODUCTION

The world is facing increasing environmental challenges amid the growing global focus on achieving the United Nations' Sustainable Development Goals (SDGs). Education is considered one of the key pillars for achieving these goals, as it plays a vital role in raising awareness among current and future generations about the importance of environmental conservation and rational use of natural resources.

In this context, the 2024 Times Higher Education Impact Rankings reflect the commitment of Saudi universities to contributing to the SDGs. A total of 32 Saudi universities were ranked among the top institutions worldwide in this field, including King Fahd University of Petroleum and Minerals, King Faisal University, Imam Abdulrahman Bin Faisal University, King Abdullah University of Science and Technology, Prince Mohammad Bin Fahd University, and King Abdulaziz University in various categories (Saudi Council of Universities, 2024).

Aligned with Saudi Vision 2030, Imam Abdulrahman Bin Faisal University (IAU) has demonstrated a strong commitment to sustainability by officially establishing a Sustainable Development Unit on 11/06/1444 AH under the Office of the Vice President for Development and Community Partnership. This unit aims to raise environmental awareness and promote the transformation of the university into a green and eco-friendly institution (IAU, 2024).

Moreover, Crown Prince Mohammed bin Salman launched the "Saudi Green Initiative" in March 2021 to promote environmental sustainability through reducing carbon emissions, increasing green cover, and restoring ecological balance.

In response to global environmental challenges, green technology has emerged as an innovative solution that focuses on environmentally friendly technologies based on renewable resources, low-impact industries, and the creation of new green economy jobs (Guo et al., 2020).

Recent studies have highlighted the importance of integrating green technology in education, especially in e-learning. Al-Omairi and Al-Harbi (2023) recommended replacing paper-based materials with digital learning tools. Al-Shahrani (2024) emphasized the need to develop curricula to support sustainability concepts and to train teachers on how to effectively present them. Additionally, Suleiman (2021) showed the effectiveness of education in raising students' environmental awareness, while Nusraningrum et al. (2024) indicated the positive influence of e-learning on green innovation and environmental management practices, identifying green technology as an effective mediating variable for achieving sustainability in higher education.

Despite these advancements, significant environmental, social, and economic challenges persist in applying green technologies in e-learning. These include inadequate infrastructure, limited training, and low levels of environmental awareness, which call for integrated efforts to enhance the role of green technologies in advancing sustainability in higher education institutions.

1.1. Problem Statement

Based on the researchers' academic and practical experience, a gap has been identified in the literature concerning the integration of green technology in e-learning, specifically within the context of Imam Abdulrahman bin Faisal University and Saudi Arabia more broadly. Current research tends to focus on the technical aspects of e-learning while paying insufficient attention to its environmental impacts or the role of green technology in mitigating these effects. There is also a scarcity of studies evaluating the environmental footprint of e-learning or proposing sustainable solutions to reduce it. Furthermore, few studies investigate the level of environmental awareness among faculty and students and its influence on adopting sustainable educational practices.

Amid rising environmental challenges, it becomes essential to adopt sustainable practices in all sectors, especially in education, which plays a major role in raising societal awareness about sustainability. Imam Abdulrahman Bin Faisal University increasingly relies on e-learning, which, despite its benefits in improving accessibility and offering flexible learning environments, also poses significant environmental concerns such as increased energy consumption and the use of electronic devices, contributing to the institution's carbon footprint.

Thus, this study aims to explore the role of green technology in promoting sustainable development through e-learning at Imam Abdulrahman bin Faisal University. It seeks to offer practical solutions to environmental challenges and enhance the environmental, social, and economic benefits that support the sustainability of the educational sector.

1.2. Research Questions

In light of the aforementioned, this study seeks to answer the following questions:

1. What is the role of green technology in achieving sustainable development at Imam

Abdulrahman Bin Faisal University from the perspective of faculty members?
2. What are the challenges facing the application of green technology in promoting sustainable development from the perspective of faculty members?
3. Are there statistically significant differences in the assessment of the role and challenges of green technology based on gender, college type, and academic rank?

1.3. Significance Of Study

The significance of this study arises from the growing global and national interest in employing green technology as an effective tool for achieving sustainable development, particularly in higher education institutions. These institutions are vital in educating future generations on sound environmental practices and the conservation of natural resources. The study holds particular importance in the Saudi context, given the Kingdom's commitment to Vision 2030, which places environmental sustainability at the forefront, as well as the national initiative "Saudi Green" aimed at reducing carbon emissions and achieving environmental balance.

This study contributes to enhancing understanding of how to integrate green technology within the e-learning system at Imam Abdulrahman bin Faisal University, thereby enabling the development of sustainable educational practices that reduce environmental impact and support national strategic objectives toward a more sustainable society. It also provides a knowledge framework that supports decision-makers and faculty members in adopting teaching methods and educational technologies aligned with environmental standards, thereby strengthening the social and environmental responsibility of academic institutions.

1.4. Theoretical Significance:

Expands the academic body of knowledge regarding the relationship between green technology and sustainable development in e-learning, enriching the scientific literature and addressing a research gap in the Saudi university context.

Clarifies the concepts and principles of green technology and how they can be effectively integrated into the e-learning system.

Provides an analytical framework for assessing the environmental impacts of educational technologies, contributing to a better understanding of the challenges and opportunities associated with e-learning sustainability.

1.5. Practical Significance:

Supports the development of educational strategies that incorporate green technology, enhancing the quality of e-learning in Saudi universities. Offers practical solutions for reducing the carbon footprint of universities in support of national environmental sustainability efforts. Enhances environmental awareness among students and faculty members, promoting a culture of sustainability within the academic community. Strengthens awareness-raising initiatives within the university campus to encourage environmentally sustainable teaching practices.

2. OPERATIONAL DEFINITIONS

2.1. Green Technology:

Green technology refers to a set of environmentally friendly technologies aimed at reducing the ecological harm caused by technological products and processes, while improving the efficiency of resource and energy use and reducing the carbon footprint (Al-Badrashini & Gharib, 2022; Al-Saadawi, 2023; Abdel-Fattah, 2022; Sukumar & Pan, 2019). Operationally, in this study, it refers to "the use of eco-friendly technologies (devices, applications, and practices) in e-learning to provide effective and low-cost educational services while minimizing resource consumption and managing waste sustainably."

2.2. Sustainable Development

Sustainable development is an integrated approach aimed at balancing economic and social progress with environmental protection to secure the rights of present and future generations (Mensah & Casadevall, 2019; Hamed & Hassan, 2023). Operationally, in this study, it is defined as "the application of sustainable development principles in e-learning at Imam Abdulrahman bin Faisal University through the use of green technologies without harming the environment."

2.3. Sustainable E-Learning

This concept refers to the use of digital technologies in education in a way that reduces the carbon footprint and conserves environmental resources, through platforms such as Learning Management Systems (LMS), Blackboard, educational videos, and online assessments (Gautam & Tiwari, 2016; Shengjergji et al., 2024). Operationally, it refers to "the use of the Blackboard system at Imam Abdulrahman bin Faisal University

to deliver content and support educational interaction in a way that promotes sustainable development."

2.4. Green Technology and Sustainable Development

Sustainability in green technology relies on practices such as material reuse, sustainable manufacturing, electronic device recycling, and safe disposal to reduce environmental impact (Murugesan, 2012). The integration of sustainability into hardware and software development is recommended to ensure environmentally responsible technologies (Shengjergji et al., 2024).

2.5. Dimensions Of Green Technology for Achieving Sustainable Development

These include behavioral attitudes and environmental awareness, supportive institutional policies, environmentally friendly practices, and technologies that enhance efficiency and sustainability (Jnr et al., 2018; Ali & Jabbar, 2021; Jessica, 2016; Hassan et al., 2022). The presence of clear policies and ongoing training is essential to promote the adoption of green technology in institutions.

2.6. Green Technology as a Tool for Achieving Sustainability In E-Learning:

Green technology contributes to creating flexible and sustainable learning environments through technologies such as artificial intelligence and virtual reality, which reduce reliance on physical resources and lower the carbon footprint (Islam et al., 2023; Forbes et al., 2023). Digital education also supports waste management and sustainable transportation options, reinforcing the concept of the "green campus" (Akay, 2024). UNESCO (2024) asserts that higher education institutions play a key role in developing students' sustainability skills and behaviors through integrating sustainable development principles into curricula and educational practices. Al-Hourani et al. (2023) recommended organizing training courses and workshops for teachers to promote green education culture and developing institutional policies that encourage the sustainable and effective use of e-learning platforms.

2.7. Instrument Validity and Reliability

A. Validity

To verify internal consistency validity, Pearson correlation coefficients were computed between each domain and the total score of the questionnaire using a pilot sample of 40 participants. Results revealed statistically significant correlations at the 0.01 level across all domains, indicating strong internal consistency.

B. Reliability

Reliability was assessed using Cronbach's alpha. The overall instrument demonstrated high reliability ($\alpha = 0.915$), with subscale alphas ranging from 0.829 to 0.926, indicating strong internal consistency.

C. Statistical Methods

Data was analyzed using SPSS. Statistical tools included: Pearson correlation, Cronbach's alpha, means, standard deviations, frequencies, percentages, independent samples t-test, and Kruskal-Wallis test.

2.8. Sample Characteristics

The study sample consisted of 217 faculty members. Females represented 53.9%, and males 46.1%. Participants were from various colleges, primarily Arts and Education (70.5%), followed by Health (12%), Science and Management (9.2%), and Engineering (8.3%). In terms of academic rank, Assistant Professors comprised 64.5%, Associate Professors 25.3%, and Professors 10.1%.

Table 1: Reliability Values of the Study Instrument and Its Dimensions.

Study Instrument	Number of Items	Cronbach's Alpha Coefficient
Overall Instrument	35	0.915
Environmental Awareness	5	0.898
Quality of Education and Training	7	0.926
Quality of Green Infrastructure in the University	5	0.907
Technical Challenges	5	0.829
Financial Challenges	4	0.903
Knowledge-Based Challenges	4	0.829
Cultural and Social Challenges	5	0.908

First: Answers to the Study Questions

First Research Question: What is the role of green technology in achieving sustainable development in e-learning at Imam Abdulrahman

bin Faisal University from the perspective of faculty members?

To answer this question, the arithmetic mean, standard deviation, and rank of the research sample's responses were calculated, as shown in the following table:

Table (2): Mean, Standard Deviation, And Ranking of the Research Sample's Responses Regarding the Role of Green Technology in Achieving Sustainable Development In E-Learning at Imam Abdulrahman Bin Faisal University (N = 217).

Statements	Mean	Std. Dev.	Rank	Agreement Level
Green technology contributes to achieving e-learning at the university.	4.47	0.69	1	Very high
Green technology reduces the negative environmental impact of e-learning at the university.	4.17	0.79	5	High
The university uses green technologies such as cloud computing or low-power software in the educational process.	4.20	0.81	4	High
The use of green technology in e-learning contributes to environmental benefits.	4.43	0.76	2	Very high
The use of green technology in e-learning enhances environmental responsibility among university affiliates.	4.41	0.78	3	High
Environmental awareness is achieved.	4.33	0.76	2	Very high
Green technology improves the quality of faculty training.	4.18	0.77	7	High
Green technology enhances the quality of education.	4.30	0.62	5	Very high
Green technology enhances student innovation.	4.39	0.77	4	Very high
Green technology helps accomplish educational tasks.	4.49	0.66	2	Very high
The use of electronic assessments reduces paper usage.	4.67	0.50	1	Very high
Green technology increases the effectiveness of e-learning.	4.24	0.81	6	Very high
Green technology creates a more interactive and sustainable learning environment.	4.43	0.76	3	Very high
Quality of education and training.	4.38	0.69	1	Very high
Green technology contributes to the recycling of electronic waste.	4.12	0.86	5	High
Green technology improves quality of life at the university.	4.43	0.52	1	Very high
Green technology improves building design for better energy efficiency.	4.20	0.81	4	High
Green technology enhances the university's infrastructure.	4.27	0.73	2	Very high
Green technology boosts resource efficiency in e-learning.	4.24	0.72	3	Very high
Quality of green infrastructure.	4.25	0.72	3	High

Second Research Question: What are the challenges of green technology in achieving sustainable development at Imam Abdulrahman bin Faisal University from the perspective of faculty members?

Table (3): Mean, Standard Deviation, And Ranking of the Research Sample's Responses Regarding the Challenges of Green Technology in Achieving Sustainable Development at the University (N = 217).

Statements	Mean	Std. Dev.	Rank	Agreement Level
Difficulty connecting devices to the network in some classrooms or virtual rooms.	3.69	1.25	1	High
Weak internet connection affects the use of green technology.	3.44	1.30	2	High
Lack of technical support related to green infrastructure.	2.98	1.39	3	Medium
Insufficient technical resources for faculty.	2.96	1.35	4	Medium
Poor technical support response.	2.79	1.50	5	Medium
Technical challenges	3.17	1.35	4	Medium
Lack of incentives for faculty to adopt green technology.	3.82	1.41	1	High
Insufficient funding for green infrastructure projects.	3.71	1.44	2	High
High costs (devices–software–maintenance).	3.54	1.30	4	High
Balancing investment in green technology and operational needs.	3.57	1.33	3	High
Financial challenges	3.66	1.37	2	High
Lack of awareness of green technology among faculty.	3.91	1.50	2	High
Lack of promotion for green technology in e-learning.	3.74	1.38	3	High
Lack of interest in using green technology in teaching.	3.62	1.43	4	High
Lack of training in using green technology.	3.98	1.51	1	High
Knowledge challenges	3.81	1.45	1	High
Resistance to green technology by some faculty.	3.50	1.40	1	High
Belief that green technology does not improve quality.	3.30	1.24	4	Medium
Unwillingness to learn green technologies.	3.30	1.23	3	Medium
Fear of change among faculty.	3.28	1.25	5	Medium
Rejection of new systems due to habit.	3.42	1.38	2	Medium
Cultural/social challenges	3.36	1.30	3	Medium

Research Question 3: Are there statistically significant differences in the role of green technology in sustainable development and its challenges according to gender, college type, and academic degree?

A) Differences by Gender:

Table 4: Statistical Significance of Differences in the Role of Green Technology in Sustainable Development and Its Challenges According to Gender.

Variables	Males Mean (M)	Males SD (SD)	Females Mean (M)	Females SD (SD)	t-value	Significance Type
Environmental Awareness Achievement	22.07	3.31	21.34	3.52	1.56	Not Significant
Quality of Education and Training	30.02	3.63	31.31	4.22	2.38*	Significant in favor of Females
Quality of Green Infrastructure of University	21.93	3.32	20.70	3.16	2.78**	Significant in favor of Males
Overall, the Role of Technology	74.02	9.93	73.35	10.46	0.48	Not Significant
Technical Challenges	11.11	3.36	14.74	4.19	6.96**	Significant in favor of Females
Financial Challenges	14.08	4.81	13.68	5.37	0.58	Not Significant
Knowledge Challenges	19.47	6.94	18.27	6.70	1.30	Not Significant
Cultural and Social Challenges	16.61	5.66	16.97	6.91	0.42	Not Significant
Overall Challenges	61.27	17.85	63.66	21.34	0.85	Not Significant

Note:

Partial confirmation of the hypothesis is evident. Statistically significant differences were found in the dimension of **Quality of Education and Training** in favor of females, and in **Quality of Green Infrastructure of the University** in favor of males. This suggests that females perceive education and training as a more significant contributor to enhancing the role of green technology in sustainable development, while males emphasize the importance of green infrastructure quality. Additionally, significant differences in **Technical Challenges** were found favoring females, indicating that females view technical challenges as a greater barrier to green technology than males. No significant differences were found in other dimensions or in the overall role of green technology

B) Differences by College Type: To assess differences according to college type, the **Kruskal-Walli's test** was used instead of one-way ANOVA due to unequal group sizes.

Table 5: Results Of Kruskal-Wallis Test for Differences in Perceptions of the Role of Green Technology and Its Challenges According to College Type.

Variables	College Type	N	Mean Rank	Chi-square (χ^2)	Significance Level (p)
Environmental Awareness Achievement	Health Sciences	26	74.33	41.63**	0.00
	Engineering	18	67.75		
	Science & Admin	20	60.25		
	Arts & Education	153	126.12		
Quality of Education and Training	Health Sciences	26	64.31	49.35**	0.00
	Engineering	18	45.81		
	Science & Admin	20	87.50		
	Arts & Education	153	126.84		
Quality of Green Infrastructure	Health Sciences	26	79.13	32.66**	0.00
	Engineering	18	67.36		
	Science & Admin	20	67.58		
	Arts & Education	153	124.39		
Overall, the Role of Technology	Health Sciences	26	74.10	38.04**	0.00
	Engineering	18	57.00		
	Science & Admin	20	74.38		
	Arts & Education	153	125.58		
Technical Challenges	Health Sciences	26	125.87	13.54**	0.00
	Engineering	18	103.42		
	Science & Admin	20	150.93		
	Arts & Education	153	101.31		
Financial Challenges	Health Sciences	26	121.56	21.30**	0.00
	Engineering	18	64.64		
	Science & Admin	20	68.35		
	Arts & Education	153	117.40		
Knowledge Challenges	Health Sciences	26	89.08	17.46**	0.00
	Engineering	18	61.92		
	Science & Admin	20	101.40		
	Arts & Education	153	118.92		
Cultural and Social Challenges	Health Sciences	26	100.50	28.27**	0.00
	Engineering	18	88.78		

	Science & Admin	20	176.75		
	Arts & Education	153	103.97		
Overall Challenges	Health Sciences	26	91.15	15.01**	0.00
	Engineering	18	70.61		
	Science & Admin	20	144.23		
	Arts & Education	153	111.94		

Note:

Statistically significant differences exist in perceptions of the role of green technology (across dimensions) in favor of **Arts and Education Colleges**.

Differences in perception of challenges were significant in favor of **Science and Administration Colleges**, particularly regarding **Technical, Cultural, and Social Challenges**, and the overall challenges.

Health Sciences Colleges showed significant differences favoring them in **Financial Challenges**, and **Science and Administration Colleges** in **Knowledge Challenges**

C) Differences by Academic Degree:

Table 6: Results Of Kruskal-Wallis Test for Differences in Perceptions of the Role of Green Technology and Its Challenges According to Academic Degree.

Variables	Academic Degree	N	Mean Rank	Chi-square (χ^2)	Significance Level (p)
Environmental Awareness Achievement	Assistant Professor	140	108.40	0.773	0.67
	Associate Professor	55	108.98		
	Professor	22	112.84		
Quality of Education and Training	Assistant Professor	140	101.08	0.101	0.951
	Associate Professor	55	120.66		
	Professor	22	130.23		
Quality of Green Infrastructure	Assistant Professor	140	113.82	7.10*	0.02
	Associate Professor	55	103.39		
	Professor	22	92.34		
Overall, the Role of Technology	Assistant Professor	140	106.73	2.89	0.23
	Associate Professor	55	110.94		
	Professor	22	118.64		
Technical Challenges	Assistant Professor	140	88.58	45.83**	0.00
	Associate Professor	55	138.25		
	Professor	22	165.82		
Financial Challenges	Assistant Professor	140	85.69	56.06**	0.00
	Associate Professor	55	149.55		
	Professor	22	155.95		
Knowledge Challenges	Assistant Professor	140	89.87	41.19**	0.00
	Associate Professor	55	151.77		
	Professor	22	123.82		
Cultural and Social Challenges	Assistant Professor	140	96.94	15.83**	0.00
	Associate Professor	55	133.55		
	Professor	22	124.39		
Overall Challenges	Assistant Professor	140	86.10	53.80**	0.00
	Associate Professor	55	148.45		
	Professor	22	156.09		

Note:

Partial Confirmation of the Hypothesis:

- Statistically significant differences exist in the perception of the role of green technology, specifically in the dimension of **Quality of Green Infrastructure**, favoring **Assistant Professors**. This suggests that assistant professors perceive the quality of green infrastructure as a greater contributor to sustainable development than other academic ranks.
- Significant differences were found in perceptions of overall challenges, as well as **Technical** and **Financial Challenges**, favoring **Professors**.
- **Associate Professors** showed significant differences in **Knowledge** and **Cultural and Social Challenges**, indicating that they view these as more substantial barriers

2.9. Sampling Procedure and Data Collection

A purposive sampling technique was employed to select faculty members from various colleges at Imam Abdulrahman Bin Faisal University, as the study targeted individuals directly involved in teaching and e-learning practices. The questionnaire was distributed electronically using the university's official communication platforms and email system to ensure accessibility and broad participation across

disciplines.

A total of 217 valid responses were collected and included in the final analysis. Participation was voluntary, and respondents were informed of the study's purpose and the confidentiality of their responses prior to completing the survey. To reduce potential non-response bias, multiple reminder messages were sent during the data collection period to encourage participation from different academic departments.

3. DISCUSSION

The current study sought to examine whether statistically significant differences exist in faculty members' perceptions of the role of green technology in sustainable development and its associated challenges, based on gender, college type, and academic rank. The statistical analysis revealed nuanced insights, which are discussed as follows:

Gender Differences: The results showed partial support for the hypothesis related to gender differences. Specifically, statistically significant differences were found in the dimension of quality of education and training in favor of female faculty members, and in quality of green infrastructure in favor of males. This suggests that female participants are more likely to perceive education and training as key contributors to enhancing the role of green technology in sustainable development, which may be attributed to their greater involvement in teaching and student engagement roles that emphasize educational quality and sustainability awareness. On the other hand, male faculty members viewed the university's green infrastructure more positively, perhaps reflecting their involvement in administrative or technical roles related to facilities and infrastructure. Moreover, females reported significantly higher perceptions of technical challenges, indicating a heightened sensitivity or awareness toward obstacles in applying green technologies, such as lack of digital systems or renewable energy tools. This could reflect differing experiences with technological resources across departments or genders. No statistically significant gender differences were observed in the overall perception of green technology's role or other dimensions of challenges, indicating a general consensus between male and female faculty members in these areas.

Differences by College Type: Significant differences were also found based on the type of college. Faculty members from Arts and Education colleges showed the highest mean ranks in their perception of the role of green technology across all dimensions. This finding may reflect the growing emphasis in these fields on sustainability integration into curricula and community service. In contrast, faculty from Science and Management colleges perceived higher levels of technical, cultural, and social challenges, which may be attributed to their practical exposure to technological applications and policy-related barriers. Meanwhile, Health colleges perceived financial challenges more acutely, possibly due to the high costs associated with medical technologies and infrastructure upgrades. Interestingly, Science and Management colleges also expressed stronger concerns about knowledge-related challenges, likely reflecting their awareness of gaps in training or research in green technology fields. These differences indicate that each discipline has its unique context in implementing green practices, and therefore, tailored strategies are needed to address specific barriers and promote sustainable practices effectively.

Differences by Academic Rank: Regarding academic rank, statistically significant differences were identified in several dimensions. Assistant Professors demonstrated stronger agreement with the role of green infrastructure in promoting sustainability. This could be due to their active involvement in research or recent exposure to modern teaching environments that emphasize green facilities. Conversely, Professors perceived greater technical and financial challenges, possibly due to their broader institutional perspective or leadership roles that expose them to budgeting and strategic planning difficulties. Associate Professors, meanwhile, reported higher perceptions of knowledge, cultural, and social challenges, reflecting their experience in curriculum development or societal engagement initiatives. These findings suggest that academic experience and responsibilities influence how faculty members view both the potential and obstacles of green technology in achieving sustainable development.

4. CONCLUSION

This study explored faculty perceptions of green technology's role in sustainable development and related challenges. Findings showed overall positive views, especially regarding environmental awareness, education quality, and infrastructure. Gender differences indicated that females valued training more and perceived greater technical challenges, while males emphasized infrastructure. Differences by college type revealed stronger support among arts and education faculty, and more concerns about challenges among science and

management faculty. Academic rank influenced perceptions, with assistant professors focusing on infrastructure and senior faculty on challenges. These results highlight the need for tailored strategies in implementing green technology. Universities should address technical, financial, and cultural barriers to enhance adoption. A context-specific approach is essential. Future research may examine institutional policies and support mechanisms.

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Declarations

Funding: No funding was received for this study.

Ethics Statement: Ethical approval was not required for this study, as it involved voluntary participation of faculty members through anonymous surveys and did not include any clinical or experimental interventions.

Consent to Participate: Consent to Participate declaration: not applicable.

Consent to Publish: Consent to Publish declaration: not applicable.

Data Availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest: The authors declare no conflict of interest.

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