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University students' awareness of eco-friendly technology and reception of digital short messages

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ABSTRACT

Universities are increasingly expected to advance sustainability awareness. Yet little is known about how students in Saudi higher education receive short eco-friendly technology messages distributed through campus digital channels. This mixed-method descriptive study also empirically examined student eco-tech micro-message exposure and further tested student eco-tech micro-message reception (attention, comprehension, cultural salience, design appeal, credibility, and perceived impact). Three hundred and twenty six students (180 males, 146 females) filled out a questionnaire. Cross-channel exposure was low and awareness as well as the general eco-awareness was high. Positive relation between message exposure and total awareness (r =. 36, p <. 01) and with all three aspects of response/awareness (r =. 19–. 34). A gender difference was only found for exposure, rated higher by males (d = 0.33), and not for recognition. The qualitative track (about 120 relevant answers) found that students are mostly fans of social media and messaging apps (especially WhatsApp), because they are habitual and instantaneous. 71 Successful messages were brief, actionable, and culturally relevant often involving moral–religious framing and simple analogies. Some students suggested clearer sourcing, stronger connections to Vision 2030, specific examples of what could be implemented on campus and cleaner visual design. The findings indicate that to increase the educational value of eco-tech micro-messages for Saudi Universities, it is necessary to improve distribution mechanisms as well as adopt microlearning techniques into culturally relevant message design.

KEYWORDS: eco-friendly technology, microlearning, cognitive load theory, media reception, Saudi higher education

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Introduction

The UN has identified environmental sustainability and green technology as integral components of global development priorities, raising the anticipation that universities have an obligation to be environmentally responsible and commit themselves to present issues of student awareness towards sustainability (Alshammari, 2025; Lozano et al., 2013). Institutions of higher education are identified as important agents for change to drive such curricular reforms because they can infuse sustainability throughout operations, curriculum and daily activities (Too & Bajracharya, 2015) helping students develop environmentally friendly values and behaviors.

In parallel with these responsibilities, contemporary university has become a highly mediated environment in which institutional communication is increasingly delivered through digital platforms. Short-form digital messages (short texts or visuals sent through LMS, campus display screens, official social media and messengers) are commonly used to engage students, coinciding with mobile media usage trends and the on-demand preference of content (Díaz Redondo et al., 2021; Torgerson & Iannone, 2020). These types of messages can be used as microlearning opportunities: brief, repeated information that potentially aids retention, engagement and recall (and reduces cognitive overload) (Shail, 2019; Sweller, 2020). Repeated intermittent exposure to short sustainability encouragement messages may be used as an opportunity to ramify key concepts and incite daily eco-friendly acts among the student cultures (Garcia et al., 2022; Shail, 2019).

It is an explicitly nationalized issue in the case of Saudi Arabia, thanks to Vision 2030 and efforts like the Saudi Green Initiative that have raised public awareness regarding environmental concerns and eco-friendly technologies (Khan, 2022). Despite such policy focus, education for sustainable development has been characterized as taking long time to become operational in formal education and that references within the policy can more generally remain general with little guidance for implementation (Essa and Harvey 2022). When formal curricula do not consistently provide detailed sustainability learning opportunities, informal and co-curricular communication channels become important for strengthening awareness.

While research suggests that education and media may interact to cultivate environmental awareness and pro-environmental inclinations, it has mostly revolved around mass campaigns, activism or formal curricular interventions as opposed to the routine micro-level communications embedded in daily university life. This discrepancy is more exaggerated in the context of Saudi Arabia. Prior work suggests that media exposure is associated with greater ecological knowledge and greener self-reported behaviors among university students (Widdatallah & Abdallah, 2026). Little was known about the quality of micro-messages from universities or how students evaluated them. If short eco-tech messages are clear, culturally relevant and action-oriented and if students believe these messages to be credible and motivating is crucial information for designing effective communication regarding sustainability.

In addressing these gaps, this article investigates students' reception of digital short messages on eco-friendly technology disseminated in a Saudi university context. It asks: (1) What are the characteristics and quality of current digital short messages about eco-friendly technology disseminated in the university? (2) How do science students receive and interpret these messages, and to what extent is their exposure associated with environmental awareness? (3) What improvements do students recommend enhancing the effectiveness of digital eco-friendly messages? Employing an explanatory mixed methods design, the research combines quantitative measures of exposure and reception/awareness with qualitative evidence that explains what students see, believe in, remember and want to change.

Literature Review and Theoretical Framework

Education for Sustainable Development (ESD) in Higher Education

ESD provides an overarching pedagogical rationale for communicating eco-friendly technologies to university students. Environmental education contributes towards the broader discourse of ESD supported by UNESCO and in line with UN Sustainable Development Goals (SDGs), which seeks to embed sustainability across all levels of education, so that learners acquire relevant knowledge, skills and values to contribute to a sustainable future (Hajj-Hassan et al., 2024). Research in the field of education and learning has been focused on exploring how educational policy and practice bring about sustainability transitions to date, in which ESD research has flourished in varied policy contexts (Lysgaard et al., 2015) since SDGs were integrated into the discussion. SDG 4.7 specifically calls for education that promotes sustainable development, including environmental sustainability and an understanding of practices and technologies that protect ecosystems (Kopnina, 2017).

In universities, ESD is often discussed as both a curricular and an institutional mission. A living laboratory or campus as a classroom strategy to sustainability is an approach that creates space in the university environment, operations and infrastructure, and student life for environmentally responsible practices to be modeled. Sustainability in higher education supports a holistic institutional approach for embedding sustainability in student learning outcomes (Lozano et al., 2013). Community involvement is key: a "sustainable campus" perspective emphasizes learning to engage students and employees in sustainable initiatives, because awareness does not necessarily have the same impact as shared norms and mutual action (Too & Bajracharya, 2015).

Implementing ESD typically requires approaches beyond traditional didactic instruction. Project based learning, participatory campaigns, and experiential activities assist students in relating sustainability to the daily choices they make and their local communities (Lay, 2019). Yet, ESD integration is uneven among regions and institutions. Within Saudi Arabia, documentary analysis of media and policy documents reflect that although the national strategies provide a strong sense of sustainability, the actual practical directions for integrating ESD into formal education can be vague about implementation and

assessment (Essa & Harvey, 2022). Empirical studies of Saudi universities also support the existence of institutional barriers and differences in campus sustainability maturity, suggesting that turning sustainability rhetoric to visible actions demands commitment from organizations and alignment of resources (Alshammari 2025).

In such contexts, informal and co-curricular learning opportunities can complement formal curricula. These types of points around sustainable living being spread by university communications might offer a low-cost, scalable reinforcement of ESD. These micro- level channels can prioritize certain eco-friendly technologies and behaviors (such as environmentally friendly equipment, waste classification, and reusable products) and support these in terms of institutional image, national strategies and student life. Therefore, evaluating the quality and reception of short sustainability messages is relevant to understanding how universities can operationalize ESD in everyday practice.

Digital Tools, Social Media, and Environmental Education

The use of digital technologies is being acknowledged as a leveraging instrument for environmental education, favoring the access to information, interactive learning and immediate dissemination of campaigns awareness. One systematic review of environmental education research relating to digital tools identified emerging evidence that digital media could promote sustainability knowledge when tools are in harmony with pedagogical needs and local conditions (Hajj-Hassan et al., 2017). On the other hand, research at the crossroads of environmental education and ICT underlines that technology can be conducive to environmental education through multimedia explanations, interactive resources, and immediate communication for example when learning experiences are made real and exciting (Lay, 2019).

Social media is a unique setting for environmental communication that combines high potential reach with participatory features. Recent studies suggest that the use of social media can influence environmental awareness in terms of gaining more exposure to environmental information and facilitating peer conversations. For instance, studies of access and usage patterns of WeChat in China suggest that exposure to social media can even influence environmental awareness. Nonetheless, these effects may differ for subgroups and are conditional upon pattern of usage (Xie et al., 2024). In terms of cross-cultural research, social media usage with respect to environmental awareness has been studied in Saudi context which explores associations between visiting social media website and the information it provides may influence individuals' understanding and application of the information they found on those websites (Alsahafi, 2020).

However, social media also poses challenges. Attention is divided, quality of content varies and education messages vie entertainment. Despite the many benefits, frequent use of social media among Arab university students' presents with gratifications as being connected and entertained along with costs as distraction and information overload (Abu Backer & Awad, 2025). For universities, these considerations mean that content needs to be short, appealing and only treated as of value in the race for attention if also relevant and newsworthy. Therefore, the format and design of a message is much more critical.

Institutional Sustainability Communication on Campus

Universities communicate sustainability not only through curricula and large initiatives but also through routine institutional messaging that shapes campus norms. Campus sustainability scholars have emphasized that the involvement of university community members (i.e., active participation in mobilizing) is crucial for the program's success: students conceptualize sustainability as meaningful when they learn about it through having experiences of it being practiced on campus rather than see it at a distance, appearing merely as rhetoric around policy documents (Too & Bajracharya, 2015). Global considerations on higher education for sustainable development also point out that the institutional strategy must be translated into everyday practice and communication, thus making sustainability visible, repeated, and reinforced through social networks (Lozano et al., 2013).

In Saudi Arabia, translating sustainability commitments into campus practices can pose institutional and organizational challenges. Faculty views at Saudi universities indicate that sustainability situations can be limited by governance models, the availability of resources, and differing institutional priorities (Alshammari 2025). And in such an environment, communication is a usable lever: Communication that sends consistent messages that position priorities, render expected behaviors as common protocol, and relate what the individual does on behalf of the institution. Short digital messages can serve as micro-prompts that repeatedly signal what counts as sustainable behavior on campus (such as saving energy, sorting waste, or reducing single-use plastic), thereby supporting the development of pro-environmental norms.

Short messages can also bridge the gap between macro-level sustainability agendas and micro-level daily choices. Messages that specifically connect campus actions to a national sustainability agenda (e.g., Vision 2030 and SDGs) can help students regard sustainability as part of civic engagement rather than place an emphasis on personal responsibility alone (Khan, 2022; Kopnina, 2017). Meanwhile, successful institutional communication should be clear of abstractions. Messages citing specific campus locations and behaviors (e.g., recycling bins in buildings, water conservation in restrooms, or paper usage for course work) appear to be most successful at eliciting a response from students. This suggests that message quality is in part a factor of contextual pertinence. The closer a message hews to students lived routines, the more readily it can be translated into action.

Finally, campus messaging can complement formal ESD by providing repetition and timing that traditional courses cannot always achieve. Because micro-messages can be distributed across weeks and semesters, they can create a sustainability rhythm that keeps key ideas salient. This is consistent with more general ESD claims that sustainability learning benefits from

when learners are exposed to (coherent) messages across settings, classes, hierarchical levels of the implementing institution and its local environment (Hajj-Hassan et al., 2024; Lysgaard et al., 2015).

Microlearning and Short-Form Digital Content

Microlearning is when small learning units are structured in a short time frame and with an individual way of completion. Microlearning developed in response to the new media environment and the needs of work-based learning, which stressed flexibility; repetition; and interweaving of content into everyday practice (Hug, 2005; Hug & Friesen, 2009). In higher education and corporate training, microlearning has been conceptualized as a useful medium to provide small learning units via mobile means so that learners can repeat the information repeatedly when needed (Torgerson & Iannone, 2020).

Design rules for mobile microlearning are around brevity, attention and responding to what technology can do. Jahnke et al. (2020) posits that engineering for mobile microlearning is most effective when design chunks of learning are conspicuously defined, bite sized for easy uptake, and followed by a period of reflecting and applying. In online and blended learning environments, microlearning has also been described as a tool for engaging students, maintaining attention, and encouraging continuous learning through bite-sized tasks (Semingson et al., 2015).

A key practical question is how microlearning units are delivered. Universities often rely on existing platforms such as LMS announcements, email, and official social media. The integration of microlearning content into traditional e-learning platforms also shows that micro-units can be incorporated in existing systems, but the design and usability should be adjusted to platform restrictions (Díaz Redondo et al., 2021). The incorporation of micro-learning and social media has come into play. A recent review of literature argues that social media can help in microlearning through quick and easy sharing, short form multimedia and peer engagement but also highlight credibility and distraction challenges (Denojean-Mairet et al., 2024).

Short-form video platforms have further normalized micro-content. Research of "nanolearning" (e.g., Ahmadi et al., 2022) has revealed that TikTok can be leveraged to learn in informal settings, evidencing that learners may absorb chunks and pieces of skills and concepts through short, repeated clips. In the line of environmental communication, in analyzing TikTok posts on climate issues and emotionalism are among the most common types of social actors and persuasive style, stories about emotions with emotional production of arguments seem to be effective (Dubey et al. predictor for interaction 2025). These results illustrate the important point that micro-learning content can serve educational purposes if it is cognitively controllable and socially engaging as well.

Microlearning design also raises questions about sequencing and reinforcement. Guidance for designing microlearning emphasizes that micro-units need to be logical. A logical flow of ideas in the completed product may be spaced over time should also provide opportunities to apply learning (Torgerson & Iannone, 2020). It appears from reviews that repetition and spacing are the retention heroes, especially when students come back to key ideas in multiple ways (Shail, 2019). For sustainability communication, this means that universities should not rely on one-time posts. They should spread out a consistent pool of micro-messages on the same paths (e.g., saving energy or conserving water) over the course of several weeks and across channels, changing examples and visuals to maintain interest.

Research in microlearning and social media also stress the importance of being brief yet accurate. At the same time, short messages imply opportunity cost risk of simplifying too much or very partial deletion of evidence and therefore loss of trust (Denojean-Mairet et al., 2024). Good micro-messages consist of a basic statement possibly along with an optional path to further information (e.g. QR code or link). This layered approach means that students who want more detail can get it, without adding to cognitive load for those who only lightly engage.

Cognitive Load Theory and Instructional Message Design

Cognitive Load Theory (CLT): A central tenet of CLT explains why microlearning and short messages can help learning. According to CLT, working memory is capacity limited; thus, effective learning materials should minimise intrinsic cognitive load, eliminate extraneous load and support germane processing that leads to the construction of schemata (Sweller, 2020). In the case for eco-tech micro-messages, if micro-message provides one relatively simple message (e.g., "turn off unused devices"), its intrinsic load is low, but once there is the introduction of technical terms or more than one idea at a time, it grows very fast. Extraneous load is particularly important for short messages sent as mobile notifications or displayed on digital screens, which students tend to see while on the go or in-between activities. Poor layout, small type size, or dense text and distracting graphics may increase extraneous load so that messages will not be read or remembered. Design in instructional message stresses readable typographical, clear data hierarchy and visual organization (Ramlatchan, 2021). In micro-content these design principles are not optional, since in just seconds, recipients decide to pay attention to the message.

The instructional design literature also suggests that visuals can be powerful when they align with the message goal. Meaningful images, pictures or graphic icons and simple sketches can facilitate comprehension and enhance retrieval, while decorative imagery may interfere with learning (Ramlatchan, 2021; Sweller 2020). When it comes to green tech messages, tried and true images would also be those such as recycling or water icons, energy or transportation icons, before and after shots of waste reduction. Due to this reason, the present study investigates how students perceive the visual clarity and design appeal in relation to message reception.

Beyond readability, message design choices also influence perceived professionalism and trust. In digital environments, audiences frequently use surface cues (such as layout consistency, spelling accuracy, and visual balance) to infer whether

content is credible. From an instructional message design standpoint, consistent use of templates (colors, typefaces and logo placement) also serves to help learners begin processing information with the confidence of authenticity by reducing the time it takes to orient within a message (Ramlatchan, 2021).

In eco-tech communication, this can be especially important when messages circulate across multiple channels, because inconsistent designs may be mistaken for unofficial or promotional content. Thus, designing for CLT is not just about cutting copy; it is also about carefully selecting to minimize search effort and direct attention to the intended action (and provide optional old evidence cues without increasing extraneous load (Sweller, 2003).

Reception Theory, Credibility, and Cultural Resonance

Message reach is not enough if messages are misinterpreted by audiences. Reception theory in cultural studies claims that it is audiences who create meanings rather than the media and argues that rational media producers treat their content as a series of linked messages using theories of story sequence or montage to construct an audience's multi-interpretive fantasies. According to Hall encoding/decoding model, audiences could take the dominant reading (in line with the messaged intent), negotiate reading or oppositional readings heading upon the given social context and knowledge of people. In sustainability communication, this implies that the same message may be interpreted differently across student groups, depending on how it aligns with local norms and perceived institutional legitimacy.

Reception theory has also been applied to environmental communication, such as the role of eco-labels and how audiences interpret environmental signals and claims. Reception processes influence the extent to which environmental cues are trusted, understood and accepted (Mariam, 2021). Likewise, eco-tech messages from university sources may be evaluated in terms of content as well as by perceived motivations and quality of the organizations that sponsor them.

Credibility is a particularly salient issue in digital environments where misinformation is common. Messages from authorities with verifiable content that do not overstate risk may help students perceive messages as credible. These cues can be conceptualized in terms of reception theory (Hall, 1997); institutional identity and evidence may lead to dominant readings while ambiguity might engender negotiated or oppositional readings.

Cultural resonance is also essential. There are Islamic ethical principles in Saudi Arabia that provide an affordable and efficient way of achieving stewardship. An Islamic perspective on environmental education would focus on beliefs such as moderation, stewardship and avoiding harm while also integrating culturally relevant materials for securing sustainability (Setianingrum et al., 2024). Messages that employ the common moral language may resonate more positively and enhance motivation.

Uses and Gratifications, Exposure, and Pathways to Awareness and Behavior

Uses and gratifications theory complements reception theory by focusing on why audiences choose certain channels and attend to certain messages. The approach argues that individuals use media to satisfy needs such as information seeking, social interaction, entertainment, and identity maintenance (Katz et al., 1973). For college-age students, these expectations drive platform choice: messaging apps and social networking are used in a sustained manner for socialization and coordination, so they are high-opportunity channels for micro-messages.

Among Arab university students, intensive social media use is associated with multiple gratifications but also with risks such as distraction (Abu Backer & Awad, 2025). The fact that micro-messages must also deliver an immediate return (whether in terms of information, usefulness or identity-relevant framing) to be recognized and remembered is thereby implied. It also implies universities should consider channel fit: a message might be well designed, but not effective when sent using low-attention channels or at times students are unlikely to engage.

There is empirical evidence for the importance of exposure. Findings on social media studies reveal that exposure to environmental content raises scrutinization (Kazin et al., 2018). University students, who are exposed to the mass media, associate environmental literacy with pro-environmental behaviors (Widarath & Abdallah, 2012). This rhetoric about sustainability is likewise shaped by national levers and policy narratives in Saudi Arabia where citizens are expected to contribute to the SDGs as environmental sustainability outcomes (Khan, 2022). Therefore, eco-tech micro-messages may contribute to awareness by repeatedly foregrounding sustainability concepts, presenting practical behaviors, and linking actions to national and institutional identity.

Behavioral change, however, is not automatic. The Theory of Planned Behavior proposes that attitudes, perceived social norms, and perceived behavioral control shape behavioral intentions and behaviors (Ajzen, 1991). Micro-messages could impact these factors by establishing (a) positive attitudes towards eco-friendly technology, (b) awareness that it is socially normative to behave sustainably on campus, and (c) feasible means for increasing perceived control. This study, therefore, measures perceived impact on awareness and behavioral intentions as part of reception and qualitatively explores students' self-reported behavioral changes attributed to the messages.

Short-form environmental communication also benefits from understanding what drives engagement and sharing. Content analyses of platforms such as TikTok reveal that environmental messages are frequently hidden inside stories, jokes or identity performances. Such emotional or narrative content might result in increased place engagement compared to purely factual postings (Dubey et al., 2025). Universities can create micro messages that contain light story telling (mini localized scenario or campus story) but the information should still be true and clear. Yet, short-form formats can amplify credibility

issues if messages seem generic or unsubstantiated. Students could be dubious about environmental messages, unless they identify the source and if the latter is an institutionally known name in an information environment that media's bombarding audiences at a fast pace with mixed quality of information (Abu Backer & Awad, 2025; Mariam, 2021).

Conceptual Framework for the Present Study

Bringing together these considerations, this study defines digital short messages on green technology as microlearning-based-informal-ESD interventions that are mediated through the university's communication channels. Quality of message is a function of clarity, brevity, cues to veracity, cultural salience and graphic design (Ramlatchan, 2021; Sweller, 2020). Exposure represents the extent to which students encounter these micro-messages across channels.

The framework proposes that exposure increases opportunities for message processing, and that reception processes mediate the relationship between exposure and awareness and intentions. When messages are cognitively manageable (CLT), culturally relevant (reception theory), and accessed through preferred formats and channels (uses and gratifications), students will be more likely to attend to, understand, believe, and find such messages relevant. These reception effects will be associated with greater environmental knowledge and higher intentions of green behavior. The study quantitatively tests associations between exposure-awareness and, through qualitative data, examines the message features and communication practices students perceive to make them more effective.

Operationally, evaluating micro-messages in a university requires attention to both message properties and audience experience. Message characteristics were topical focus (technology versus general conservation), action recommendations specificity, and the presence of credibility cues (e.g., official job title or sources). Audience experience comprises attention, understanding, perceived relevance and impact. Such a merging of indicators is consistent with the study's reception-based focus and enables researchers to progress beyond mere exposure counts. Such an approach further allows for ESD assessment by being able to establish which message-content aspects are considered educational vs. generic reminders (Hajj-Hassan et al., 2024; Ramlatchan, 2021).

Methodology

Design

The research followed a mixed-analytical descriptive (triangular) model that focused on exposure and reception of digital technology (and about ecological safeness) short text messages in higher education context at Saudi Arabia. The amount of exposure that students received across mediums, including their levels of perceived reception and eco-consciousness, were then quantitatively analyzed based on survey responses. Open-ended qualitative responses were employed to describe students' understandings, memorable messages, perceived barriers and needs for improvement. This integrated approach permitted the study to cross-validate quantitative patterns with qualitative information that derives from what students say.

Participants and Context

Participants were 326 university students enrolled in science-related programs (180 males, 146 females). Participants were students in a Saudi Arabian public university that broadcasts sustainability-focused micro-messages across a variety of online platforms, such as campus screen displays, LMS notifications, official social media accounts, university-wide email lists and informal student messaging groups. The emphasis on science students is justifiable as eco- friendly technologies and environmental sustainability are frequently referred to in scientific- based curricula, which may influence baseline recognition and concern.

Research Questions

RQ1: What are the characteristics and perceived quality of current digital short messages about eco-friendly technology disseminated in the university?

RQ2: How do science students receive and interpret these messages, and to what extent is their exposure associated with environmental awareness?

RQ3: What improvements do students recommend enhancing the effectiveness of digital eco-friendly messages?

Measures and Data Sources

The survey contained a closed question and an open-ended qualitative question. The exposure scale explored: how often students receive eco-friendly technology messages through five channels; campus digital display boards, the LMS, university social media accounts, email from university and informal student's WhatsApp or other student channels. Each is a channel-specific measure of exposure and a total score for exposure was created by summing the five items.

Reception and eco-awareness were measured by six dimensions (five items in each): attention and engagement, comprehension, cultural/ context relevance, attractiveness/ design/ presentation, trust and credibility, perceived effect on awareness and behavioral intention. Items were rated on a Likert-type scale, and dimension scores were computed by summing item responses (range 5–25). The overall awareness score represented the sum across 30 items (range 30–150).

Open-ended questions prompted students to: (a) identify the best channels for message receipt and explain why; (b) recall a message that captured their attention and what in particular about it was memorable; (c) discuss what made some

messages hard to understand and offer suggestions for improvement; (d) specify how messages could be more representative of campus and local values; (e) propose design improvements; (f) indicate what raised confidence in message claims, and (g) describe a subsequent behavior or decision that they attributed to reading the most recent message.

Quantitative Data Analysis

Quantitative analyses were performed with IBM SPSS (®) 25. Exposure and each reception/awareness dimension were described as means and standard deviations by descriptive statistics. Differences between male and female students in exposure and awareness-related constructs were tested using independent-samples t tests. Pearson correlations were used to test relationships between exposure and dimensions of awareness, and the overall one awareness score. Statistical significance was claimed at $p < .05$, and correlations between $p < .01$.

Prior to inferential analysis, survey data were screened for completeness and plausibility. Descriptive inspection was used to identify missing responses and extreme values. Assumptions for group comparisons (approximate normality and variance equality) were considered when interpreting t-tests. Because the study is descriptive, results are interpreted in terms of both statistical significance and practical magnitude (e.g., the effect size for the exposure difference) rather than relying solely on p values.

Qualitative Data Analysis

Qualitative responses were analyzed using thematic analysis (Braun & Clarke, 2006). In preparation, all open-ended responses were reviewed and cleaned to remove blank entries and answers unrelated to eco-friendly technology or sustainability (e.g., "no answer," unrelated personal updates, or commercial promotions). Post-cleaning, about 120 responses were available for thematic analysis.

Coding proceeded iteratively. Responses were then organized according to question (channels, memorable messages, barriers, localization, design, credibility and behavior change). For each group, recurring ideas were labeled and iteratively defined at higher levels as common beliefs and opportunities for intervention. Themes were checked against the data for coherence and distinctiveness. Representative excerpts were translated into English for reporting while preserving meaning and contextual nuance.

To increase qualitative trustworthiness, the analysis maintained an overt connection between codes and raw response data by ensuring examples were retained for each theme and checking back to previous coding decisions as themes developed (Braun & Clarke, 2006). Translations were made with cultural and semantic conservatism in mind; when culturally bound terms were employed, a translation or paraphrase was intended to replicate the sense of the original (e.g. moral framing) as well other than to be literally, word-for-word equivalents. Reported themes highlight consistent patterns expressed in the responses and are directly relevant to the research questions.

Findings

Quantitative Findings

Exposure to digital eco-tech micro-messages (RQ2)

Students reported below-average exposure to eco-friendly technology messages across university channels (total exposure score: $M = 13.48$, $SD = 4.14$). At the channel level, university social media platforms were identified as the most attended to communication channel ($M = 3.25$; $SD = 1.20$), followed by campus digital signage ($M = 2.96$; $SD = 1.14$). Low exposure was reported via the LMS ($M = 2.40$, $SD = 1.18$), university email ($M = 2.38$, $SD = 1.31$) and student-centered informal WhatsApp channels ($M = 2.49$, $SD = 1.25$). This profile suggests that students are more likely to encounter eco-tech micro-messages through public-facing social media rather than through formal instructional systems or email-based communication.

Table 1

Descriptive statistics for exposure to eco-tech micro-messages by channel

Channel	Example item	M	SD
Digital display boards	I see short eco-tech messages on the university's digital screens.	2.96	1.14
LMS	I receive similar messages through the learning management system (LMS).	2.40	1.18
University social media	I view this content via the university's social media accounts.	3.25	1.20
University email	I receive sustainability-related messages via university email.	2.38	1.31
Student WhatsApp/other channels	Environmental messages appear in student WhatsApp groups or informal channels.	2.49	1.25
Total exposure score	Sum of 5 items.	13.48	4.14

Note. Higher values indicate greater self-reported exposure.

Reception, eco-awareness, and perceived message quality (RQ2)

Across reception/awareness dimensions, students reported above-average scores. Interest and engagement were high (M = 18.71, SD = 3.29), suggesting that many students will stop and read brief environmental messages and consider them interesting compared to other college communication. above average comprehension levels (M = 18.55, SD = 3.02), indicating that the messages are perceived as being clear, focused and comprehensible. Cultural and contextual acceptability (M = 17.58, SD = 3.25) as well as attractiveness/design (M = 18.47, SD = 3.03), were above average for the statements suggesting that students overall found the messages to be reflective of local mores and to be visually legible. Trust and credibility were also both above average (M = 18.49, SD = 3.30), which indicates that many messages would be interpreted as originating from a trusted source or providing true information. The effect of messages on awareness and behavioral intentions was also above average (M = 18.34, SD = 3.43), which shows agreement that messages can increase knowledge and encourage feasible/sustainable actions. Overall awareness across all items was high (M = 110.15, SD = 16.06), indicating a generally strong awareness profile among the sample.

Table 2

Descriptive statistics for reception/awareness dimensions

Dimension	M	SD
Attention and engagement	18.71	3.29
Comprehension	18.55	3.02
Cultural and contextual relevance	17.58	3.25
Attractiveness and design	18.47	3.03
Trust and credibility	18.49	3.30
Perceived impact on awareness and intentions	18.34	3.43
Overall awareness (30 items)	110.15	16.06

Note. Dimension scores represent sums of five items per dimension (range 5–25). Overall awareness is the sum across 30 items (range 30–150).

Gender differences (RQ2)

Independent-samples t tests indicated a statistically significant gender difference only in exposure. Males reported higher exposure (M = 14.08, SD = 4.41) than females (M = 12.75, SD = 3.65), t (324) = 2.92, $p < .05$. The effect size was small (Cohen's d = 0.33). No significant gender differences were found for attention and engagement, comprehension, cultural relevance, attractiveness/design, trust/credibility, perceived impact, or for the total awareness score (male M = 110.37, SD = 16.96; female M = 109.89, SD = 14.93). These results suggest broadly similar reception and awareness profiles across genders once exposure is accounted for.

Table 3

Gender differences in exposure and overall awareness

Variable	Male M	Male SD	Female M	Female SD	t(df)	p
Exposure (total)	14.08	4.41	12.75	3.65	2.92(324)	< .05
Overall awareness (30 items)	110.37	16.96	109.89	14.93	0.27(324)	n.s.

Note. n.s. = not significant.

Associations between exposure and awareness (RQ2)

Every dimension of awareness was significantly and positively related to exposure ($p <. 01$). The coefficient of correlation ranged between r =. 19 (by attractiveness/design) to r =. 34 (cultural/contextual=relevant) as well as the total awareness score (r =. 36, $p <. 01$). The strongest relationship was between exposure and cultural/contextual relevance, implying that drivers of message exposure are grounded in the values on campus or in the local community with which messages resonate. Although the effect sizes were small, they replicated across factors, suggesting that message exposure is meaningfully linked to students' profiles of reception and awareness.

Table 4

Correlations between exposure and awareness dimensions

Outcome	r with exposure
Attention and engagement	.334**
Comprehension	.301**
Cultural and contextual relevance	.344**

Attractiveness and design	.193**
Trust and credibility	.319**
Perceived impact on intentions	.296**
Overall awareness	.360**

Note. ** $p < .01$.

Qualitative Findings (RQ1 and RQ3)

The qualitative data reports on what students recall message-wise, which channels they felt were effective, and where improvements could be made. The cleaning action consisted of filtering out no-responses and answers not about sustainability (i.e., "I don't know," events in personal life, commercial ads), which yielded around 120 relevant responses for the analysis.

RQ1: Characteristics and perceived quality of current messages

Through recruited examples, messages were generally short and akin to slogans, emphasized simple environmental practices. Cleanliness, water conservation, energy saving, recycling and planting of trees were the messages most often remembered. Many were framed in culturally familiar moral language (e.g., "Cleanliness is part of faith"), which students described as memorable and motivating. Explicit mentions of eco-friendly technology and its related policy narratives (e.g., Vision 2030) seemed to be less common in institutional messaging that students could recall, indicating the enduring influence of conventional eco-moral slogans relative to newer messaging about technology. While students either reported that message with visuals (photos, icons, or short videos) were more memorable and caught their attention. Across responses, participants rarely referenced specific eco-technologies (e.g., renewable energy), suggesting an opportunity to diversify topics beyond general conservation.

RQ3: Students' recommendations and perceived improvements

Recommendations were categorized into six topics corresponding to the open-ended prompts: preference of channels, attention-grabbing elements, barriers in comprehension, localization strategies, design refinements and credibility indicators. Students also described behavioral changes they attributed to messages, such as reducing plastic, saving water, and turning off devices.

Theme 1: Social media and messaging apps are perceived as the most effective channels

Most students nominated social media and instant messaging (especially WhatsApp) as the most effective channels for receiving eco-messages. Their rationales focused on speed, practice and timely feedback. WhatsApp is the easiest, one student said, because it's "always available," while others passed along that Facebook and WhatsApp groups are where "college groups and friends" share daily information. Clearinghouse email was considered good for records and not so good for immediate attention, especially for students who do not check it frequently.

Theme 2: Memorable messages rely on culturally familiar framing, emotional resonance, and actionable tips

Students most often recalled short, familiar, and value-laden messages. Lots of examples invoked moral or faith-based framings, like "Cleanliness is half your faith," which students found to be motivating and locally relevant. Others emphasized metaphorical or emotive language, such as the phrase "Our planet breathes when we cut plastic," which students said they found powerful because it was short and symbolic. Practical tips were easy to remember, as they were also applicable in daily life (e.g., "Turn off the unused equipment and you will save energy," "A drop of water equals life", reminders of using a reusable bottle or reducing printing). Overall, messages students remembered best were focused on a single idea and included a specific call to action.

Theme 3: Barriers to understanding include complex language, excessive length, and weak visual readability

Students claimed that messages can be challenging to comprehend when inundated with technical vocabulary or more formal language or being too long. Several students cited English terms as a barrier, while others described messages as "scientific language without explanation." Visible barriers consisted of small fonts, crowded designs and inadequate spacing that made messages difficult to read quickly on walls or screens. Recommended enhancements included simplifying language, using short sentences, structuring content in bullet form and augmented with icons or pictures to illustrate meaning.

Theme 4: Students want stronger localization to campus life, local environmental issues, and national initiatives

To enhance relevance, students requested that messages be linked with daily campus activities, such as waste bins, classrooms, bathrooms (with water) and cafeterias (with plastics). They also suggested linking the messages to local environmental threats (like water shortage and high energy consumption) or national trends such as Vision 2030 or green efforts. One conventional recommendation was to link sustainability advice with religious, cultural values without using a completely directive tone. Students argued that messages feel more persuasive when they reflect "our habits and traditions" and when they include examples from the university itself.

Theme 5: Design improvements emphasize clarity, attractive visuals, and institutional identity

Color that complements, larger fonts with greater legibility, better balance in spacing and a cohesive visual presence in alignment with the university were just some of the ways students suggested design enhancements. They also suggested cutting the density of text and employing just one bold header with icons or images in support. Several students suggested combining short text with a photo or a simple infographic, noting that "pictures are easier to remember" and that visuals help simplify complex information.

Theme 6: Credibility is strengthened by clear institutional identity and verifiable information

Trust was associated with apparent institutional cues: perceived clear sender (college, deanship, unit), university logo and professional tone. Students also recommended messages to include references, basic statistics or hyperlinks for more in-depth reading. The least trustworthy were those marked as unknown or missing evidence messages.

Theme 7: Self-reported behavior changes centers on every day, low-cost actions

The behaviors that students described enacting because of these messages were, by and large, pragmatic low-cost responses (e.g., carrying re-usable bottles or cups which would then reduce plastic volume, turning off lights/devices, saving water - running the faucet while brushing teeth for shorter durations). The students stressed the importance that when messages are actionable within routine, they make more of an impact and a message about personal responsibility is linked to the greater good.

Table 5

Examples of frequently recalled eco-messages and dominant focus

Example message (English translation)	Dominant focus	Notable feature
"Cleanliness is part of faith."	Public cleanliness	Religious–moral framing
"A drop of water equals life."	Water conservation	Concrete, memorable metaphor
"Turn off unused devices to save energy."	Energy saving	Direct call to action
"Our planet breathes when we reduce plastic."	Reducing plastic	Emotional/metaphorical appeal
"Plant a tree as if you plant a life."	Greening and afforestation	Positive, motivating tone
"Together for a green campus."	Campus sustainability	Collective identity cue
"Use reusable bottles."	Waste reduction	Simple behavior prompt
"Recycling gives resources a second life."	Recycling	Short explanatory framing
"Eco-friendly technologies are our path to Vision 2030."	Eco-tech and national vision	National narrative alignment
"Reduce paper use and support digital transformation."	Sustainable digital practices	Institutional practice link

Note. Examples reflect common types of messages recalled by participants in open-ended responses.

Discussion

This study contributes evidence about micro-level sustainability communication in Saudi higher education by linking exposure to eco-tech micro-messages with students' reception and eco-awareness. At the quantitative level, students described low levels of exposure to institutional outlets and slightly above-average pickup, with a particularly high overall awareness. This finding indicates that even though students' exposure to messages may be low, those they do receive appear to be salient and well-developed. The findings complement microlearning literature in that short repeating content can indeed be interesting and easy to remember, when it is concentrated, easy-to-process, and provided in formats matching the learners' media use routines depending on multimedia exposure (Jahnke et al., 2020; Semingson et al., 2015). This might indicate some significant improvement with the reach of messages.

Students' above-average ratings for attention, comprehension, and design support CLT-informed expectations. CLT predicts that concise messages with a readable design reduce extraneous load and facilitate quick decoding (Sweller, 2020). Qualitative student complaints regarding lengthy text, small fonts and overcrowded layouts directly correspond to extraneous load worries and offer useful design advice based on the instructional message design principles (Ramlatchan, 2021). Taken together, the results reinforce the idea that micro-messages can function as informal learning units, but only when design and language are tightly controlled.

There was a significant positive correlation between exposure and general awareness (r =. 36). This finding is also in line with wider evidence that exposure to environmental content can be predictive of greater levels of awareness (Xie et al., 2024), as well as studies demonstrating a relationship between media exposure and environmental knowledge and pro-environmental tendencies among university students (Widdatallah & Abdallah, 2026). Correlations, albeit modest,

were evident for all dimensions of reception/awareness, implying that expanding reach might result in a gradual increase in perceived value. This is particularly relevant in contexts where ESD implementation within curricula remains uneven or generalized, making informal channels a practical complement to formal instruction (Essa & Harvey, 2022).

Qualitative findings provide insight into what types of messages might be more likely to be decoded positively. That students fall back on culturally familiar moral language, such as faith-based cleanliness slogans, indicates that cultural resonance is a potent avenue to acceptance. Reception theory posits that messages are more likely to be read in a manner consistent with the intended message when they match the values and experiences of the readers (Hall, 1980). Environmental education research through Islamic windows highlights stewardship -mutual and human responsibility-, presents culturally relevant frames to make sense of sustainability communication (Setianingrum et al., 2024). In the current data, moral–religious framings seemed to serve as "trust and relevance shortcuts", prompting attention and recall.

At the same time, students' recalled message corpus was dominated by traditional cleanliness and conservation slogans. The message analysis indicated fewer references to Vision 2030, SDG 4.7, or explicitly technological pathways to sustainability. This may reflect a communication gap: national sustainability narratives are prominent in policy discourse (Khan, 2022) and institutional sustainability challenges are recognized within Saudi universities (Alshammari, 2025), yet students may not frequently encounter micro-messages that explicitly connect eco-friendly technology to these broader agendas. Strengthening this connection could help universities translate macro-level policy priorities into campus-level learning opportunities. Aligning micro-messages with explicit ESD learning aims may help close this gap. As universities position micro-messages as part of their ESD strategy, messages might link SDG language to visible campus activities rather than requiring students to rely on inferential reasoning (Essa & Harvey 2022; Kopnina 2017).

Students' channel preferences point to a second gap: the most effective channels, from students' perspectives, are messaging apps and social platforms. This aligns with uses and gratifications theory, which predicts that attention follows habitual platforms and perceived utility (Katz et al., 1973). The use of social media among Arab university students is common and motivated by gratifications such as communication, along with challenges like deviation and information overload (Abu Backer & Awad, 2025). Universities, therefore, might need a re-distribution strategy in which WhatsApp-style channels and official social media are considered as focus dissemination channels for reaching target audiences but where messages remain credible, non-obtrusive and delivered at the right intervals.

The gender results add nuance. Males reported higher exposure, but there were no gender differences in awareness or reception. This might suggest that sources other than university micro-messages influence eco-consciousness or that the effects of message exposure are similar after messages have been received. From a Theory of Planned Behavior perspective, awareness alone may not translate into different behavioral outcomes without supportive norms and enabling conditions (Ajzen, 1991). Thus, universities need to accompany micro-message with visible action opportunities (for instance recycling facilities; energy saving campaigns and student-driven environmental initiatives) so as to increase the perceived behavioral control as well as the social norms (Too & Bajracharya, 2015).

Practical implications follow from the combination of CLT, microlearning, and reception insights. First, the messaging design is necessarily micro: one idea, one action, plain language and a visual that directly connects to what's being said. Second, credibility should be consistently signaled, (using official sender identity, logos and verifiable references/links) to satisfy students' trust criteria and in line with reception research on environmental claims (Mariam, 2021). Third, cultural and contextual specificity of message: locally informed examples and locally preferred environmental values to increase the relevance of message and to cultivate more dominant interpretations of it (Hall, 1980; Setianingrum et al., 2024).

One noteworthy pattern is the combination of low reported exposure with high overall awareness. This may suggest that students' eco-awareness is shaped by hybrid sources of information (coursework, peer discussion and related national and social-media sustainability discourses) supporting their changing attitudes towards environmental responsibility (Alshammari, 2025; Khan, 2022; Xie et al., 2024). From this viewpoint, university micro-messages might act less as information providers and more as prompts to reinforce the presence of sustainability in everyday contexts. Enhancing the reach through preferred channels may thus enhance reinforcement effects and facilitate the conversion of existing awareness into supportive campus norms.

Limitations should be acknowledged. The self-reported nature of the data and its cross-sectional design reduced causal inference. The qualitative message analysis relied on student-recalled messages and perceptions of the messages, rather than using a systematic sample to retrieve from an official institutional message archive. The sample was limited to science students in one university only, thus being the generalizability of findings. Future work could (a) employ objective content analysis to official university message archives, (b) experimentally manipulate message variants (e.g., moral framing, statistical evidence, source cues, or video vs. text), and (c) adopt longitudinal designs testing if repeated exposure predicts behavioral outcomes over time.

Conclusion

The present research considered digital short messages relating to eco-friendly technology at a university in Saudi Arabia, and investigated students' exposure, reception, and suggestions for improvement. Survey results indicated that students perceived a lower level of exposure to eco-tech micro-messages in terms of exposure, but higher reception and eco-awareness. Of importance, repeated exposure was uniformly and positively related to awareness-related dimensions, indicating that

increasing message exposure can promote more robust sustainability learning.

Qualitative findings provided actionable guidance for strengthening message effectiveness. Students favored fast, familiar channels such as social media and messaging apps, and they remembered messages that were brief, visually clear, culturally resonant, and action oriented. Faith- and value-based framings, emotionally engaging metaphors, and practical tips were perceived as particularly effective. Students also highlighted barriers (e.g., complex language, crowded design, and unclear sourcing) and called for clearer language, stronger campus-based examples, and explicit credibility cues.

The findings indicate that Saudi universities can boost the development of informal ESD when combining microlearning-oriented design with culturally tailored framing and optimizing dissemination along preferred digital means among students. If routine campus messaging can be converted into regular, believable and meaningful eco-tech learning moments, positioned within the context of both campus policy and national sustainability targets, then universities could reinforce students' everyday pro-environmental practices and underpin more extensive commitments to sustainable development. Subsequent research should test message variations and frequencies that enhance not only attention but also continued pro-environmental behavioral intention within a university context. Collectively, these results posit that thoughtfully designed micro-messages can offer broad-reaching culturally salient ESD reinforcement if coupled with strong dissemination and credible sourcing.

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