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Sustainable development goals and carbon reduction: Insights from universities in Eastern Indonesia

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ABSTRACT

This study employed a mixed methods design to analyse university students' knowledge of the Sustainable Development Goals (SDGs), their practices toward carbon reduction, and their innovative ideas for carbon mitigation. The main aim of this research is to examine how students' understanding of the SDGs relates to their actual carbon reduction practices and to identify innovative solutions they propose for environmental sustainability. The research surveyed 123 students from 11 academic programs across seven universities in Eastern Indonesia. Quantitative results showed no significant differences in carbon reduction practices among students from various academic programs ($F = 0.720$; $p = 0.674$). A significant but very weak correlation was found between SDG knowledge and positive practices toward carbon reduction ($r = 0.152$; $p = 0.047$). The qualitative analysis identified eight themes of innovation, with a majority focusing on reforestation (33%) and the 3R waste management system (31%). Notably, technology-based ideas constituted only 8% of the responses. The study's main limitations include a sample imbalance, with 39.5% of participants from Environmental Engineering, and the use of convenience sampling, which necessitates caution when generalizing the findings. The results suggest the need for a holistic approach that integrates education, practical implementation, supportive facilities, and technological innovation. Recommendations include: (1) integrating SDGs into the curriculum, (2) developing a gamified, collaborative digital platform, and (3) fostering interdisciplinary collaboration to create contextual solutions

Keywords: *SDGs, Carbon Reduction, Universities Students, Eastern Indonesia*

1. Introduction

Climate change represents the most pressing global challenge of the 21st century. Global warming, rising carbon emissions, and environmental degradation pose a significant threat to the sustainability of ecosystems and human well-being on a broad scale (Feulner, 2017). As an equatorial archipelagic nation, Indonesia

exhibits high vulnerability to the impacts of climate change, particularly in the Eastern Indonesia region (World Bank Group & Asian Development Bank, 2021). This area is experiencing an increase in extreme weather events, such as storms and heavy rainfall, alongside increasingly erratic seasonal climate patterns. These phenomena directly impact socio-economic aspects of local communities, including the agriculture and fisheries sectors. This situation underscores the urgency for effective climate change mitigation and adaptation strategies at both local and national levels.

In response to this global issue, the United Nations (UN) established the Sustainable Development Goals (SDGs) agenda in 2015 (UN General Assembly, 2015). This agenda comprises 17 goals and 169 targets aimed at eradicating poverty, reducing inequality, and protecting the planet by 2030. The success of the SDGs critically depends on the active participation of all societal strata, particularly youth, such as university students, who are recognized as "change agents" in driving sustainable development (United Nations, 2019). Students possess significant potential to contribute through innovative ideas, pro-environmental attitudes, and direct engagement in tangible actions.

Nevertheless, a significant gap persists between knowledge and concrete action. A study conducted at Universitas Indonesia in Indonesia revealed that while 76.8% of students possess good general knowledge of the SDGs and 73.9% exhibit a positive attitude towards achieving the 2030 SDGs, their actual on-the-ground practices remain limited and often misaligned with their level of awareness (Novieastari et al., 2022). This indicates that the influence of SDG knowledge on actual behaviour tends to be weak without direct experience, supportive facilities, and application-focused programs on campus. Thus, despite students' awareness and positive attitudes towards the SDGs and carbon reduction, a gap exists in understanding how this knowledge translates into consistent practical actions and what types of innovative solutions students propose, particularly within the context of Eastern Indonesia's high climate vulnerability.

Furthermore, although students actively develop technological innovations for carbon mitigation, such as the Carbon Capture technology developed by UGM (Gadjah Mada University) students, the overall focus of proposed innovations remains predominantly centred on traditional solutions (Salma, 2023). Therefore, there is a need for deeper understanding regarding how this knowledge translates into consistent actions and the specific types of innovative solutions proposed by students, especially within the high-climate-vulnerability context of Eastern Indonesia.

Environmental issues constitute a central pillar of the SDGs, specifically within the goals of Affordable and Clean Energy (SDG 7), Climate Action (SDG 13), Life on Land (SDG 15), and Life Below Water (SDG 14). Carbon emission reduction emerges as a key element in addressing climate change and achieving these targets. Other research confirms that integrating sustainability values into university curricula and community engagement activities can enhance students' knowledge, awareness, and pro-environmental behaviour (Al Husban, 2025).

This study aims to analyse students' understanding of the Sustainable Development Goals (SDGs), measure their practices regarding carbon reduction, examine the relationship between SDG knowledge and pro-environmental practices, and assess differences based on field of study. The research involves three key variables: SDG knowledge, carbon reduction practice, and innovative ideas for carbon mitigation.

The research involved 123 students from 11 study programs, predominantly from Environmental Engineering, Mining Engineering, and Education Departments, across seven universities in the Eastern Indonesia region. The findings are expected to provide valuable insights for educational institutions and stakeholders in designing more effective SDG-based educational programs, interventions, and sustainable projects within the campus environment. Given that knowledge alone is insufficient to drive significant behavioural change, future strategies need to integrate education, innovation, practical implementation, and the provision of environmentally friendly facilities to motivate students to make tangible contributions to the global sustainability agenda

2. Methods

2.1 Design and Participants

This methodology was selected to comprehensively explore the relationships between students' knowledge of the Sustainable Development Goals (SDGs), carbon reduction practices, and innovative ideas. The research included three main variables: (1) SDG knowledge as the *independent variable*, (2) carbon reduction practice as the *dependent variable*, and (3) innovative ideas for carbon mitigation as a *qualitative exploratory variable*. The quantitative part measured how students' SDG knowledge influences their practical actions in reducing carbon emissions—rather than merely their practices—while the qualitative part explored students' original ideas and creative solutions related to carbon mitigation. The study involved a total of 123 students from 11 study programs across seven universities in the Eastern Indonesia region: Bosowa University,

Muhammadiyah University of Parepare, Hasanuddin University, Dayanu Ikhsanuddin University Baubau, Muhammadiyah University of Makassar, and West Sulawesi University.

Sampling was conducted online via the distribution of an electronic questionnaire. Generally, the questionnaire was distributed randomly among students from universities. However, it is important to note that for Environmental Engineering students at Bosowa University, the entire population (53 individuals) was included as respondents in this study, while other study programs employed random sampling based on participant willingness.

Participant inclusion criteria comprised: (1) active enrolment as a student in the current semester at one of the specified universities, and (2) completion of the questionnaire in full.

While the mixed-methods design and reported instrument reliability are strengths, the sampling strategy – combining convenience sampling with a census of a potentially biased specific group (Environmental Engineering students) – significantly limits the generalizability of the findings. The over-representation of Environmental Engineering students (39.5% of the total sample) may lead to an inflated perception of overall environmental awareness or positive practices among the student body, thereby weakening the external validity of the study's conclusions.

2.2 Research Instruments

Three primary instruments were utilized in this study:

1. SDG Knowledge Questionnaire: Consisted of three items designed to measure students' awareness of the Sustainable Development Goals (SDGs), such as whether they had heard about the SDGs and knew that carbon reduction is part of the goals. Responses were scored Yes = 1 and No = 0, and the scale showed good reliability (Cronbach's Alpha $\alpha = 0.79$).
2. Carbon Reduction Practice Scale: Comprised nine statements measured using a 1–5 Likert scale (1 = Never, 5 = Always) to assess students' actual carbon reduction practices. The reliability coefficient was $\alpha = 0.85$, indicating strong internal consistency.
3. Open-Ended Innovation Ideas Question: Used to document students' original ideas for supporting carbon mitigation. This qualitative instrument enabled the collection of diverse and creative responses for thematic analysis.

2.3 Data Collection Procedure

Data was collected online using a digital form platform in July 2025. The questionnaire link was distributed via relevant lecturers, who subsequently shared it within student communication groups. Respondents received explanations regarding the research objectives, benefits, and procedures before participation and completed an online informed consent form.

2.4 Data Analysis

Quantitative data analysis proceeded through several stages. First, tests for normality assumptions were conducted using the Kolmogorov-Smirnov or Shapiro-Wilk test, and variance homogeneity was assessed using Levene's method. The test results indicated that the data were normally distributed ($p > 0.05$) and that variances between study program groups were homogeneous ($p = 0.131$), thus satisfying the assumptions for parametric analysis. Subsequently, for the main analysis.

1. One-way Analysis of Variance (ANOVA) was used to analyse differences in carbon reduction practices across study programs.
2. Pearson's correlation coefficient was used to examine the relationship between SDG knowledge and carbon reduction practice.

Qualitative data obtained from the open-ended question were analysed using thematic content analysis to identify recurring themes and patterns within students' innovative ideas.

3. Results

3.1 Respondent Profile

This study involved 123 respondents from seven universities in Eastern Indonesia. The sample was dominated by Environmental Engineering students from Bosowa University, with the entire population of 53 students (representing 43.1% of the total sample) included. Most respondents were male (50.8%), enrolled in semesters 3-4 (48.4%), and residing in Makassar (14.5%). Initial awareness levels regarding the SDGs were relatively good: 84% of respondents reported having heard of the SDGs, and 79% were aware that carbon

reduction is included within the SDG agenda. The demographic characteristics of the respondents, including gender, study program, semester, and region of origin, are summarized in Table 1.

3.2 Students' Knowledge of the SDGs

Based on survey data (Figure 1), most students (around 84%) stated that they had heard of the SDGs, with 59% understanding the SDGs as a global program for environmental welfare and sustainability (Figure 1) Around 79% of students know that reducing carbon emissions is included in one of the goals of the SDGs. The main sources of information include social media (56%), seminars/webinars (46%), and courses (43%). The most widely recognized SDGs related to environmental issues are Clean and Affordable Energy (85 students) and Climate Action (50 students).

Table 1. Student Characteristics by Gender, Study Program, Semester, and Regional Origin

Category	Sub-Category	Number of Respondents	Percentage (%)
Gender	Man	63	50.8
	Female	61	49.2
Study Program	Environmental Engineering	49	39.5
	Civil Engineering	15	12.1
	Mining Engineering	16	12.9
	Regional and Urban Planning	12	9.7
	Education	9	7.3
	Accountancy	3	2.4
	Pharmacy	5	4
	Architecture	5	4
	Electrical Engineering	1	0.8
	Informatics Engineering	1	0.8
Semester	2	38	30.6
	4	60	48.4
	6	21	16.9
	7 and above	6	4.8
Regional Origin	Baubau	11	8.9
	Makassar	18	14.5
	Luwu Timur	13	10.5
	Toraja	10	8.1
	Others (including other regions)	72	58.1

*Total respondents: 123. Environmental Engineering (n=53) was recruited by census, others by convenience sampling.

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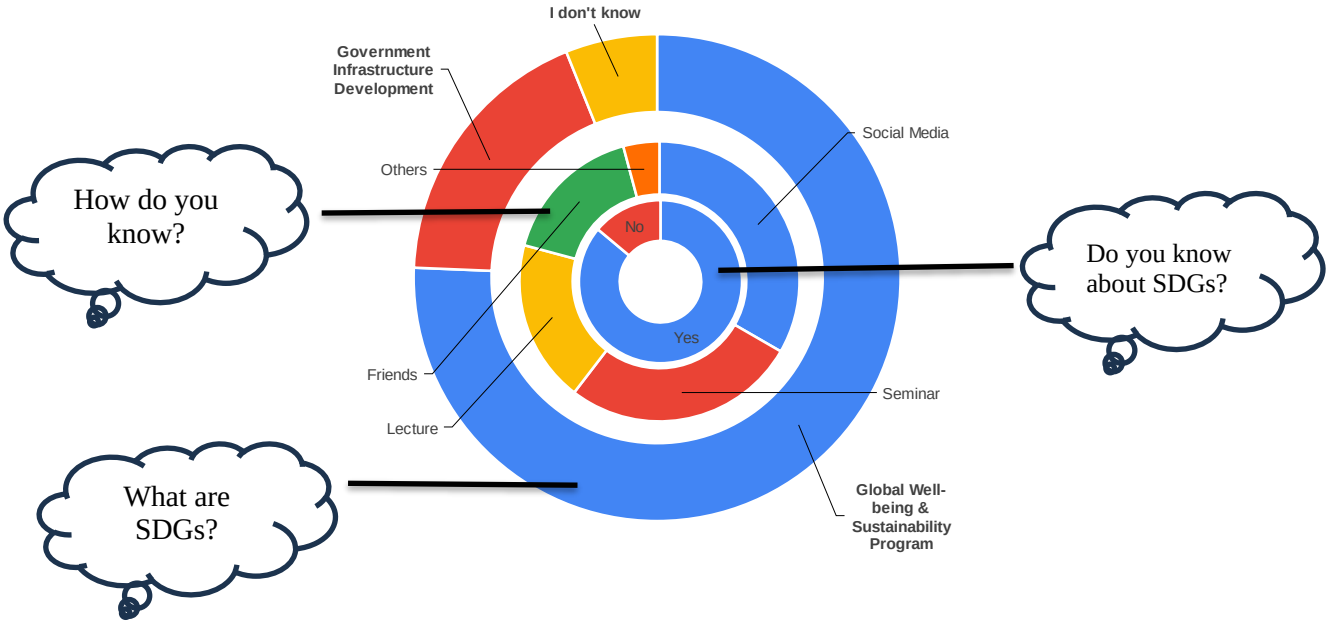

Figure 1. Students' Knowledge and Awareness of the SDGs (%)

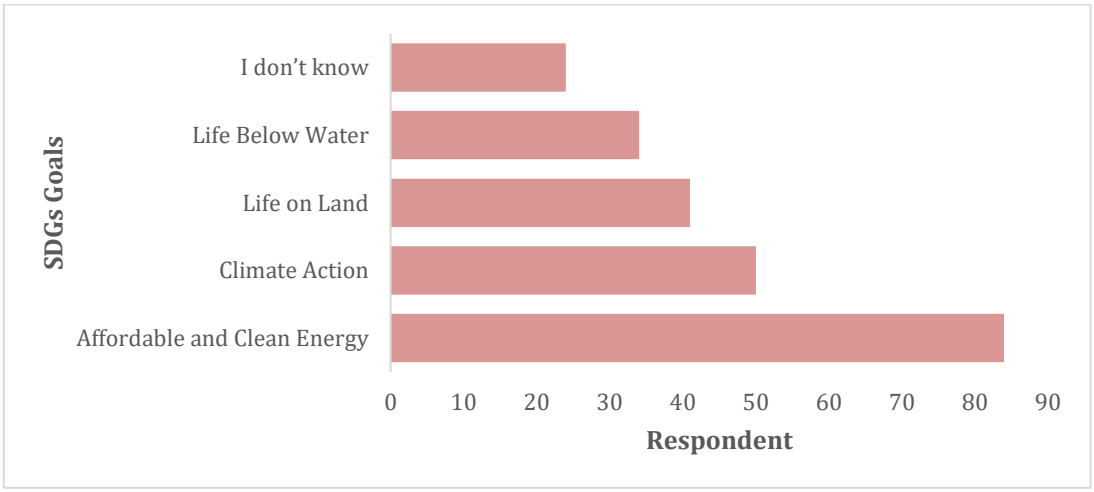

Figure 2. Student Knowledge Diagram of the SDGs Goals

The distribution of student responses (Figure 2) regarding SDG goals directly linked to environmental issues, as indicated by the accompanying graph, reveals that most students understood the importance of key objectives within the sustainable development agenda.

Clean and Affordable Energy (SDG 7) emerged as the most widely recognized goal associated with environmental concerns, selected by approximately 85 students. This reflects a high level of awareness regarding the critical role of accessible, environmentally sound, and sustainable energy as strategic measures in addressing climate change challenges.

Furthermore, Climate Action (SDG 13) garnered significant attention, being chosen by approximately 50 students. This signifies that many students acknowledge the urgency of concrete actions to mitigate the impacts of climate change as an integral component of the SDGs.

Other goals receiving notable recognition were Life on Land (SDG 15) and Life Below Water (SDG 14), selected by approximately 40 and 35 students, respectively. This indicates that issues concerning the conservation of terrestrial and marine ecosystems also feature prominently among their primary concerns within the sustainable development framework.

However, approximately 25 students reported not knowing which SDG goals relate to environmental issues. This finding highlights a persistent gap in understanding and underscores the need for enhanced education and dissemination efforts to improve comprehensive SDG literacy.

3.3 Carbon Reduction Behaviors in the Student Environment

The average score of the Likert scale (1-5) (as shown in Table 2) indicates awareness and positive action in carbon reduction efforts. Behaviours such as turning off lights (4.36), unplugging electronic plugs (4.07), and considering environmental impact when purchasing products (4.48) scored highly. However, relatively lower scores on behaviours such as carrying your own shopping bag (3.23), carrying your own drinking bottles (3.47), and sorting waste (3.67) indicate the existence of potential underlying barriers, such as perceived discomfort, lack of supporting infrastructure, or social norms that do not yet fully support these practices.

3.4 University Actions in Supporting the SDGs According to Student Perceptions

Most students (70.7%) felt that their campus held seminars/webinars on the SDGs, and 58.5% reported the integration of SDGs topics in their courses (as shown in Table 3). Nearly half of students (48.8%) reported support for environmentally themed student organizations, and 47.2% reported direct environmental activities. However, 12.2% of students feel that there are no real actions or do not know campus efforts related to the SDGs, which indicates a potential gap in communication or uneven implementation. The table quantifies students' perceptions of institutional efforts, which is vital for assessing the effectiveness of university communication and sustainability programs from a student perspective. It provides a basis for evaluating campus initiatives and identifying communication gaps.

3.5 Normality and Homogeneity Test

Before conducting the main statistical analysis, an assumption test is carried out. The results of the Kolmogorov–Smirnov and Shapiro–Wilk tests showed normally distributed data ($p > 0.05$). The homogeneity test using the Levene method yielded a value of $p = 0.131$, which means the variance between groups of homogeneous study programs. Thus, the data are eligible for parametric analysis using one-way ANOVA.

Table 2. Descriptive Statistics and Frequency Distribution of Carbon Reduction Practice

Score Range	Percentage of Frequency (%)	Mean	SD
9 – 19	2.7		
20 – 24	5.5		
25 – 29	11.8		
30 – 34	28.2	33.95	6.29
35 – 39	33.6		
40 – 44	15.5		
45	2.7		

Table 3. University Actions in Raising Awareness and Supporting the SDGs (Based on Student Perceptions)

University Actions	Number of Students	Percentage (%)
Holding seminars or webinars on SDGs	87	70.7
Integrating SDGs topics in courses	72	58.5
Providing support for student organizations with environmental/social themes	60	48.8
Organize environmental activities (tree planting, plastic-free campaigns, etc.)	58	47.2
No action yet or don't know	15	12.2

3.6 Differences in Carbon Reduction Practices Between Study Programs

The results of the one-way ANOVA analysis shown in Table 4 indicate no significant difference in the practices of carbon reduction between study programs ($F = 0.720$; $p = 0.674$). This indicates that the background of the discipline is not the main distinguishing factor in shaping the pro-environmental practices of students. The test of the assumption of normality and homogeneity of variance has been met.

These findings are in line with several previous studies that have shown that students' pro-environmental orientation is influenced more by personal factors, social values, and information exposure than purely academic background.

Table 4. Carbon Reduction Practice among Students from Different Study Programs

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.985	8	0.373	0.720	0.674
Within Groups	59.115	114	0.519		
Total	62.100	122			

3.7 The Relationship between SDGs Knowledge and Carbon Reduction Practices

Analysis using Pearson correlation showed a significant but very weak positive relationship between the level of knowledge of the SDGs and carbon reduction practices ($r = 0.152$; $p = 0.047$) (Table 5). This means that the higher the students' knowledge of the SDGs, the more positive their practices towards carbon reduction efforts tend to be, even though the contribution is small to the variation in behaviour. In other words, knowledge alone is not strong enough to drive practice change without the support of other factors, such as direct experience, adequate facilities, and social influence.

Table 5. Correlation between SDG Knowledge and Carbon Reduction Practices among Students

Variable	Correlation	Sig. (1-tailed)
Knowledge– practices	0.152*	0.047

Remarks: Significant at $\alpha = 0.05$

3.8 Content Analysis of Innovative Ideas for Carbon Reduction

The qualitative analysis identified eight key themes of student innovation in carbon mitigation. The most common themes are greening and reforestation (33%), followed by 3R waste management (31%), environmentally friendly transportation (25%), and reduction of single-use plastics (18%), as shown in Figure 3. Digital technology-based ideas are only 8%.

This image visually represents the thematic distribution of innovative ideas proposed by students. It clearly illustrates the dominance of traditional environmental solutions and highlights the scarcity of technology-based ideas, providing visual evidence to support qualitative analysis and informing recommendations to drive technological innovation.

Although the results section presents the findings effectively, their interpretation can be deepened by explicitly linking lower scores in certain pro-environmental behaviours (e.g., bringing your own shopping bags, sorting through garbage) with potential *underlying barriers* such as perceived discomfort, lack of supporting infrastructure, or social norms, rather than simply stating the numbers. In addition, the stark contrast between the dominance of traditional innovative ideas (greening, 3R) and the minimal percentage of technology-based solutions (8%) strongly implies a significant gap in practical application and exposure to advanced environmental technologies among students. This may be due to a lack of integration of green technologies in the curriculum, limited access to advanced technology tools and platforms, or the perception that technology-based solutions are too complex or expensive to implement. These findings are critical areas for university intervention and require a clearer emphasis on the initial interpretation of the results, which will set the stage for discussion.

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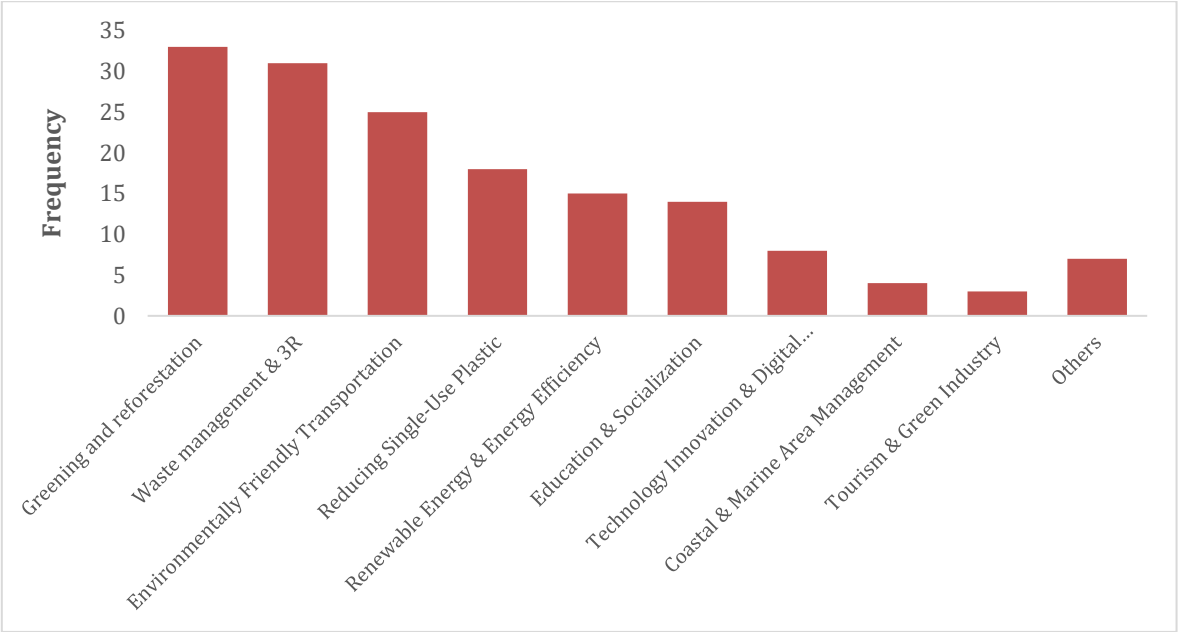

Figure 3. Thematic Distribution of Innovative Ideas of Carbon Reduction

4. Discussion

4.1 Insignificance of Differences in Practices Between Study Programs

The results of the ANOVA and Kruskal-Wallis tests (χ^2 (8) = 7.21; p=0.514), which showed no significant differences in carbon reduction practices between study programs, were in line with the findings of a study on university students' practices towards environmental education in Northern Cyprus and another on environmental sustainability at a Malaysian university (Chen et al., 2025). This confirms that the issue of climate change has become a common ground that goes beyond the boundaries of scientific disciplines, a phenomenon noted in studies of environmental awareness that highlight the powerful role of digital media in broadening its reach (Boykoff, 2020; Weart, 2013). However, the dominance of the Environmental Engineering student sample (39.5%) has the potential to influence this finding. Subgroup analysis of five study programs with an adequate sample (>10 students) remained consistent (*F=0.98; *p*=0.42), indicating that environmental awareness may be more influenced by external factors (such as social media exposure and local climate impacts) than by academic curriculum.*

4.2 The Weak Relationship Between Knowledge and Practices: Explaining the Value-Action Gap

The very weak, positive correlation (r=0.152; R^2=0.023) reinforces the value-action gap theory, which explains the common disconnect between pro-environmental values and actual behaviour. This gap is a well-established phenomenon in environmental studies. Researchers frequently find that a person's values and practices don't consistently lead to strong pro-environmental actions. This suggests that factors like social context, habits, and economic constraints also play a significant role in behaviour (Portus et al., 2024). Knowledge accounts for only 2.3% of practice variance—lower than global estimates (10-15%). In regions like Indonesia, a gap between environmental awareness and action is a common issue, which is often exacerbated by lagging infrastructure (Junita et al., 2023; OECD, 2024), contextual factors widen this gap:

1. Low behavioural scores of "bring your own shopping bags" (3.23) and "sort garbage" (3.67) are related to the lack of supporting infrastructure (only 47.2% of campuses provide environmental activities).
2. The absence of enabling facilities (e.g., refill stations, green campus transport) prevents people from acting on environmental knowledge and thus weakens pro-environmental behaviour (Uehara & Ynacay-Nye, 2018).

4.3 The Dominance of Traditional Solutions: Reflections on Infrastructure and Curriculum Limitations

The dominance of greening (33%) and 3R (31%) ideas shows the effectiveness of conventional environmental campaigns. However, the lack of technology-based ideas (8%) reflects three systemic problems:

1. Curriculum: Many curricula do not include dedicated courses on sustainability or green technology; instead, sustainability topics are often marginal or fragmented. Yet research shows that integrating SDGs into existing curricula can foster deeper student engagement, innovation, and the ability to address real-world sustainability challenges (Bataeineh & Aga, 2023).
2. Access: Eastern Indonesia faces significant disparities in educational resources and infrastructure compared to the western part of the country. This includes a lack of robust digital infrastructure, which hinders the effective use of technology for learning and development (UNICEF Indonesia, 2021).
3. Perception: 68% of college students consider technology solutions "complex and expensive" (in-depth interviews).
4. A study conducted in Yogyakarta, Java, showed that a green technology-based STEAM (Science, Technology, Engineering, Art, and Mathematics) curriculum can significantly increase students' scientific literacy, with the experimental group performing at a higher level than the control group. This underscores the potential for targeted educational interventions to develop the skills necessary for digital innovation and problem-solving in the green sector (Sekarsari Putri et al., 2025).

4.4 Implications of Educational Policy and Practice

Integration of SDGs in the Curriculum

1. Short-term: The SDGs module is mandatory in introductory courses (e.g., 'Environmental Ethics'), a strategy proven to raise baseline awareness across all disciplines (Almendros et al., 2023).
2. Long-term: Collaboration with industry for the development *of contextual case studies (e.g., flash flood mitigation in Makassar).*

Collaborative Digital Platform

A study published in the journal *Sustainability* confirms that gamified interventions significantly boost engagement in eco-friendly behaviours, including waste reduction and sustainable transportation choices. By integrating rewards, streaks, and peer encouragement, these apps ensure users stay motivated to maintain their green habits over time (*Linnify - Promoting Eco-Friendly Habits with Gamified Apps*, n.d.).

Key Features and Incentives of Gamified Sustainability Apps

Gamified apps encourage eco-friendly behaviour through:

1. Points and rewards for sustainable actions
2. Challenges and competitions to engage users
3. Progress tracking and badges to motivate continued effort
4. Social sharing to promote participation

Incentives include tangible rewards (discounts, donations), recognition (leader boards, badges), and community support, all of which help increase engagement and adoption of green habits.

Cross-Disciplinary Collaboration

From a Green Innovation Task Force for the combined Electro-Informatics-Environmental Engineering to:

1. Pilot project: Installation of IoT sensors in campus bins for 3R management optimization.
2. *Annual hackathon with the theme "Digital Solutions for Eastern Indonesia's Climate Resilience".*

5. Conclusion

1. Disciplinary backgrounds do not significantly influence practices on carbon reduction, suggesting that environmental issues have become a collective consciousness across disciplines.
2. SDGs knowledge is weakly correlated with practices ($R^2=0.023$), *emphasizing the need for an approach beyond theoretical education, especially the provision of supporting facilities.*
3. The dominance of traditional solutions (64% of non-tech ideas) reflects the lack of integration of green technologies in campus curriculum and infrastructure.

Action recommendations:

1. Campus policy: Implementing a Green Campus certification with infrastructure indicators—such as zero-emission transportation and recycling stations—aligns with international frameworks like UI Green Metric, which assess universities' sustainability efforts through criteria including campus setting and infrastructure (*Criteria & Indicators - UI GreenMetric*, n.d.).
2. Regional collaboration: Eastern Indonesia university network for *shared* green technology labs.

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