Regional Case Study

Sustainability Literacy on Food Waste Education: A Preliminary Study

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Abstract

Food waste contributes significantly to global greenhouse gas (GHG) emissions and reflects low sustainability awareness, particularly in developing countries such as Indonesia. This study aimed to assess the level of sustainability literacy, comprising knowledge, skills, and values, among vocational high school students in Bogor City within the context of food waste. Using a descriptive quantitative method with 125 respondents, data were collected through a 21-item questionnaire and were analyzed using descriptive statistics. The findings show that while students demonstrated good sustainability skills (76.95%) and values (73.63%), their sustainability knowledge was only fair (57.81%), indicating a cognitive-behavioral gap. Spearman's correlation analysis revealed no significant relationship between sustainability knowledge and skills ($\rho = 0.109$, $p = 0.226$), reinforcing the need for holistic and integrative learning interventions. These results underscore the importance of developing interactive, value-driven educational media, such as e-books, to enhance students' environmental literacy and foster sustainable behavior. This preliminary study serves as a foundation for designing contextually relevant educational strategies to support food waste reduction and sustainability education in Indonesia.

Keywords: Sustainability literacy; food waste; environmental education; student perception

1.   Introduction

Food waste accounts for up to 10% of total global greenhouse gas emissions, making it one of the main causes of accelerated climate change (FAO, 2011). Indonesia is the largest food waste generator in Asia (Asiah et al., 2022), with a weak culture of sustainable consumption and low sustainability literacy regarding the environmental impact of food waste (Elzagi et al., 2023). The issue of food waste should be a concern for everyone, including for education. However, research on food waste has focused more on quantification and logistics than intervention effects (Piras et al., 2023). An approach that can be used to reduce this problem is

environmental education (EE) (Malefors et al., 2024). Relevant and contextualized education has been shown to be effective in building ecological awareness, especially if implemented from the school age (Tilbury, 2011).

Education for Sustainable Development (ESD) enables the transition to a sustainable future, as envisioned by the UN Sustainable Development Goals (SDGs2) (Kioupi & Voulvoulis, 2022). The issue of food waste is closely related to sustainability literacy, which encompasses a combination of knowledge, skills, and values that enable individuals to think critically. These are grouped into three elements: sustainability knowledge, sustainability skills, and sustainability-relevant values (Murray & Cotgrave, 2007). The academic environment is the formation and transmission of knowledge, skills, values, and attitudes that will enable students/graduates to Engage Deeply in building a sustainable future and improving their decision-making towards sustainability (Prada et al., 2020), which depends on the pedagogical and research functions of higher education (Blewitt & Cullingford, 2004). In the context of modern education, digital media such as interactive media can combine text, images, and animations, thus increasing students' involvement in the learning process (Witabora, 2012).

This technology-based learning medium facilitates the learning process in terms of effectiveness and efficiency (Firmadani, 2020). In addition, it facilitates flexibility and independent learning through digital devices commonly used by students. Low-carbon educational media are attractive to students because the illustrations are interesting and the functions displayed are updated according to the character of students who are accustomed to technology; therefore, learning through electronic media can increase students' sustainability literacy (Warliyah et al., 2023). One of the main social issues is food waste, which contributes to the excessive consumption of natural resources, hindering economic growth and environmental protection (Fan et al., 2023). To address this issue, engaging and interesting educational materials that capture students' attention must be created. Owing to its negative impact on human well-being, food loss and food waste are urgent issues (Saputra et al., 2024).

Therefore, this study aims to describe students' level of understanding, attitude, and behavior towards the issue of food waste as well as their profiles towards food waste education media. It is hoped that this research will contribute to the development of more effective and applicable learning strategies to support environmental education (EE) in schools. Understanding these aspects is crucial for designing educational content that informs and inspires action. By aligning learning strategies with students' real-life experiences, schools can play a key role in cultivating responsible habits regarding food consumption and waste.

2. Methods

Based on the research objectives and issues explored, this study adopted a descriptive quantitative approach using a survey method. The concept of sustainability literacy used in this research refers to Murray's framework, which categorizes sustainability literacy into three main domains: sustainability knowledge, sustainability skills, and sustainability-relevant value. The participants of this study were vocational high school (SMK) students from grades X, XI, and XII in SMK Pembangunan, Bogor City. In total, 125 students voluntarily participated in the questionnaire. Data collection was conducted in December 2024. The instrument used in this study was a closed-ended questionnaire consisting of 21 items distributed across three domains.

    1. Sustainability Knowledge
        a. Understanding basic ecological principles,
        b. Approaching problems and situations from a systems perspective
        c. Assessing the impact of technology use and human actions
    2. Sustainability Skills:
        a. Using sustainability-based tools, objects, and work procedures

3. Sustainability: Relevant Values

    a. Feeling compassion, empathy, and respect for other people and living beings

    b. Appreciating and evaluating others' work from diverse perspectives based on different backgrounds, motivations, and intentions

    c. Committing to fairness and inclusivity in achieving sustainability

    d. Respecting and appreciating nature and all living beings

Once the data were collected, the responses were processed and analyzed using descriptive statistical techniques to identify students' understanding, attitudes, and behaviors related to food waste as well as their profiles and preferences regarding educational media on food waste. The questionnaire consisted of 19 items and was measured using a four-point Likert scale without a neutral option to capture the students' level of agreement more decisively. The scale is presented in the following table.

Table 1. Likert Scale Used in the Questionnaire

Score	Response Option
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree

After the questionnaires were collected, they were processed as follows. Each student's response was analyzed quantitatively using descriptive statistics, including percentage and mean scores. The total score of each student was calculated using the following formula (1):

$$\text{Assessment score (\%)} = \left(\frac{\text{score}}{\text{total score}}\right) \times 100 \tag{1}$$

The total score obtained refers to the cumulative score of each item answered by a student, and the maximum possible score is the highest achievable score across all items (i.e., number of items × 4). After calculating each respondent's score, the results were interpreted using a predefined classification scale, as presented in Table 2 below.

Table 2. Interpretation criteria for student questionnaire scores

Percentage Score	Category
81 – 100%	Very Good
61 – 80%	Good
41 – 60%	Fair
21 – 40%	Poor
0 – 20%	Very Poor

Descriptive results were then visualized in the form of frequency tables and/or bar charts, with detailed breakdowns by sustainability literacy indicators and components. This analysis aimed to provide a clearer picture of students' understanding, values, and behavior related to food waste and also serves as a foundation for the development of a targeted educational intervention, namely an interactive e-book on food waste, to enhance students' environmental literacy.

3.   Result

The results of the sustainability literacy assessment are presented in a series of frequency tables and a summary chart, providing detailed breakdowns by domain and indicator. This structure offers a comprehensive view of students' knowledge, skills, and values related to food waste, enabling the interpretation of both cognitive understanding and behavioral attitudes toward sustainable consumption. As shown in Table 3, students' sustainability knowledge falls into the "Fair" category, with a score of 57.81%. This divergence suggests that simply increasing awareness is insufficient without reinforcing the affective and behavioral domains, especially through immersive, value-laden learning experiences tailored to students' cultural and local realities. Although students show awareness of the basic ecological principles and environmental impact of food waste, their understanding is often superficial and fragmented. Many students struggled to approach problems from a systems perspective or to assess the consequences of technological and human actions, indicating a need for deeper conceptual integration.

Table 3. Sustainability knowledge

Category	Question number	Strongly Disagree		Disagree		Agree		Strongly Agree	
		F	%	F	%	F	%	F	%
A. Understand basic ecological principles	1	4	3.2	29	45.6	57	23.2	35	3.2
	2	1	0.8	26	20.8	61	48.8	37	29.6
	3	3	2.4	47	37.6	59	47.2	16	12.8
B. Approaching problems and situations from a systems perspective	4	2	1.6	53	42.4	51	40.8	19	15.2
	5	10	8	42	33.6	51	40.8	22	17.6
	6	4	3.2	36	28.8	65	52	20	16
C. Assess the impact of technology use and human actions	7	23	18.4	58	46.4	37	29.6	7	5.6
	8	10	8	35	28	46	36.8	34	27.2
	9	34	27.2	45	36	36	28.8	10	8

The data on sustainability knowledge indicate that students have a moderate understanding of the basic ecological principles, concepts of food waste and food loss, and environmental consequences of unsustainable consumption. Table 4 presents the students' sustainability skills, with an overall score of 76.95%, categorized as "Good." However, responses indicate that a considerable proportion of students remain hesitant or inconsistent in practicing sustainable behavior, such as using environmentally friendly tools or procedures. This gap suggests that, while awareness exists, practical applications need to be reinforced through experiential, hands-on learning strategies.

Table 4. Sustainability skills

No	Indicator Domain Sustainability Skills	Q	Strongly Disagree		Disagree		Agree		Strongly Agree	
			F	%	F	%	F	%	F	%
1	Using tools,	10	70	56.0	30	24.0	22	17.6	3	2.4
2	objects, and	11	34	27.2	57	45.6	21	16.8	13	10.4

No	Indicator Domain Sustainability Skills	Q	Strongly Disagree		Disagree		Agree		Strongly Agree	
3	work procedures	12	32	25.6	67	53.6	20	16.0	6	4.8

The analysis in Table 5 shows that the domain of sustainability-relevant values, with a score of 73.63% ("Good"), still reveals important challenges. Students scored low on indicators involving empathy, social responsibility, and justice, especially questions related to respect and compassion. These findings indicate that affective engagement remains underdeveloped and that strengthening students' emotional and ethical connections to sustainability is essential.

Table 5. Sustainability-relevant values

No	Indicator domain Sustainability-Relevant Values	Q	Strongly Disagree		Disagree		Agree		Strongly Agree	
			F	%	F	%	F	%	F	%
1	Feel care,	13	51	40.8	56	44.8	13	10.4	5	4
2	empathy and respect thing	14	26	20.8	70	56	24	19.2	5	4
3	Appreciate and	15	63	50.4	43	34.4	16	12.8	3	2.4
4	assess the work of others from multiple perspective	16	9	7.2	52	41.6	47	37.6	17	13.6
5	Committed to	17	15	12	60	48	29	23.2	21	16.8
6	equity and inclusiveness, to how to achieve sustainability	18	71	56.8	39	31.2	10	8	5	4
7	have respect for nature	19	18	14.4	66	52.8	33	26.4	8	6.4

Table 6 and Figure 1 summarize the students' performance across all three domains. While sustainability skills and values achieved "Good" ratings, sustainability knowledge remained in the "Fair" range. This imbalance suggests that behavioral intentions and attitudes may progress faster than conceptual comprehension, underlining the importance of balanced, integrated instruction that addresses all aspects of sustainability literacy.

Table 6. Summary of sustainability literacy scores by domain

Domain	Average	Percentage (%)	Category
Sustainability Knowledge	2.31	57.81%	Fair
Sustainability Skills	3.08	76.95%	Good
Sustainability-Relevant Values	2.95	73.63%	Good

From the Table 6, some results can be interpreted into Figure 1. The results of the study indicate varying levels of sustainability literacy among students in the context of food waste education. The

sustainability knowledge domain scored an average of 2.31 (57.81%), falling into the "Fair" category. This suggests that while students possess basic awareness of the ecological principles and environmental consequences of food waste, their conceptual understanding remains limited, particularly in recognizing the systemic links between consumption behavior and environmental degradation. In contrast, the sustainability skills domain received a higher score of 3.08 (76.95%), categorized as "Good," indicating that students are relatively capable of applying environmentally conscious practices, such as utilizing sustainable tools and procedures in daily activities. Similarly, the sustainability-relevant values domain also fell within the "Good" range, with a score of 2.95 (73.63%), reflecting the initial internalization of values, such as empathy, social responsibility, and respect for the environment. However, the imbalance between knowledge, skills, and values underscores the critical gap between cognitive awareness and behavioral implementation. Therefore, educational interventions must go beyond merely transmitting information; they should adopt transformative approaches that integrate value-based learning and contextual experiences to foster more meaningful and lasting behavioral changes in students. The consequences were conveyed to students, and this awareness persisted after a few months, although it did not result in behavioral changes (Leal Filho et al., 2024). To address these challenges, the development of interactive educational tools must be grounded in local narratives, language, and everyday practices, ensuring that students can connect abstract sustainability concepts with tangible, relatable actions. Many students seldom reported engaging in proactive behaviors such as reducing food waste at home or participating in school-based sustainability programs, and some expressed disagreement with statements related to empathy, responsibility, and care toward food-related environmental impacts.
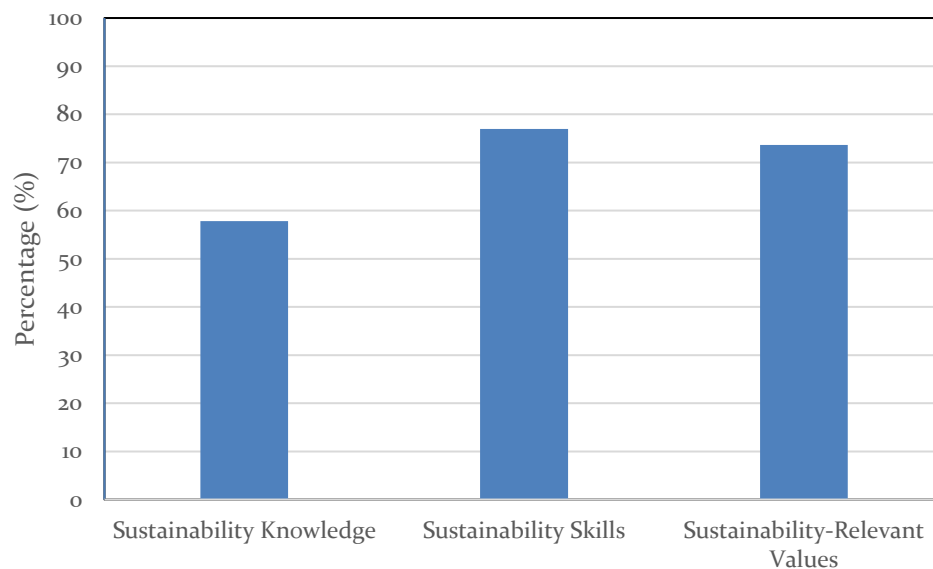

Figure 1. Students' sustainability literacy by domain

This imbalance between knowledge and action highlights a critical gap in sustainability education, namely the urgent need for integrative learning experiences that move beyond information transfer. Effective sustainability education must cultivate not only awareness, but also competence and character, enabling students to engage in reflective practices, problem-solving, and value-driven decision-making. A lack of environmental literacy may hinder society from making sustainable choices (Miterianifa and Mawarni, 2024). A balanced foundation of knowledge, skills, and attitudes is required to develop critical food sustainability competencies (McManus et al., 2025). Accordingly, the sustainability literacy profile presented here serves not only as a diagnostic baseline, but also as a well-founded rationale for educational innovation. This

underscores the urgency to design and implement learning media that support holistic sustainability education in schools. Several studies emphasize the importance of instilling awareness about food waste among school-aged children, as such awareness has the potential to create multiplier effects when transferred to household behavior and future family practices (Bathmanathan et al., 2023). To further explore the dynamics of sustainability literacy development, this study examined how students' knowledge, skills, and values differed across grade levels. By clustering the data based on students' academic years (grades X, XI, and XII), it becomes possible to observe patterns of progression and identify critical gaps in learning outcomes. This stratification not only provides deeper insight into how sustainability competencies evolve with age and educational exposure but also offers practical implications for curriculum refinement and targeted educational interventions.

The comparison of sustainability literacy across grade levels revealed subtle yet meaningful trends in students' development. In the domain of Sustainability Knowledge, Grade XII students achieved the highest average score (2.40), followed by Grades XI (2.28) and X (2.27). Although the difference appears marginal, it suggests a gradual increase in the conceptual understanding of food waste and ecological issues as students progress through higher grades. This may be attributed to cumulative exposure to environmental topics across the curriculum, or to increased maturity in interpreting sustainability-related concepts.

Table 7. Summary of sustainability literacy scores by domain by clustering

Average	Knowledge	Skills	Relevant Values
X	2.27	3.00	2.93
XI	2.28	3.02	1.21
XII	2.40	3.27	3.01

The Sustainability Skills domain showed a more pronounced growth across levels. Grade XII students scored 3.27, while grade XI scored 3.02, and grade X reached 3.00. This indicates that students in higher grades are better at applying sustainability knowledge through actionable behaviors, such as prudently utilizing food, sharing excess food, and participating in waste-reduction activities. The development of skills over time may reflect their greater involvement in extracurricular programs, practical experiences, or enhanced decision-making abilities as they approach graduation. However, a notable inconsistency appeared in the Sustainability-Relevant Values domain. While grades X and XII scored relatively high (2.93 and 3.01, respectively), grade XI students scored only 1.21 on average, indicating a significant drop. However, this unexpected decline warrants further investigation. It is possible that students in grade XI experienced transitional academic pressure or a curriculum gap that deprioritizes value-oriented learning. Alternatively, the score may reflect lower engagement or shifts in perception during mid-adolescence. The anomaly found in Grade XI's values score raises important pedagogical questions about how emotional and ethical learning outcomes are maintained over time, particularly during critical developmental periods. Nevertheless, this inconsistency emphasizes the need for continuous reinforcement of sustainability values across all grade levels to ensure alignment between knowledge, skills, and character.

Table 8. Correlations of Sustainability Knowledge and Sustainability Skill

Correlations			Sustainability Knowledge	Sustainability Skill
Spearman's rho	Sustainability Knowledge	Correlation Coefficient	1.000	0.109

Correlations		Sustainability Knowledge	Sustainability Skill
	Sig. (2-tailed)	.	0.226
	N	125	125
Sustainability Skill	Correlation Coefficient	0.109	1.000
	Sig. (2-tailed)	0.226	.
	N	125	125

Spearman's rank-order correlation was conducted to further explore the relationship between students' cognitive knowledge and sustainability-related skills. This non-parametric test was selected after the data failed to meet the assumptions of normality, as indicated by the Shapiro-Wilk and Kolmogorov-Smirnov tests ($p < 0.001$ for both knowledge and skills variables). The analysis yielded a weak and statistically non-significant correlation between Sustainability Knowledge and Sustainability Skills domains ($\rho = 0.109$, $p = 0.226$, N = 125). This result indicates that students who possess a higher cognitive understanding of food waste do not necessarily exhibit stronger sustainability skills in practice. The lack of a significant relationship reinforces the observation that cognitive awareness alone may be insufficient to drive sustainable behavioral change, underscoring the need for pedagogical strategies that integrate value-based and skill-oriented learning approaches. Several peer-reviewed studies have highlighted a persistent gap between sustainability knowledge and practical behavior. For instance, research at Sultan Idris University has found a weak positive correlation between SDG knowledge and student practice ($r = 0.228$; $p < 0.05$) . Similarly, Tuononen et al. (2022) emphasized that knowledge alone does not guarantee sustainable practices without deeper engagement in values and motivation. Our findings, with a non-significant Spearman's rho of 0.109 ($p = 0.226$), provide further evidence that the theoretical understanding of food waste needs to be complemented by value-driven and practice-oriented educational interventions aimed at bridging the knowledge–action gap. Active student participation, encouragement, and the desire to act more consciously toward the environment are essential for fostering strong environmental awareness. Learning should not only build cognitive competence, but also foster attitudes, motivation, and willingness to act according to environmental contexts (Masriah et al., 2025). Consequently, students are more inclined to act wisely and responsibly in relation to their environment (Rachman et al., 2024).

In the context of ESD, achieving the Sustainable Development Goals requires reducing food waste at the consumer level (Wang et al., 2024). These three pillars underpin the concept of sustainability: environmental, social, and economic. The environmental pillar emphasizes the conservation of natural resources and the protection of ecosystems; the social pillar underscores justice, equity, and inclusiveness; and the economic pillar highlights responsible consumption and sustainable livelihoods. These three elements form the foundation of educational strategies that nurture future generations committed to sustainability (Siraj-Blatchford & Pramling-Samuelsson, 2016). Research on educational media Among the 19 articles reviewed, only a few utilized interactive media as pedagogical tools and many failed to demonstrate long-term behavioral change despite increased awareness. This gap reflects a key weakness in current educational practices, and cognitive understanding may be addressed; however, translation into sustainable behavior remains limited. Furthermore, most food waste education studies are concentrated in developed countries, with minimal contextual adaptation for developing nations, such as Indonesia (Saldiana et al., 2025).

France's National Assembly passed a law prohibiting supermarkets from destroying edible food and requiring partnerships with food banks, as well as integrating food waste prevention into school curricula (Lisa Jahns, 2019). Such policies exemplify a systemic approach to food waste reduction by combining legal,

societal, and educational strategies. Indonesia could benefit from similar efforts by integrating anticipatory education on food waste into its national curriculum, fostering a culture of responsible consumption starting from early education. This underscores the urgency of developing contextually relevant and engaging learning media, particularly digital and interactive formats that can bridge the gap between knowledge and action. Addressing food waste requires a cross-sectoral approach that not only relies on normative education, but also leverages learning strategies that engage students cognitively, affectively, and behaviorally. International studies and progressive policies have highlighted that effective sustainability education must begin at the school level and involve students as active change agents within their immediate communities.

Therefore, this study represents a significant first step in mapping the sustainability literacy profiles of students in Indonesia within the context of food waste. The results provide not only a baseline for environmental education, but also a strong justification for further research: the development of an interactive food waste-themed e-book. Such media are expected to enhance sustainability literacy more holistically, bridging the gap between knowledge and action while cultivating stronger environmental character and awareness among the younger generation of Indonesia. By mapping sustainability literacy at the student level, this research can also inform educational policymakers in crafting targeted curricula that align with Indonesia's broader environmental and climate action goals.

5. Conclusion

This study provides a foundational exploration of students' sustainability literacy in the context of food waste. Through a structured assessment involving knowledge, skills, and values, the results indicated that students possessed a relatively strong cognitive understanding of the ecological and environmental dimensions of food waste. However, this knowledge has not yet been translated into consistent sustainable behaviors or internalized values, as shown by the significantly lower scores in the domains of sustainability skills and sustainability-relevant values. These findings point to a critical gap in current sustainability education: while theoretical awareness may be sufficiently addressed, pedagogical approaches remain limited in their ability to foster reflective thinking, behavioral engagement, and long-term value formation. Global comparisons and literature analysis also confirm the scarcity of interactive and context-specific educational tools addressing food waste, particularly within the Indonesian education system. As such, this study not only maps a clear sustainability literacy profile among vocational school students but also strengthens the argument for innovative educational interventions. In response to this gap, the development of a digital, interactive e-book focusing on food waste has emerged as both timely and necessary. It offers a promising pathway to bridge the knowledge–action divide and cultivate more holistic, future-oriented sustainability competencies among students. This study serves as a crucial diagnostic phase that will inform the next stage of research: designing and testing contextualized educational media that can foster behavioral transformation and environmental responsibility among students in Indonesia.

Acknowledgement

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