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An Analysis of Students' Sustainability Awareness through Learning Using an ESD-Based E-Module

Analisis Kesadaran Berkelanjutan Siswa melalui Pembelajaran Menggunakan E-Modul Berbasis Education for Sustainable Development (ESD)

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Abstract

This study aims to analyze students' sustainability awareness after learning using an e-module integrated with Education for Sustainable Development (ESD) on the theme of traditional Indonesian fermented foods. The research employed a quantitative method using a questionnaire based on the Guttman scale, adapted from Gericke et al. (2018), consisting of 27 items covering three aspects: sustainability knowingness, sustainability attitudes, and sustainability behaviour. The data were analyzed using percentage calculations and N-Gain analysis. The results showed an increase in all aspects of students' sustainability awareness, with improvements of 8.1% in knowledge, 5.9% in attitudes, and 18.4% in behaviour. However, the N-Gain results indicated that these improvements were still in the low category. This suggests that the use of ESD-based e-modules has not been significantly effective in enhancing students' sustainability awareness within a short period. Therefore, continuous and sustained learning, along with the involvement of multiple stakeholders, is needed to optimize the development of students' sustainability awareness.

Penelitian ini bertujuan untuk menganalisis profil kesadaran berkelanjutan siswa setelah pembelajaran menggunakan e-modul bermuatan Education for Sustainable Development (ESD) dengan tema makanan fermentasi tradisional Indonesia. Metode penelitian yang digunakan adalah kuantitatif dengan instrumen berupa angket skala Guttman yang diadaptasi dari Gericke et al. (2018), terdiri atas 27 pernyataan yang mencakup tiga aspek, yaitu sustainability knowingness, sustainability attitudes, dan sustainability behaviour. Data dianalisis menggunakan persentase dan uji N-Gain. Hasil penelitian menunjukkan bahwa terjadi peningkatan pada seluruh aspek kesadaran berkelanjutan siswa, yaitu pada aspek pengetahuan sebesar 8,1%, sikap sebesar 5,9%, dan perilaku sebesar 18,4%. Meskipun demikian, hasil analisis N-Gain menunjukkan bahwa peningkatan tersebut masih berada pada kategori rendah. Hal ini menunjukkan bahwa penggunaan e-modul bermuatan ESD belum efektif secara signifikan dalam meningkatkan kesadaran berkelanjutan siswa dalam waktu singkat. Oleh karena itu, diperlukan pembelajaran yang berkelanjutan dan berkesinambungan serta keterlibatan berbagai pihak untuk mengoptimalkan pengembangan kesadaran berkelanjutan siswa.

Article Information

Keywords:
Education for Sustainable Development; sustainability awareness; e-module; student behavior

Kata kunci:
Pendidikan untuk pembangunan berkelanjutan; kesadaran berkelanjutan; e-modul; perilaku siswa

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A. INTRODUCTION

Within the framework of the agenda 2030, there are 17 Sustainable Development Goals (SDGs) that serve as a guideline for achieving a sustainable society. These goals are based on three main dimensions, namely economic, social, and environmental (Ali, 2017). Education for Sustainable Development (ESD) emerges as an approach that integrates these three dimensions into the educational process. ESD plays a strategic role in supporting the achievement of the SDGs by developing both knowledge and competencies, enabling learners to face increasingly complex global challenges.

ESD is understood as an effort to empower learners to make informed and responsible decisions and to act consciously regarding sustainability issues. Learners are expected to develop a comprehensive understanding of the interconnections among global challenges, both at individual and collective levels, including their impacts and consequences on economic, social, and environmental aspects (Phillips & Howard, 2024). Therefore, the development of knowledge, skills, and values is carried out through an interdisciplinary approach, enabling learners to act as agents of change. This approach has also been shown to positively influence learning outcomes, such as improved understanding and learning motivation.

In line with this concept, the implementation of ESD in education emphasizes the integration of various disciplines, such as biology, chemistry, and engineering, within a contextual and meaningful learning environment (Czok et al., 2023). The integration of ESD into science education is particularly important, as science provides the conceptual foundation and critical thinking skills necessary to understand sustainability issues (Rahmawati et al., 2025). Therefore, ESD-based learning not only focuses on conceptual mastery but also on developing students' awareness and responsibility toward environmental, social, and economic sustainability.

Education for Sustainable Development directs students toward changes in attitudes and values related to environmental appreciation. Every action should consider its long-term consequences on ecosystem balance. This attitude is referred to as sustainability awareness (Arbuthnott, 2008). Sustainability awareness is one of the key outcomes expected from ESD-based learning, encompassing awareness of protecting and respecting the environment and surrounding life. Therefore, this awareness should be introduced from an early age to support sustainable development (Clarisa et al., 2020).

The development of environmental awareness and empathy is essential in helping students address environmental problems. In this context, students are expected to develop positive attitudes toward the environment. Sustainable education aims to increase awareness and encourage behavioral changes toward more sustainable practices (Baldwin, 2016). In this context, sustainability awareness involves three main aspects: cognitive (knowledge and understanding), affective (values and attitudes), and behavioral (intentions and skills). The interaction among these aspects enables learners not only to understand existing conditions but also to reflect on their own behavior and promote change. One way to foster sustainability awareness is through ESD-based learning by selecting topics aligned with the three pillars of ESD (Mochtar, 2014).

Educators play a strategic role in guiding students toward sustainable development thinking. The integration of ESD into learning can foster sustainability awareness, reflected in students' sensitivity, responsibility, and active participation in the sustainable use of natural resources. Furthermore, the development of sustainability awareness helps students understand sustainability concepts and integrate environmental issues into their social and professional lives (Erdogan & Tuncer, 2014).

This study was conducted after students used an e-module designed by integrating ESD concepts with the theme of traditional Indonesian fermented foods. The use of e-modules supports technology-based learning that aligns with current educational needs. The developed e-module has been validated in terms of practicality and accessibility. This is in line with Yang & Xiu (2023) who state that educational technology innovation is essential in addressing the increasing complexity and uncertainty of the future, as well as in strengthening sustainable education. The integration of technology into ESD curricula also enables the enhancement of sustainability awareness through innovative instructional design in the digital era.

The selection of traditional Indonesian fermented food as the theme of this study is based on its relevance to the three pillars of ESD, namely environmental, socio-cultural, and economic aspects. Although numerous studies have examined the implementation of ESD in education, most have focused on conceptual development or the measurement of knowledge and attitudes, with limited attention to integrating local contexts, such as traditional fermented foods, into digital learning materials. In addition, studies that comprehensively measure sustainability awareness—including knowingness, attitudes, and behaviour—through the use of e-modules remain limited.

Therefore, this study offers novelty in the development and implementation of an ESD-based e-module that incorporates the local context of traditional Indonesian fermented foods and comprehensively measures students' sustainability awareness across three main aspects. This study aims to analyze students' sustainability awareness after participating in learning using the developed ESD-based e-module. Through ESD-based science learning, students are expected to develop awareness and a mindset that encourages them to act as agents of change in the context of sustainable development.

B. METHOD

The instrument employed in this study was a questionnaire. The questionnaire consisted of a set of statements to be completed by students. These statements were related to the themes presented in the e-module and the concepts of Education for Sustainable Development (ESD), and were structured using a Guttman scale with response options such as "Yes–No" or "Agree–Disagree."

The data obtained were analyzed quantitatively by calculating the percentage of students' responses regarding their sustainability awareness, which were subsequently categorized. The sustainability awareness questionnaire was adapted from the instrument developed by Johan Gericke et al. (2018) in the study entitled *"The Sustainability Consciousness Questionnaire: The Theoretical Development and Empirical Validation of an Evaluation Instrument for Stakeholders Working with Sustainable Development,"* and was further adjusted to align with the context of this research.

The profile of students' sustainability awareness, as obtained from the questionnaire responses, was analyzed using the Guttman scale. This scale employs dichotomous responses, such as "yes–no," "true–false," and "agree–disagree." The resulting data are dichotomous in nature and can be analyzed quantitatively. In the scoring process, each "agree" response was assigned a score of 1, while each "disagree" response was assigned a score of 0. The scores were then calculated using the following formula:

$$Percentage = \frac{Total\ score\ obtained}{Maximum\ possible\ score}\ x\ 100\% \qquad \ldots(1.1)$$

After obtaining the percentage values, the results were classified based on the criteria proposed by Hassan et al. (2010), as shown in Table 1.

Table 1. Percentage of Sustainability Awareness

Percentage	Category
0,0-39,9	Low
40,0-69,9	Moderate
70,0-100	High

C. RESULTS AND DISCUSSION

Sustainability awareness was measured before and after the learning process using a developed e-module incorporating Education for Sustainable Development (ESD) with the theme of traditional Indonesian fermented foods. The researcher employed a questionnaire adapted from the instrument developed by Johan Gericke et al. (2018), consisting of 27 statements. These statements were categorized into three dimensions: sustainability knowingness, sustainability attitudes, and sustainability behaviour. The results of the data analysis on students' sustainability awareness are presented in Table 2

Table 2. Percentage of Pre-test and Post-test Data on Students' Sustainability Awareness Questionnaire

Sustainability Awareness (%)	**Aspect of Sustainability Awareness**						**Number of Students**
	Knowingness		*Attitudes*		*Behavior*		
	Pre	Post	Pre	Post	Pre	Post	
Score %	70.6	78.7	80.4	86.3	53.5	71.9	60
Category	High	High	High	High	Low	High	
Improvement	8.1%		5.9%		18.4%		

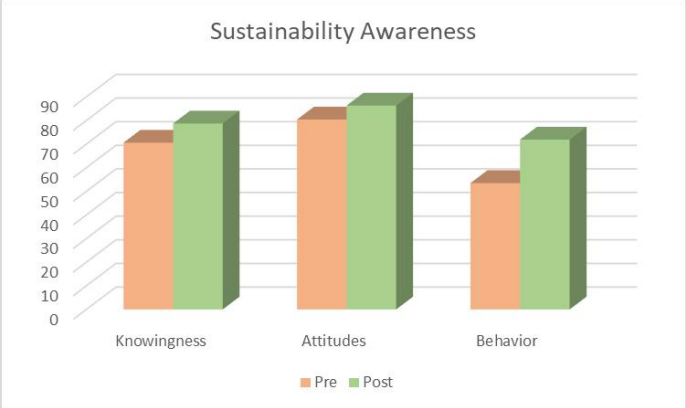

Figure 1. Pretest and Postest Data on Student's Sustainability Awareness

Based on Table 2, there was an increase in all aspects of sustainability awareness—namely sustainability knowingness, sustainability attitudes, and sustainability behaviour—after the implementation of learning using the developed ESD-based e-module. Specifically, the increase reached 8.1% in knowledge, 5.9% in attitudes, and 18.4% in behaviour.

These findings indicate that students have developed an understanding of sustainability awareness, although it may not yet be fully reflected in their daily practices. This result is consistent with the statement of Arbuthnott (2008), which asserts that learning integrated with

ESD aims to guide students toward changes in attitudes and values in appreciating the environment. Every action should consider its long-term consequences for ecosystem balance. The purpose of collecting pre-test and post-test data in this study was to examine the differences in students' sustainability awareness before and after participating in learning using the ESD-based e-module.

The knowingness aspect shows that the initial percentage of 70.6% indicates that students already possessed a basic understanding of sustainable living. After the implementation of the e-module, this percentage increased to 78.7%, suggesting an improvement in students' knowledge of sustainability concepts following their engagement with the learning materials. For instance, students demonstrated an understanding that: (1) knowledge of environmentally friendly processing of natural products is essential for sustainable development; (2) knowledge of fermented foods derived from natural ingredients can serve as a solution to food-related issues and should be disseminated widely to the public; and (3) sustainable development requires individuals to reduce various types of waste, including food waste. Initially, only 70.6% of students agreed with these statements; however, after using the e-module, this figure increased to 78.7%. This finding indicates that students have developed a sufficient understanding of sustainable living concepts. In this context, understanding the level of knowledge is crucial, as noted by Gusti et al. (2015), who state that knowledge is a fundamental domain in shaping individual actions, as behavior grounded in knowledge tends to be more effective than behavior without such a foundation.

The second aspect, sustainability attitudes, shows that the initial percentage was 80.4%, which increased to 86.3% after the use of the e-module. Attitudes generally refer to individuals' feelings or perspectives toward particular ideas. For example, students expressed agreement with statements such as: (1) governments should promote the consumption of healthy and nutritious foods, such as fermented foods, to prevent hunger; (2) poverty alleviation is an important topic within Education for Sustainable Development; and (3) excessive use of natural resources poses a serious threat to the health and well-being of future generations. Approximately 80% of students agreed with these statements both before and after the intervention. Such perspectives reflect the characteristics of individuals who have developed an understanding of sustainability concepts.

The third aspect, sustainability behaviour, showed an increase from 53.5% in the initial measurement to 71.9% after the implementation of the e-module, indicating an improvement of 18.4%. Behaviour refers to the way individuals demonstrate their knowledge and attitudes through actions. The findings suggest that although students exhibited relatively high levels of knowledge and attitudes, these were not fully translated into habitual sustainable behaviours, as indicated by the relatively low initial percentage (53.5%). For instance, behaviours such as: (1) engaging in discussions with peers or teachers about solutions to food-related problems; (2) composting food waste into organic fertilizer; and (3) reducing the use of plastic bags in daily life were initially not widely practiced by students. However, after the implementation of the ESD-based e-module, there was a noticeable increase in the number of students engaging in these activities.

Nevertheless, it should be noted that the assessment of sustainability behaviour in this study has limitations. The observation period was relatively short, spanning only a few days, which may not be sufficient to capture long-term behavioural changes. Therefore, although an increase in percentage was observed, it cannot be conclusively stated that a sustained behavioural change has occurred. This is consistent with the findings of Hanisch & Eirdosh (2023), which indicate that behavioural change is one of the most difficult outcomes to achieve in *Education for Sustainable Development* (ESD). Behavioural science is increasingly recognized as a

fundamental basis for addressing sustainability challenges, where behavioural change and action competence are key goals of ESD, alongside the development of knowledge, skills, values, and attitudes.

After examining the percentage increase between the pre-test and post-test data, further analysis was conducted to determine the N-Gain values associated with the use of the ESD-based e-module. The N-Gain data are presented in Table 3.

Table 1.3. *N-Gain* of Sustainability Awareness

Number of Students	Aspect of Sustainability Awareness	*N-Gain*	Category
60	*sustainability knowingness*	0.21	Low
	sustainability attitudes	0.16	Low
	sustainability behavior	0.38	Low

Based on Table 3, all aspects of N-Gain fall within the "low" category. This indicates that although there were observable improvements in sustainability knowingness, sustainability attitudes, and sustainability behaviour, the overall effectiveness of the ESD-based e-module in enhancing students' sustainability awareness remains limited. In other words, the developed e-module has not demonstrated a substantial impact on improving students' sustainability awareness.

This finding may be attributed to the nature of sustainability awareness itself, which cannot be significantly transformed within a short period or through only a few learning sessions. This result is consistent with the findings of Hassan et al. (2010) and Michalos et al. (2011) who emphasize that the development of sustainability awareness values in students requires a prolonged and complex process. Consequently, studies conducted over a short duration tend to yield weak relationships or limited effects. Several other studies have also reported similar findings regarding the challenges of implementing attitude assessment instruments in classroom settings.

In addition to the limited duration of the study, the assessment of sustainability awareness cannot rely solely on students' self-reports; teacher involvement is also essential. Teachers play a critical role in evaluating students' sustainability awareness from an observational and pedagogical perspective. However, time constraints remain a significant challenge in practice.

As highlighted by Setiadi (2016) and Retnawati (2016), the implementation of attitude assessment instruments in classroom settings is time-consuming and often difficult due to the large number of students that must be evaluated. Effective time management is a crucial factor in ensuring the successful implementation of attitude assessments. Many teachers report that balancing instructional responsibilities with assessment tasks remains suboptimal. During the learning process, teachers tend to focus primarily on delivering instructional content, which often results in the neglect of attitude assessment activities.

The relatively low improvement in sustainability awareness observed in this study suggests that continuous habituation is necessary to foster students' understanding and practice of sustainable living. Such habituation should not be limited to instructional materials but should also involve real-life experiences, guidance from teachers and parents, and exposure through media. For example, integrating ESD principles consistently across various learning activities in schools can help reinforce sustainability awareness.

As noted by Erdogan & Tuncer (2014), educators bear the responsibility of guiding students toward sustainable development thinking. The integration of Education for Sustainable Development into teaching practices fosters sustainability awareness characterized by sensitivity, responsibility, and active participation in the sustainable use of natural resources. The development of such awareness enables students to better understand sustainability concepts and to integrate environmental considerations into their future professional and social lives. One effective approach is the implementation of ESD-based learning through the selection of topics aligned with the three pillars of ESD (Mochtar, 2014).

Another factor contributing to the low level of sustainability awareness is the influence of contextual and cultural factors. These factors play an important role in shaping students' sustainability awareness. School, family, and community environments that do not fully implement sustainable practices may hinder the development of sustainable behaviour, even when students already possess adequate knowledge and positive attitudes. In addition, cultural values embedded in daily life shape students' mindsets and habits in applying sustainability concepts. Berglund et al. (2020) states that sustainability awareness varies across regions, with significant differences observed in the aspects of knowledge (*knowingness*), attitudes (*attitudes*), and behaviour (*behaviour*) among students from different cultural backgrounds. This indicates that the development of sustainability awareness is influenced not only by instructional approaches but also by broader socio-cultural contexts.

D. CONCLUSION

Education for Sustainable Development (ESD) is able to improve students' sustainability awareness in terms of knowledge (*sustainability knowingness*), attitudes (*sustainability attitudes*), and behaviour (*sustainability behaviour*). The highest improvement was observed in the behavioural aspect, followed by knowledge and attitudes. However, the N-Gain analysis indicates that the overall improvement remains in the low category, suggesting that the effectiveness of the e-module in enhancing sustainability awareness has not yet been optimal. These findings imply that the development of sustainability awareness cannot be achieved in a short period, but rather requires a continuous, integrated, and contextual process. Behavioural change, as a key indicator of sustainability awareness, is the most complex aspect and requires habituation as well as direct experiences in everyday life. In addition, contextual and cultural factors also influence the level of students' sustainability awareness. Therefore, the implementation of *Education for Sustainable Development* (ESD) should be carried out consistently within the learning process, supported by active teacher involvement, the school environment, and students' real-life experiences. Future research is recommended to be conducted over a longer period and to employ more comprehensive approaches in order to provide a more optimal understanding of the development of students' sustainability awareness.

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