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Developing the 'Save the Earth!' E-Module as an ESD-Based Learning Tool to Enhance Sustainability Awareness and Critical Thinking among Indonesian Students

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ABSTRACT This study aims to develop and evaluate the *Save the Earth!* An e-module based on Education for Sustainable Development (ESD) to enhance students' critical thinking and sustainability awareness within the framework of the Pancasila Student Profile Project (P5). Utilizing the ADDIE development model, the e-module was designed around five interactive learning stages (Orientation, Contextualization, Real Action, Mini Exhibition, and Final Reflection) and integrated multimedia features to support project-based learning. The module's feasibility was assessed by expert validators, yielding average scores of 4.50 (media expert) and 4.60 (content expert), both categorized as "Very Feasible." Practicality testing conducted through small-group and field trials yielded average scores of 4.30 and 4.26, respectively, indicating that the module was "Very Practical" for classroom use. Effectiveness was measured using a one-group pre-test–post-test design. Statistical tests showed significant improvements ($p < 0.05$) in both critical thinking and sustainability awareness. N-Gain scores revealed moderate improvement in critical thinking (0.67) and significant improvement in sustainability awareness (0.74). These results indicate that the *Save the Earth!* An e-module is a valid, practical, and effective educational tool. It holds strong potential for broader dissemination and future development, including integration with digital platforms and expansion to other P5 themes to promote transformative sustainability education.

Keywords: E-module, Education for sustainable development, Pancasila student profile, Critical thinking, Sustainability awareness, Project-based learning

1. INTRODUCTION

The growing complexity of global development has created critical challenges across sectors, particularly the escalating environmental crisis driven by unsustainable human activities. Ecosystem degradation, climate change, and biodiversity loss pose a serious threat to the continuity of life on Earth. This environmental crisis is exacerbated by insufficient public and governmental awareness of the importance of ecological structures beyond mere live trees, underscoring the need for education to foster a more nuanced understanding of these ecosystems (Thorn et al., 2020). Engaging students in environmental education not only raises awareness but also equips them with the requisite skills to enact sustainable practices (Adnyana et al., 2023; Dey & Paria, 2025). In this context, education plays a strategic role in equipping future generations with the awareness, values, and skills necessary for environmental sustainability.

One promising pedagogical response to this challenge is Education for Sustainable Development (ESD), a holistic educational approach that integrates environmental, social, and economic issues into the learning process. Promoted by UNESCO, ESD supports the achievement of the Sustainable Development Goals (SDGs) by fostering critical thinking, problem-solving, and action-oriented learning among students (UNESCO, 2020). The effectiveness of ESD is further underscored by studies on sustainability consciousness, which encompass knowledge, awareness, and proactive behavior regarding sustainable development (Pauw et al., 2015). ESD's holistic

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approach, integrated across various educational frameworks, ensures that students are not merely passive recipients of information but active participants in problem-solving and decision-making processes related to sustainability (Hayat et al., 2024).

In Indonesia, ESD has been incorporated into the national *Kurikulum Merdeka*, particularly through the *Proyek Penguatan Profil Pelajar Pancasila* (P5), a project-based learning initiative designed to nurture Indonesian learners who are faithful, critical thinkers, creative, independent, collaborative, and globally-minded. A crucial aspect of this curriculum is its focus on the characteristics of Pancasila students, which encapsulates the ideals of Indonesian national philosophy centered on character education and community values (Saesaputri et al., 2024; Nurdyansyah et al., 2022). By integrating project-based learning themes, particularly in sustainability, the P5 initiative offers students opportunities to engage meaningfully with their environments (Khalifatun et al., 2024; Yasa et al., 2023). One of the P5 priority themes, Sustainable Lifestyle, aligns closely with ESD principles. Through this theme, students are encouraged to explore real-life environmental issues in their local context and engage in meaningful, solution-oriented projects.

The implementation of P5 across schools in Indonesia, however, still faces several challenges. Previous studies (Delviyani et al., 2025; Nabila et al., 2023; Palangda et al., 2023; Rizal et al., 2022; Sulistianti et al., 2024) have reported difficulties experienced by teachers in designing relevant and contextual projects, constrained by limited infrastructure, time allocation, and a lack of training or structured teaching materials. A preliminary study conducted by the authors involving 12 schools in South Sulawesi found that most schools lacked structured, systematic modules for P5. Teachers reported challenges in creating pedagogically sound projects that incorporate sustainability values, often relying on fragmented online content that fails to align with the ESD framework.

This problem was also evident at MAN Insan Cendekia Gowa, where many students demonstrated low levels of environmental care, as evidenced by behaviors such as littering, wasteful resource use, and a lack of initiative to participate in eco-friendly school activities. Although all of the students acknowledged the importance of protecting the environment, fewer than half could name examples of sustainable lifestyle practices in advance. When prompted to provide specific actions, most students offered surface-level answers, such as "throwing trash in the bin," lacking a deeper understanding of sustainable consumption, energy conservation, or waste reduction. This gap suggests that students' sustainability awareness, particularly in the behavioral and practice dimensions, remains underdeveloped.

In addition, students demonstrated limited critical thinking skills, particularly in analyzing environmental problems, generating creative solutions, and connecting ideas to real-world contexts. This finding aligns with the 2018 PISA report, which ranked Indonesian students in the lower tier globally in critical thinking and problem-solving competencies. Moreover, both sustainability awareness and critical thinking are essential and interrelated competencies in 21st-century education. As emphasized by UNESCO (2020), sustainability awareness is not merely about theoretical understanding. However, it requires the ability to critically assess information, identify root causes of problems, and make ethical and ecological decisions. Some students face difficulties in problem-solving and critical thinking due to insufficient understanding and practice, which directly affects their capacity to address complex issues such as environmental sustainability (Iman & Fitriani, 2023). Without critical thinking, environmental awareness remains superficial and unlikely to lead to meaningful action. Conversely, critical thinking becomes more grounded and impactful when it is directed toward solving complex, real-world sustainability challenges.

Redman & Wiek (2021) further stress that effective sustainability education must integrate critical thinking, self-reflection, and action orientation, while Sterling (2001) advocates for transformative learning approaches that challenge students to adopt new ways of thinking. These insights highlight the urgent need for structured learning materials that support teachers in delivering P5 meaningfully and help students internalize ESD values through inquiry, reflection, and problem-solving.

Responding to this need, this study aims to develop a digital learning resource in the form of an ESD-based e-module titled *"Save the Earth!"* The module is designed to align with the "Sustainable Lifestyle" theme of P5 and to address two key objectives: enhancing students' sustainability awareness and critical thinking skills. Sustainability awareness and critical thinking skills serve as essential foundations for fostering students' understanding of environmental issues and their ability to engage in informed, responsible decision-making. Sustainability awareness refers to the continuous effort to respect and protect the environment, encompassing an understanding of the ecological, social, and economic interconnectedness that encourages responsible citizenship and supports the development of environmentally literate behaviors (Sihombing et al., 2024; Sulastri et al., 2023; Agustira et al., 2025). Meanwhile, critical thinking skills, described as the ability to analyze information, evaluate perspectives, and solve complex problems, are crucial for cultivating higher-order thinking skills needed for environmental awareness (Hanan et al., 2023; Shutaleva, 2023; Noorhapizah et al., 2021). The "Save the Earth!" e-module integrates and enhances sustainability awareness and critical thinking skills, preparing students to be responsible global citizens capable of addressing contemporary environmental issues.

Digital e-modules are considered a strategic solution due to their accessibility, flexibility, and appeal to today's tech-savvy students (Gustinasari et al., 2017; Ramadani et al., 2023). Research in science education has demonstrated that learning activities incorporating video and inquiry-based exploration significantly enhance students' motivation and conceptual understanding (Afriani et al., 2019). This supports the rationale for developing interactive, context-based digital modules, as applied in the "Save the Earth!" e-module, where ESD principles are embedded to encourage deeper learning and critical reflection.

In addition, Saraswati et al. (2019) demonstrated that interactive e-modules structured as digital chemistry magazines achieved high validity and positive user acceptance, with material and media aspect scores exceeding 90% and user satisfaction above 86%. These findings reinforce the feasibility of developing flexible, multimedia learning tools—such as the "Save the Earth!" e-module—that can support deeper engagement and accessibility in diverse learning contexts. Furthermore, a comprehensive literature review has highlighted the critical need for incorporating STEM and ESD perspectives in science education to address global challenges such as climate change, microplastic pollution, and biodiversity loss; such integration is essential for enhancing students' scientific literacy and contextual understanding in sustainability education (Sihombing et al., 2024). Collectively, these insights underscorethe importance of developing high-quality digital learning resources that foster sustainability competence through meaningful, inquiry-driven experiences.

Accordingly, this study was conducted to address the need for structured and context-based sustainability learning resources within the P5 framework by developing an ESD-based digital e-module titled *"Save the Earth!"*. To guide this effort, the study formulated three research objectives: (1) to create the *Save the Earth!* e-module aligned with the "Sustainable Lifestyle" theme of P5, (2) to evaluate its feasibility and practicality as a digital learning resource, and (3) to examine its effectiveness in improving students' sustainability awareness and critical thinking skills. These objectives delineate the scope of the study and serve as the foundation for the design, implementation, and evaluation of the e-module.

2. METHOD

2.1 Development Model

This study employed a Research and Development (R&D) approach using the ADDIE instructional design model (Branch, 2009), which consists of five systematic phases: Analyze, Design, Develop, Implement, and Evaluate. The ADDIE model was selected for its structured yet flexible framework, allowing integration with digital media development through the Multimedia Development Life Cycle (MDLC) approach (Sutopo et al., 2019). This integration, as depicted in Figure 1, supported the production of a pedagogically meaningful and interactive digital e-module tailored to the Indonesian curriculum.

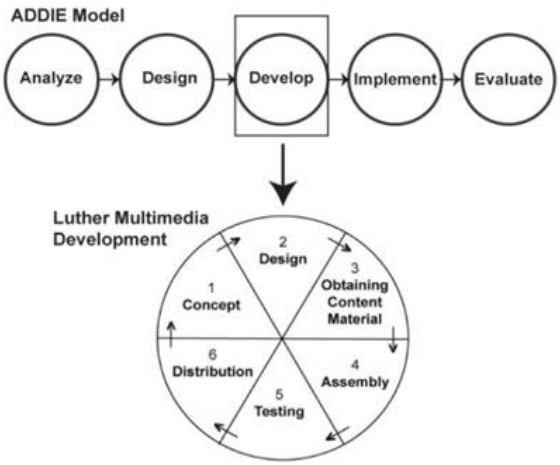

Figure 1 ADDIE Model integrated with MDLC

To ensure pedagogical rigor and internal consistency, each stage of the ADDIE model was applied systematically. During the Analyze stage, curriculum requirements, student characteristics, and learning needs related to sustainability education were identified. The Design stage involved formulating learning outcomes, preparing assessment instruments, and developing the storyboard and visual layout aligned with ESD and P5 principles. In the Develop stage, the e-module prototype was produced using the MDLC workflow, incorporating multimedia elements such as visuals, videos, narratives, and reflective prompts. The Implementation stage consisted of classroom utilization of the e-module within the P5 project, enabling students to engage with each learning activity. Finally, the Evaluate stage involved reviewing validation data, practicality feedback, and pre- and post-test results to refine and finalize the e-module.

The participants comprised all 46 Grade X students at MAN Insan Cendekia Gowa who were engaged in the *Sustainable Lifestyle* theme of the Pancasila Student Profile Project (P5). The study used saturated sampling (total population sampling), in which the entire accessible population meeting the inclusion criteria was included. This approach was appropriate because all Grade X students participated in P5 activities relevant to the intervention, the population size was manageable, and total inclusion avoided sampling bias.

MAN Insan Cendekia Gowa was selected as the research site based on a needs analysis that indicated that, although the school consistently implements P5, both teachers and students lacked structured ESD-based digital learning resources. Sustainability learning in the school tended to rely on fragmented online materials,

underscoring the need to develop a comprehensive e-module aligned with P5 and ESD principles.

The sample size of 46 students met the minimum requirement for paired pre–post experimental comparisons. Based on Cohen's (1998) estimation for a medium effect size (d = 0.50), with α = 0.05 and a statistical power of 0.80, a minimum of 34 participants is required. Thus, the available sample provided adequate statistical power to detect meaningful learning improvements. Similar sample sizes have been used successfully in previous R&D studies on ESD and digital learning modules (Khoiri et al., 2023; Ekamilasari & Pursitasari, 2021).

A one-group pretest–posttest design was used to evaluate the effectiveness of the developed e-module. Students completed the sustainability awareness questionnaire and the critical thinking test before and after using the e-module during P5 learning activities.

2.2 Research Instruments

Sustainability Awareness Questionnaire

The sustainability awareness instrument consisted of 15 items adapted from Hassan et al. (2010). The adaptation process included forward translation, expert review to ensure contextual relevance, and pilot testing with 22 students to check clarity and reliability.

Example items include:

"I pay attention to how my daily habits affect the environment."

"I try to reduce waste by reusing or recycling whenever possible."

The questionnaire measured three dimensions: sustainability practice awareness, behavioral/attitudinal awareness, and emotional awareness. Pilot testing yielded a Cronbach's alpha of 0.81, indicating high internal consistency.

Critical Thinking Test

The critical thinking assessment comprised 10 open-ended items aligned with five indicators of critical thinking (Facione, 2015): identifying problems, analyzing information, constructing arguments, proposing solutions, and reflective evaluation. Example item:

"A cafeteria in your school still uses single-use plastics. Identify the core sustainability problem and propose a solution supported by evidence."

Responses were scored using a 0–4 analytic rubric adapted from Ennis (2011), and two independent raters assessed the answers. Two experts, a media expert and a content expert, validated the e-module's feasibility. Inter-rater reliability was calculated using Cohen's Kappa, yielding a value of 0.79, categorized as substantial agreement (Landis & Koch, 1977). This indicates strong consistency in the evaluators' judgments.

2.3 Data Analysis

Feasibility and Practicality

Feasibility and practicality were assessed using 5-point Likert scales covering content quality, media design, usability, and alignment with P5 and ESD principles. Score classifications followed the criteria outlined by Akbar (2013), Riduwan (2022), and Sugiyono (2013), as shown in Table 1.

Table 1 Criteria for feasibility and practicality

No	Average Score	Category of Feasibility/ Practicality
1	4.21 – 5.00	Very Feasible/ Practical
2	3.41 – 4.20	Feasible/ Practical
3	2.61 – 3.40	Moderately Feasible/ Practical
4	1.81 – 2.60	Less Feasible/ Practical
5	1.00 – 1.80	Not Feasible/ Practical

Scores from experts, teachers, and students were converted into percentages to determine the feasibility and practicality categories.

Effectiveness Testing

The effectiveness of the *Save the Earth!* The e-module was examined through a structured pre–post evaluation framework that assessed two key learning outcomes: sustainability awareness and critical thinking skills. Effectiveness testing followed standard R&D procedures for instructional products and aligned with the objectives of the P5 Sustainable Lifestyle theme.

To measure learning gains, students completed a pre-test before engaging with the e-module and a post-test after completing all five learning stages. The sustainability awareness questionnaire measured behavioral and attitude awareness, emotional awareness, and practice awareness, while the critical thinking test assessed students' ability to identify problems, analyze information, construct arguments, propose solutions, and engage in reflective evaluation.

Quantitative analyses were conducted to determine whether the e-module produced statistically and pedagogically meaningful improvements. Normality tests (Shapiro–Wilk) were performed to determine the appropriate statistical procedures. Depending on distribution patterns, either paired-sample t-tests or Wilcoxon signed-rank tests were used to evaluate pre–post differences. Additionally, normalized gain (N-Gain) scores were calculated to categorize the magnitude of learning improvement into low, moderate, or high classifications, following Hake (1999), as shown in Table 2.

Table 2 N-Gain classification category

N-Gain Score Range	Category
≥ 0.70	High
0.30 – 0.69	Moderate
< 0.30	Low

This combination of statistical testing and N-Gain analysis provided a comprehensive evaluation of the module's effectiveness, capturing not only significance but also the extent of conceptual and cognitive development achieved by students after using the e-module.

3. RESULT AND DISCUSSION

This section presents the study's findings based on the three research objectives: (1) developing the *Save the Earth!* e-module, (2) evaluating its feasibility and practicality, and (3) examining its effectiveness in improving sustainability awareness and critical thinking. Results are discussed together with theoretical and empirical evidence to provide a comprehensive interpretation of the product's performance.

3.1 Development of the ESD-Based *Save the Earth!* E-Module

Save the Earth! The e-module was developed using the ADDIE–MDLC framework to ensure that the final product was pedagogically sound, visually coherent, and aligned with the Sustainable Lifestyle theme of P5. Needs analysis revealed that the learning materials for sustainability topics in participating classrooms were predominantly textbook-based, lacked contextual relevance, and lacked interactive features, contributing to passive learning and low student motivation. This finding reinforces earlier research by Bommeri et al. (2024) and Nurdiyanto & Nurhanurawati (2022), who emphasize that monotonous instructional materials tend to reduce student engagement and limit higher-order learning.

To address these gaps, the e-module was structured into five sequential learning stages: Orientation, Contextualization, Real Action, Mini Exhibition, and Final Reflection. Each stage was designed to scaffold students from conceptual awareness toward practical environmental action. The design followed backward design principles (Wiggins & McTighe, 2005), ensuring alignment between competencies, performance tasks, and learning activities. Project-based learning (PBL) underpinned the instructional structure, supporting inquiry, collaboration, and problem-solving. Interactive features such as green stories, reflective boxes, crossword puzzles, inquiry activities, and collaborative tasks were embedded to stimulate multimodal engagement and to align with Mayer's multimedia learning principles.

Visually, the module used an intentional combination of typography, color schemes, and layout design, developed in Canva, to promote accessibility and sustained motivation. The content aligned with the Indonesian national curriculum, SDGs, and key ESD competencies (UNESCO, 2020), situating the module within global and national sustainability frameworks. This approach mirrors the findings of Saraswati et al. (2019), who reported that multimedia-rich e-modules significantly improve motivation and comprehension in environmental learning contexts.

Beyond these structural and multimedia considerations, the development process aligns more deeply with transformative ESD frameworks. UNESCO (2020) emphasizes that sustainability learning must shift from knowledge acquisition to meaning-making and value transformation. By integrating real dilemmas, reflective activities, and opportunities for student-led action, the module embodies this "learning for transformation." Research by Shayan et al. (2022) supports this, showing that ESD interventions become transformative when students critically interpret environmental issues, negotiate ethical choices, and develop personal agency. Thus, the *Save the Earth!* e-module situates itself as both an instructional tool and a catalyst for sustainability-oriented identity formation within the P5 curriculum. Overall, the first research objective was achieved through the creation of a structured, engaging, and theoretically grounded e-module that integrates ESD principles within P5 learning.

3.2 Feasibility and Practicality of the E-Module

Feasibility

Expert validation yielded high feasibility scores: 4.50 for media aspects and 4.60 for content aspects, both classified as "Very Feasible". These results indicate that the e-module met expectations regarding content accuracy, pedagogical clarity, interactive coherence, and technical quality. The high inter-rater reliability (Cohen's Kappa = 0.79) strengthens the credibility of these evaluations.

These findings are consistent with previous studies (Saraswati et al., 2019; Sihombing et al., 2024), which show that digital modules aligned with ESD principles receive high feasibility scores due to their contextual authenticity, interactive components, and alignment with inquiry-based pedagogies.

Practicality

Practicality testing in both small-group (mean = 4.30) and field trials (mean = 4.26) also categorized the e-module as "Very Practical". Students found the module engaging and easy to use, while teachers expressed that it facilitated PjBL, reduced instructional preparation time, and helped structure the P5 activities more efficiently.

This aligns with Afriani et al. (2019), who highlight that inquiry-based digital resources improve student engagement, comprehension, and classroom flow. These practicality results also affirm the importance of structured digital resources for P5 implementation—a need highlighted by Delviyani et al. (2025), Sulistianti et al. (2024), and Palangda et al. (2023).

The positive feasibility and practicality results also show that the module effectively addressed several systemic challenges in P5 implementation. Teachers often struggle to translate P5 competencies into structured daily learning due to limited time, lack of ready-to-use resources, and uneven digital infrastructure. The module's clarity, scaffolding, and activity sequencing helped reduce this cognitive and logistical burden. This is consistent with Khoiri et al. (2023), who concluded that visually coherent and well-scaffolded digital modules can enhance motivation, persistence, and teacher confidence during sustainability learning. Therefore, the e-module

demonstrates not only pedagogical soundness but also practical relevance to real classroom conditions.

3.3 Effectiveness in Improving Sustainability Awareness and Critical Thinking

Sustainability Awareness

Students' sustainability awareness, as illustrated in Table 3, improved significantly, with mean scores increasing from 44.43 to 67.26. The Wilcoxon test ($V = 0$; $p < 0.001$) confirmed the statistical significance of these gains, and the N-Gain score of 0.74 (high category) demonstrated substantial pedagogical impact. The majority of students (65.22%) showed high gains, with none in the low category (see Table 4).

Table 3 Statistics of students' sustainability awareness

Test	Pretest	Posttest
Mean	44.43	67.26
Wilcoxon	51	70

Table 4 N-Gain distribution of sustainability awareness

Category	Frequency	Percentage
High	30	65.22%
Moderate	16	34.78%
Low	0	0%

The analysis of students' sustainability awareness demonstrates that the *Save the Earth!* The e-module generated substantial and equitable improvements across cognitive, affective, and behavioral dimensions. Quantitatively, students' mean scores increased from 44.43 in the pretest to 67.26 in the posttest. Because the posttest data were not normally distributed (Shapiro–Wilk $p = 0.011$), the Wilcoxon Signed-Rank Test was used, yielding $V = 0$; $p < 0.001$, confirming a statistically significant gain. The normalized gain (N-Gain) of 0.74, categorized as high, further indicates that the intervention had a substantial pedagogical impact, with 65.22% of students achieving high gain and none achieving low gain. These patterns suggest not only cognitive advancement but also meaningful shifts in emotional connection and behavioral readiness toward sustainability.

A deeper understanding of this improvement is visible in the boxplot comparison (Figure 2). The pretest boxplot shows a relatively low median, a wide interquartile range (IQR), and a single outlier above the upper whisker. This outlier reflects a student who possessed significantly higher initial sustainability awareness, likely due to prior personal or contextual exposure to environmental issues—an expected phenomenon in sustainability education where students arrive with uneven ecological experiences (Suryawati et al., 2023). The broad spread of pretest scores suggests that students entered the P5 Sustainable Lifestyle project with highly varied levels of understanding, attitudes, and familiarity with sustainability themes, consistent with Repanovici et al.'s (2021) claim that sustainability literacy is

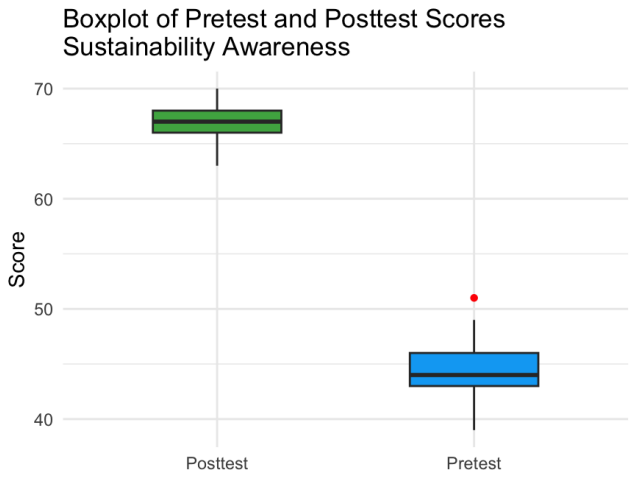

Figure 2 Boxplot analysis of sustainability awareness

shaped by unequal access to environmental information and values.

In contrast, the posttest boxplot reveals a sharply higher median and a significantly narrower IQR, indicating that students' awareness became more aligned after completing the module. Importantly, no outliers appear in the posttest, meaning that even the lowest-performing students improved sufficiently to remain within the typical distribution, and the previously high-performing outlier no longer scored excessively above the group. This equalization of performance is pedagogically meaningful: it reflects not only improvement in average understanding but also greater equity in learning outcomes, a critical goal of Education for Sustainable Development (ESD). As Shobah et al. (2025) and Fathurohman et al. (2023) argue, high-quality ESD interventions must minimize learning disparities, enabling learners with different starting points to progress together. The uniform upward shift of Q1, median, and Q3 in the posttest visually reinforces that improvement occurred across the entire cohort—lower achievers caught up, and higher achievers continued to progress.

These improvements can be understood in light of the module's pedagogical design. The e-module integrated green stories, reflective prompts, contextual case studies, and action-oriented tasks, all aligned with Sass et al.'s (2021) model of sustainability action competence, which emphasizes the cycle of awareness, reflection, and behavior. By embedding realistic environmental dilemmas, the module activated students' emotional engagement, which research by Suryawati et al. (2023) shows to be a precursor to more profound sustainability concern. This emotional shift matters because, as Ajzen's Theory of Planned Behavior (1991) explains, attitudes and perceived behavioral control play central roles in shaping pro-environmental intention. The upward shift across all quartiles in the boxplot may therefore reflect not only cognitive growth but also greater attitudinal readiness and

a stronger sense of agency in environmental decision-making.

The narrowing of posttest variability also supports Repanovici et al.'s (2021) observation that sustainability learning must integrate emotional sensitivity and reflective judgment to promote consistent development. The disappearance of outliers and reduction of score dispersion indicate that the *Save the Earth!* The e-module provided sufficient scaffolding for learners with low awareness, enabling them to internalize key concepts and values. This is consistent with Schröder et al. (2023), who argue that even short, well-structured sustainability training can initiate meaningful behavioral and worldview transformations.

Moreover, the findings support UNESCO's (2020) emphasis on transformative ESD, which seeks to shift learners' mindsets toward ecological responsibility through real-world engagement rather than mere factual knowledge. By guiding students through Orientation, Contextualization, Real Action, Mini Exhibition, and Final Reflection stages, the module provided repeated opportunities for students to connect personal experiences with sustainability challenges. Such staged learning mirrors the reflective-action cycle described by Sterling (2001), who argues that transformative learning arises when cognition, emotion, and ethical reasoning interact dynamically.

Taken together, the quantitative gains, the improvement in quartile distributions, the disappearance of outliers, and the alignment with established ESD frameworks indicate that the *Save the Earth!* The e-module was highly effective in elevating and equalizing students' sustainability awareness. The module not only increased conceptual understanding but also fostered emotional engagement and behavioral readiness—three pillars of sustainability consciousness recognized by Sass et al. (2021), Suryawati et al. (2023), and Repanovici et al. (2021). These outcomes affirm the module's value as a robust digital resource that supports P5 implementation while promoting inclusive and meaningful engagement with sustainability issues.

Critical Thinking

In addition to fostering sustainability awareness, the *Save the Earth!* The e-module was designed to strengthen students' critical thinking skills—an essential competency in ESD and a core component of the P5 profile. Critical thinking enables students to move beyond surface-level understanding and engage in deeper analysis of sustainability issues by identifying problems, evaluating information, constructing arguments, and proposing evidence-based actions. Given that ESD emphasizes not only knowledge but also critical thinking about complex socio-ecological challenges, it is essential to assess whether the e-module supported improvements in these higher-order cognitive abilities.

The analysis of students' critical thinking skills demonstrates that the *Save the Earth!* The e-module facilitated meaningful and equitable cognitive growth across the cohort. Quantitatively, as illustrated in Table 5, the proportion of students classified in the "high" critical thinking category increased sharply from 17.4% in the pretest to 60.9% in the posttest. In comparison, those in the "low" category dropped from 50.0% to just 6.5%. This categorical shift indicates significant improvement not only at the average level but also across performance strata, suggesting that the module effectively supported students with initially low reasoning abilities.

Table 5 Distribution of students' critical thinking skills

Category	Pretest (n)	%	Posttest (n)	%
Low	23	50.0%	3	6.5%
Moderate	15	32.6%	15	32.6%
High	8	17.4%	28	60.9%

Further examination of indicator-level performance (Table 6) reveals consistent improvement across all five dimensions of critical thinking—identifying problems, analyzing information, constructing arguments, proposing solutions, and reflective evaluation—with the most substantial gains occurring in problem identification, which rose from 3.00 to 4.29. This pattern aligns with findings by Aisyah et al. (2024), who reported that sustainability-themed inquiry tasks help students more accurately diagnose core issues due to the authenticity and complexity of real-world environmental scenarios.

Table 6 Average scores by critical thinking indicator

Indicator	Pretest	Posttest
Identifying Problems	3.00	4.29
Analyzing Information	2.98	4.00
Constructing Arguments	2.91	4.10
Proposing Solutions	3.17	3.97
Reflective Evaluation	2.77	3.74

Inferentially, the paired t-test confirmed that the improvement was statistically significant (mean difference = 10.52, $p < 0.001$), while the overall N-Gain score of 0.52, categorized as moderate, suggests that the intervention successfully built foundational critical thinking skills but that more profound mastery requires continued iterative practice (see tables 7 and 8).

Table 7 Paired sample t-test for critical thinking

Test	Value
p-value	< 0.001
Mean Diff.	10.52

Table 8 N-gain score and distribution for critical thinking

Category	Frequency	Percentage
High	9	19.57%
Moderate	32	69.57%
Low	5	10.87%

This finding is consistent with Facione's (2015) conceptualization of critical thinking as a progressive developmental process that strengthens through repeated exposure to analytical reasoning, reflective questioning, and structured opportunities for argumentation. The moderate N-Gain also echoes Mezirow's (2014) and Illeris' (2014) transformative learning theories, which posit that higher-order reasoning, especially the ability to evaluate multiple perspectives or synthesize conflicting evidence, tends to emerge through prolonged cycles of reflection and perspective-taking rather than through a single short-term intervention.

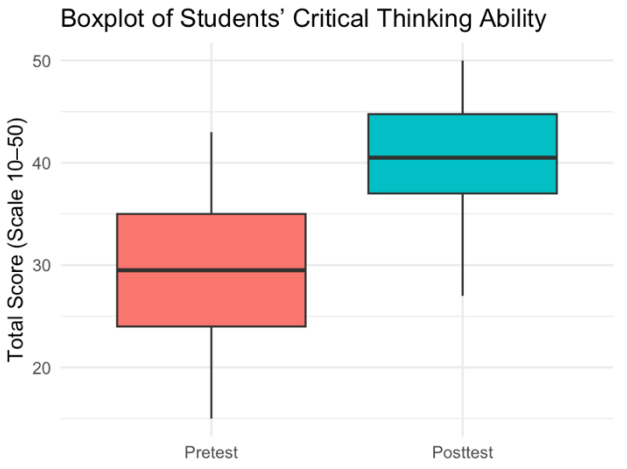

Figure 3 Boxplot of students' critical thinking scores

The boxplot comparison (Figure 3) provides further evidence of these improvements. The pretest boxplot reveals a lower median and a wider interquartile range (IQR), reflecting substantial variability in baseline analytical ability. This is typical in classrooms where inquiry and argumentation are not yet embedded as routine practices, resulting in uneven familiarity with critical reasoning. After the intervention, the posttest boxplot shows a marked upward shift in the median and a moderately narrower IQR, indicating not only improvement in central tendency but also more cohesive performance across the student cohort. A distinctive feature of Figure 3 is the absence of outliers in both the pretest and posttest distributions, suggesting that none of the students performed extraordinarily low or high relative to their peers. The absence of posttest outliers is particularly noteworthy because it implies that the e-module supported uniform cognitive improvement, enabling weaker students to reach the expected performance range while still allowing stronger students to progress without exceeding the typical distribution. This aligns with research by Ummah et al. (2023) and Pangsuma et al. (2024), who demonstrate that structured digital inquiry environments—including guided questions, reflective prompts, and contextual problem frames—can reduce variance by better supporting learners with lower baseline skills.

The upward shifts of both whiskers in the posttest boxplot further indicate that the intervention enhanced performance across the entire spectrum—from students who initially had difficulty identifying or analyzing problems to those who were already more comfortable with abstract reasoning. This pattern aligns with Setyowati et al. (2022), who found that inquiry-based digital science modules foster deeper analytical engagement by prompting students to examine evidence, justify their choices, and articulate conceptual linkages. The reflective components embedded in the *Save the Earth!* The e-module also mirrors Mezirow's (2014) and Taylor's (2017) transformative learning frameworks, which emphasize that critical thinking develops through cycles of reflection, disorientation, and reconstruction of meaning. By asking students to confront authentic sustainability dilemmas, evaluate possible solutions, and justify decisions with evidence, the module likely initiated the early stages of transformative cognitive processes.

Taken together, the quantitative gains, the consistent upward movement across all critical thinking indicators, and the cohesive distributional patterns in the boxplot demonstrate that the *Save the Earth!* The e-module effectively strengthened students' analytical and evaluative reasoning. Although the moderate N-Gain suggests that critical thinking continues to require long-term reinforcement, the clear improvements across quartiles reflect that the module successfully established the foundational competencies necessary for further development. These outcomes affirm the module's value as a pedagogically sound, inquiry-oriented digital resource that can support P5 implementation while fostering essential higher-order thinking skills within the context of Education for Sustainable Development.

4. CONCLUSION

The findings of this study demonstrate that the *Save the Earth!* e-module—developed using the ADDIE model and grounded in Education for Sustainable Development (ESD)—is a valid, practical, and effective learning tool within the Pancasila Student Profile (P5) program. Expert evaluations rated the module as "Very Feasible," while teacher and student trials confirmed its high practicality in real classroom settings. The effectiveness test further

showed significant improvements in both sustainability awareness and critical thinking, with N-Gain scores of 0.74 (high) and 0.67 (moderate), indicating the module's strong capacity to enhance essential 21st-century competencies.

The module's structured learning design, integration of contextual sustainability issues, and interactive features position it as a promising resource for broader adoption across schools implementing the Merdeka Curriculum. Although the one-group pretest–posttest design and short intervention duration limit causal generalization, the results provide convincing evidence that ESD-based digital modules can serve as impactful catalysts for environmental awareness and the early stages of higher-order reasoning. Future research may strengthen these findings by incorporating comparison groups, more extended implementation periods, and follow-up assessments. Overall, the *Save the Earth!* e-module offers a replicable and scalable model for advancing sustainability-oriented learning, reducing disparities, and supporting transformative educational practices in Indonesian secondary schools.

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