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The Influence of Electronic Modules on Environmental Literacy in Raising Environmental Awareness among Fifth Grade Elementary School Students

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ABSTRACT

This study aimed to examine the effectiveness of an ecoliteracy e-module in improving elementary school students' conceptual understanding and pro-environmental behavior. The background of this study is based on the limited availability of learning media capable of integrating knowledge, attitudes, and ecological behavior aspects in a comprehensive. The ecoliteracy e-module was developed as an alternative digital teaching material that is interactive. This study employed a pre-experimental design with a quantitative approach, involving a single group of 25 students. Data were collected through pretest and posttest assessments to measure students' improvement in understanding, as well as structured observations to identify behavioral changes related to waste management practices in the school environment. Data analysis focused on comparing scores before and after the use of the e-module, calculating the gain score, and interpreting observational findings. The results indicated a significant improvement in students' understanding after using the ecoliteracy e-module. The mean score increased from 46.20 in the pretest to 65.40 in the posttest, with a gain of 19.20 points. The normalized gain (N-Gain) value of 0.36 falls into the moderate improvement category, indicating that the e-module was reasonably effective. However, observational findings showed that this improvement in understanding was not fully followed by consistent behavioral changes. Based on these findings, it can be concluded that the ecoliteracy e-module is effective in improving elementary students' understanding of waste management and environmental awareness. Nevertheless, to promote more sustainable behavioral change, continuous habituation and supportive learning environments are still required.

Keywords: *E-Modules, Ecoliteracy, Student Behavior*

ABSTRAK

Penelitian ini bertujuan untuk menguji efektivitas modul elektronik ekoliterasi dalam meningkatkan pemahaman konseptual dan perilaku pro-lingkungan siswa sekolah dasar. Latar belakang penelitian ini didasarkan pada keterbatasan ketersediaan media pembelajaran yang mampu mengintegrasikan pengetahuan, sikap, dan aspek perilaku ekologis secara komprehensif. Modul elektronik ekoliterasi dikembangkan sebagai bahan ajar digital alternatif yang interaktif. Penelitian ini menggunakan desain pra-eksperimental dengan pendekatan kuantitatif, melibatkan satu kelompok yang terdiri dari 25 siswa. Data dikumpulkan melalui penilaian pretest dan posttest untuk mengukur peningkatan pemahaman siswa, serta observasi terstruktur untuk mengidentifikasi perubahan perilaku terkait praktik pengelolaan sampah di lingkungan sekolah. Analisis data difokuskan pada perbandingan skor sebelum dan sesudah penggunaan modul elektronik, penghitungan skor peningkatan, dan interpretasi temuan observasi. Hasil menunjukkan peningkatan yang signifikan dalam pemahaman siswa setelah menggunakan modul elektronik ekoliterasi. Skor rata-rata meningkat dari 46,20 pada pretest menjadi 65,40 pada posttest, dengan peningkatan sebesar 19,20 poin. Nilai normalized gain (N-Gain) sebesar 0,36 termasuk dalam kategori peningkatan moderat, yang menunjukkan bahwa e-

modul tersebut cukup efektif. Namun, temuan observasi menunjukkan bahwa peningkatan pemahaman ini tidak sepenuhnya diikuti oleh perubahan perilaku yang konsisten. Berdasarkan temuan ini, dapat disimpulkan bahwa e-modul ekoliterasi efektif dalam meningkatkan pemahaman siswa sekolah dasar tentang pengelolaan sampah dan kesadaran lingkungan. Meskipun demikian, untuk mendorong perubahan perilaku yang lebih berkelanjutan, pembiasaan yang berkelanjutan dan lingkungan belajar yang mendukung masih diperlukan.
Kata kunci: E-Modul, Ekoliterasi, Perilaku Siswa

INTRODUCTION

Climate change, pollution, and environmental degradation are no longer issues that are far removed from everyday life (Wahyuni et al., 2022). Their impact can be felt through increasingly unpredictable weather, more frequent flooding or droughts in various regions, declining air quality, and increasingly complex waste management issues (Lestari et al., 2023). This situation shows that the environmental crisis is not only related to natural issues, but also closely linked to the way humans produce, consume, and dispose of things (Aliyah & Falah, 2025). This means that efforts to protect the environment require a change in mindset and habits that must be built gradually, consistently, and starting from school age (Ivanka & Cahaya Nurani, 2025).

In the context of sustainable development, education plays a strategic role as it is the main channel for shaping the values, attitudes and character of the younger generation. Schools are not only responsible for transferring academic knowledge, but also for shaping citizens who are responsible for their social and natural environment (Rakhmawati et al., 2023). As ecological issues become increasingly urgent, environmental education is no longer seen as an additional subject, but rather a necessity that must be integrated into the learning process (Yunita et al., 2025). This is where the concept of ecoliteracy becomes important: ecoliteracy emphasises an understanding of the reciprocal relationship between humans and the environment, as well as the ability to make wiser decisions and take actions to preserve nature (Shamla & Eka Wulandari, 2025).

Primary school is a crucial stage in the formation of ecoliteracy. At this stage, children are undergoing rapid cognitive and socio-emotional development, making it easier to instil good habits through habit formation, role models, and direct experience (Tyas et al., 2022). Environmental education in primary schools should ideally not only teach 'what waste is' or 'why the environment must be protected', but also foster sensitivity, a sense of ownership, and responsibility through concrete actions such as disposing of waste in the right place, sorting waste, reducing the use of single-use plastics, conserving water and electricity, and maintaining the cleanliness of classrooms and school grounds (Setiadi et al., 2023). Meaningful learning occurs when students not only understand concepts, but are also able to relate them to issues around them and turn them into daily practices (Nilam Tyas et al., 2025).

However, in environmental education practice, there is often a gap between knowledge and behaviour (Vioreza et al., 2023). Many students can answer questions about the importance of cleanliness or the impact of plastic waste, but they are not yet consistent in applying this knowledge in school life (Nopiana, 2025). This gap can be influenced by many factors, such as lecture-oriented learning, a lack of contextual experience, a lack of facility support (e.g. separate rubbish bins), a weak school culture, and a social environment that is not accustomed to pro-environmental actions. These conditions show that ecoliteracy education requires

learning strategies that are not only informative but also transformative changing the way of thinking and encouraging action (Rizkyansyah et al., 2025).

With the development of technology and the demands of 21st century learning, innovative learning media are increasingly being used to improve student engagement (Anisa Sofiana Perdani et al., 2025). Digital transformation in education has opened up opportunities to deliver learning that is more engaging, adaptive, and tailored to the characteristics of today's learners (Wisman & Santoso, 2024). Primary school children live in a visual and digital era; they tend to be more responsive to interactive media that is rich in illustrations and involves exploratory activities. Therefore, the use of digital teaching materials is a relevant alternative for strengthening environmental learning (Ade Muslimat, 2022).

One form of digital teaching material that is developing is the e-module. Unlike printed modules, e-modules can be designed to be more dynamic by combining text, images, animations, videos, links, interactive exercises, quizzes, and simple project assignments (Perdani et al., 2025). E-modules also allow for more flexible learning, both at school and at home, thereby expanding opportunities for students to study independently and review material as needed (Muliadi & Pahmi, 2024). In the context of ecoliteracy, e-modules have great potential because environmental issues are easier to understand when presented through visualisations, real-life examples, contextual stories, and activities that challenge students to observe their own environment (Alda Resal et al., 2022).

However, the use of technology in learning does not automatically guarantee behavioural change (Tri Atmaja et al., 2021). Digital media can increase attention and understanding of concepts, but changes in pro-environmental attitudes and behaviours usually require time, habituation, and support from the school and family ecosystems (Taufik et al., 2024). Therefore, it is important to position e-modules not merely as 'teaching tools,' but as part of a targeted learning strategy for example, supplemented with reflection activities, real-world challenges, daily habit tracking, and reinforcement through class rules or culture. In this way, ecoliteracy learning does not stop at knowledge, but moves towards practice (Arifah, 2024).

Given the urgency of environmental issues and the need to strengthen ecoliteracy education from primary school onwards, it is relevant to conduct a study on the use of ecoliteracy e-modules (Haq et al., 2023). Research on the effectiveness of e-modules is important not only to determine whether this medium is attractive or easy to use, but also to assess the extent to which e-modules can encourage students' understanding, attitudes and, in particular, environmentally conscious behaviour (Hudhana et al., 2025). Focusing on fifth grade students is also important because at this level, students generally have more mature literacy skills, are able to think more reflectively, and are ready to be given more structured challenges (Tryanasari & Kartikasari HS, 2021). Thus, research related to ecoliteracy e-modules can contribute to the development of more effective, contextual environmental learning innovations that have an impact on real habits at school.

According to several experts, ecoliteracy is not only defined as the ability to understand environmental concepts cognitively, but also includes the process of internalising values that are reflected in environmentally friendly attitudes and behaviours in everyday life (Hilman et al., 2023). They emphasise that environmental education that stops at mastering information risks producing 'students who know', but not necessarily 'students who care' and 'students who act'(Arham et al., 2025). Therefore, ecoliteracy requires learning that touches on three

areas simultaneously: ecological knowledge (what and why), ecological attitudes (caring, responsibility, and sensitivity), and ecological behaviour (real and consistent habits) (Sajidah & Amelia, 2024). In the context of primary school, this framework is important because the developmental phase of children is a period of habit and character formation; pro-environmental behaviour instilled from an early age tends to become part of one's personal culture when reinforced repeatedly (Mulyati & Samsudin, 2023).

Ecoliteracy education essentially aims to foster a deeper awareness among students of the reciprocal relationship between humans and nature (Israwaty et al., 2023). This awareness is not merely about understanding that the environment 'must be protected', but rather realising the consequences of simple actions such as the use of single-use plastics, littering, or wasting water on the health of the school environment and community (Sugiantoro et al., 2025). At a more practical level, students are encouraged to observe environmental issues around them, identify the causes, and choose the most feasible actions within their capacity as schoolchildren (Riki Zulfiko, 2024). Thus, effective ecoliteracy learning should provide opportunities for direct experience, decision-making practice, and reflection so that students understand that small, consistent actions can have an impact.

One way that is considered effective in improving ecoliteracy among students is the use of e-modules, as this medium allows learning to take place independently, flexibly, and interactively according to the needs and learning speed of students (Hendratno et al., 2025). E-modules can make abstract ecological material more concrete through visuals, illustrations, videos, simple simulations, and interactive quizzes that encourage students to actively build understanding, rather than just receiving information (Muhyidin et al., 2025). The flexibility of e-modules also makes it easier for teachers to integrate environmental learning into various contexts, for example, by linking the material to habits in the school canteen, classroom cleanliness, daily waste management, or small projects at home (Handayani et al., 2025). On the student side, e-modules provide opportunities to review material, access real-life examples, and carry out task-based learning activities whose progress can be measured (Abdullah, 2023).

Another advantage of e-modules is their ability to connect conceptual understanding with practice. For example, after learning about the impact of plastic waste, e-modules can guide students to carry out 'action challenges' such as recording their plastic use for a week, trying to bring their own drinking bottles, sorting waste at home, or creating mini campaigns in class (Afiani et al., 2022). Activities like these help bridge the gap that often exists between knowledge and behaviour: students not only learn ecological concepts, but also practise applying them in real-life routines (Jufri et al., 2025). When e-modules are designed with reflective tasks (e.g., a simple 'today's eco-friendly action' journal), feedback, and continuous reinforcement, ecoliteracy learning has the potential to be more meaningful because it targets changes in attitudes and habits, not just an increase in knowledge scores.

Despite various environmental education efforts in primary schools, the main challenge faced is the lack of student involvement in programmes aimed at shaping environmentally conscious behaviour. This study aims to explore the use of e-modules on environmental literacy as a solution to improve students' behaviour towards caring for the environment. By utilising technology in the form of e-modules, it is hoped that students can learn in a more interesting and effective way. The main focus of this study is to determine how the

implementation of e-modules can influence students' knowledge, attitudes, and behaviour towards the environment.

The purpose of this study was to examine the effectiveness of the e-module on environmental literacy in improving the behaviour of primary school students, particularly those in Grade V. More specifically, this study aimed to assess the effect of using the e-module on improving students' knowledge of environmental issues, changing their attitudes towards the importance of preserving the environment, and how this affects students' behaviour in interacting with their surrounding environment.

METHODS

Type and Design

This study used a pre-experimental design with a quantitative approach, aiming to measure the effectiveness of the e-module on ecoliteracy in improving students' behaviour related to waste management and environmental awareness. The design used was a pretest-posttest without a control group, where data was collected by comparing the pretest and posttest scores obtained by students before and after the treatment using the e-module on ecoliteracy. The data sources in this study were 25 fifth grade students at an elementary school in Bandung who participated in an ecoliteracy programme using e-modules. The data collected consisted of two types: pretest and posttest data used to measure changes in students' understanding of ecoliteracy, and student behaviour data obtained through direct observation of their actions in waste management.

Data and Data Sources

The data collection procedure began with administering a pretest to students to measure their initial level of ecoliteracy knowledge. The pretest consisted of 20 items, including 10 multiple-choice questions and 10 short-answer questions covering waste management concepts and ecoliteracy principles. The instrument was administered directly to students without prior feasibility testing through expert judgment; however, the items were constructed based on learning indicators derived from relevant literature and instructional objectives to ensure content relevance. After the pretest, students received an intervention in the form of an ecoliteracy e-module containing material on waste management and the importance of ecoliteracy. The e-module could be accessed both online and offline depending on the technical facilities available at school. Upon completion of the learning activities, students were given a posttest consisting of the same number and type of items as the pretest to measure changes in their level of understanding.

To examine the consistency of the test instrument, reliability analysis was conducted using Cronbach's Alpha through SPSS statistical software. This analysis aimed to determine the internal consistency of the items and ensure that the instrument produced stable and reliable measurements. In addition, during the implementation of the e-module, direct observations of student behaviour were carried out to assess how far students applied their ecoliteracy knowledge in daily school activities, particularly those related to waste management.

Data collection technique

The instruments used in this study consisted of two primary tools. First, the pretest and posttest instruments were designed to measure students' cognitive understanding of ecoliteracy concepts, including waste sorting, plastic waste management, and efforts to reduce single-use plastics (Nur Asyiah Siregar et al., 2023). Each test consisted of 20 items (10 multiple choice and 10 short-answer questions). Reliability testing using Cronbach's Alpha was conducted to assess internal consistency, while formal validity testing through expert judgment was not performed.

Second, student behaviour was assessed using an observation sheet designed to record behavioural indicators related to ecoliteracy practices. The observation instrument included five indicators: (1) separating plastic waste from other waste, (2) sorting waste by type, (3) disposing of waste in proper bins, (4) reducing the use of single-use plastics, and (5) reminding peers to dispose of waste properly. Each indicator was rated using a four-point Likert scale consisting of Never (1), Rarely (2), Sometimes (3), and Always (4) (Suasapha, 2020). The observation sheet was used directly in the field without prior validity or reliability testing; therefore, the results were interpreted descriptively to reflect observable behavioural tendencies rather than standardized measurement outcomes.

Data analysis

The collected data were analysed using descriptive statistical analysis to obtain an overview of the pretest and posttest scores, including the mean, standard deviation (SD), and range of values (Nur Asyiah Siregar et al., 2023). Changes in students' understanding were measured by calculating N-Gain, which shows the difference between students' post-test and pre-test scores. Based on Hake's (1999) criteria, the N-Gain categories used were: high (≥ 0.70), moderate (0.30–0.69), and low (< 0.30). In addition, student behaviour observation data was analysed by calculating the percentage of students in each response category for each indicator. Thus, this analysis will provide an overview of the extent to which the use of the e-module on ecoliteracy can improve student behaviour in waste management and increase their environmental awareness.

RESULTS AND DISCUSSION

Results

The results of the study indicate that the use of e-modules on environmental literacy has a significant impact on improving students' understanding and behaviour in the context of waste management and environmental awareness at school. This positive impact is evident from the changes in student learning outcomes before and after the intervention, while also demonstrating that e-module based learning is able to provide a more focused, accessible learning experience that stimulates student engagement with environmental issues that are relevant to their daily lives.

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Posttest	25	20	95	65.40	3.558	17.790
Pretest	25	20	75	46.20	3.218	16.091
Valid N (listwise)	25					

Figure 1. Descriptive Statistics

Quantitatively, the effectiveness of the e-module is reflected in the pretest and posttest results, which show a significant increase in comprehension scores after students participated in a series of lessons using the e-module on ecoliteracy. The data shows that the average pretest score was 46.20 and increased to 65.40 on the posttest. This difference of 19.20 points indicates a fairly strong improvement in conceptual mastery, especially in materials that require an understanding of the cause and effect relationship between human behaviour, waste generation, and its impact on the environment.

Based on the N-Gain calculation results, the average increase of 19.20 points can be interpreted as evidence that e-modules not only function as a source of material, but also as a learning tool that facilitates a more meaningful learning process. Through interactive displays, structured assignments, and contextual examples related to waste management practices in the surrounding environment, the e-module helps students build understanding gradually from recognising types of waste, understanding the principles of reduce, reuse, recycle to considering more environmentally friendly options. Thus, the e-module on ecoliteracy has the potential to become a relevant learning strategy for strengthening environmental literacy from primary school onwards, as it is able to improve students' understanding in a measurable way while guiding the formation of pro-environmental behaviour in daily activities.

Table 1. Average N-Gain of Students

Description	Value
Number of Students	25
Average N-Gain	0.2489
N-Gain Category	Low

Table 2 presents the average N-Gain score of the students. The analysis involved 25 participants. The results show that the mean N-Gain value is 0.2489, which falls into the low improvement category. This indicates that, overall, the increase in students' learning outcomes after the intervention was limited and not yet optimal across the group.

Table 2. Pretest–Posttest Comparison Results

Variable	Mean	SD	t	df	p	Effect Size (Cohen's d)
Pretest	46.20	16.09				
Posttest	65.40	17.79	−5.863	24	< .001	1.173

The results presented in Table X indicate that students' mean score increased from 46.20 (SD = 16.09) in the pretest to 65.40 (SD = 17.79) in the posttest, suggesting an improvement in ecoliteracy understanding after the implementation of the e-module. The paired-samples t-test revealed that this difference was statistically significant, $t(24) = -5.863$, $p < .001$, indicating that the observed improvement was unlikely to occur by chance. Furthermore, the effect size analysis showed a large magnitude of effect (Cohen's $d = 1.173$), which demonstrates that the intervention had a strong practical impact on students' learning outcomes. These findings

provide empirical evidence that the ecoliteracy e-module contributed substantially to enhancing students' knowledge, particularly in relation to waste management concepts and environmental awareness.

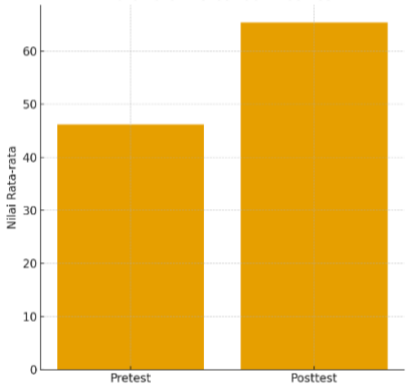

Figure 2. Graph of Average Pretest and Posttest Improvement

Based on the diagram above, an increase in students' average scores can be observed after participating in learning using the ecoliteracy e-module, with the mean rising from 46.20 in the pretest to 65.40 in the posttest. To determine whether this increase was statistically significant, a paired-samples t-test was conducted. The results indicated a significant difference between pretest and posttest scores, $t(24) = -5.863$, $p < .001$. This finding demonstrates that the observed improvement was not merely descriptive but statistically meaningful. In addition, the effect size analysis showed a large magnitude of effect (Cohen's $d = 1.173$), indicating that the intervention had a strong practical impact on students' ecoliteracy achievement. Therefore, the statistical evidence supports the conclusion that the e-module contributed substantially to improving students' understanding, particularly regarding waste management concepts and environmental awareness, rather than the improvement occurring by chance or random variation.

Furthermore, the N-Gain calculation results with an average of 0,2489, which is in the moderate category, reinforce the finding that the changes that have occurred are not merely fluctuations in value, but rather a meaningful improvement in learning. The 'moderate' category in N-Gain usually indicates that learning has been effective in improving understanding, but there is still room for improvement so that the impact can move towards the high category. In other words, the e-module has made a strong positive contribution, but the improvement is likely not yet optimal due to variations in students' initial abilities, differences in learning speeds, and external factors such as independent learning habits and learning environment support.

When linked to the characteristics of e-modules, this improvement is understandable because e-modules generally facilitate more active learning is students can reread the material, work through exercises step by step, and connect topics to real life situations around them. In the context of ecoliteracy, problem based presentations (e.g., examples of plastic waste at school/home) tend to help students build conceptual understanding as well as cause and effect reasoning (why waste needs to be managed, what the impact is, and what the appropriate actions are). This makes learning more meaningful than a one way approach, so it is natural that post-test scores increase.

However, as N-Gain is still in the moderate category, these findings also imply the need for further reinforcement strategies. Reinforcement can be carried out through discussion mentoring, brief reflection after e-module activities, and contextual assignments that encourage students to apply concepts (e.g., classroom waste audits, journals on the habit of bringing drinking bottles, or simple sorting projects). With this kind of reinforcement, e-modules not only serve as a digital learning resource, but also spark deeper learning, so that students' understanding has the potential to be higher and more stable between individuals.

Discussion

Based on the findings, the implementation of the ecoliteracy e-module demonstrated a positive effect on improving students' knowledge related to waste management and environmental awareness. The increase in mean pretest and posttest scores indicates that students developed a better conceptual understanding after participating in e-module–based learning. This result is consistent with previous studies reporting that digital learning modules can enhance students' comprehension by presenting material in structured, interactive, and accessible formats that support independent learning and cognitive engagement. Such findings support earlier research showing that technology-based instructional media contribute significantly to conceptual learning gains in environmental education contexts.

Despite the overall improvement, variability in students' learning gains was observed. Two students achieved very high normalized gain scores (N-Gain = 0.900 and 0.875), indicating optimal utilization of the e-module content. In contrast, two students showed no improvement (N-Gain = 0), suggesting that individual differences such as prior knowledge, learning motivation, reading ability, or learning support outside the classroom may influence learning outcomes. This variation aligns with previous studies emphasizing that digital instructional tools do not automatically guarantee uniform learning gains, as learner characteristics and contextual factors play a substantial role in determining effectiveness.

In terms of behavioural outcomes, although students demonstrated increased awareness of environmental concepts, consistent pro-environmental behaviour was not fully achieved. Observational data indicated that most students only occasionally sorted waste or reduced single-use plastic use. This pattern suggests that cognitive understanding does not automatically translate into behavioural change. Prior research has similarly shown that environmental knowledge alone is insufficient to produce stable behavioural transformation, as behaviour is influenced by habit formation, environmental reinforcement, and social norms (Tri Atmaja et al., 2021). One possible explanation is that pro-environmental behaviour requires repeated practice and reinforcement over time before becoming internalized habits. Without continuous habituation, newly acquired knowledge tends to remain at the cognitive level rather than manifesting as consistent action.

Another contributing factor may be the limited presence of a supportive environmental culture within the school context. Studies indicate that students are more likely to adopt sustainable behaviour when school environments consistently model and reinforce such practices through routines, rules, and facilities (Marpelina et al., 2025). In this study, inconsistent behaviour may be linked to insufficient systemic support, such as limited waste-sorting infrastructure, lack of routine environmental programs, or minimal teacher reinforcement. Furthermore, although some students disposed of waste properly, many did

not remind their peers to do so, suggesting that collective responsibility and environmental social norms had not yet been fully established. Previous research highlights that collaborative approaches such as project based environmental activities, peer monitoring, and reward systems can strengthen social responsibility and promote behavioural consistency (Hidayati Azkiya et al., 2022).

Overall, these findings reinforce previous research demonstrating that ecoliteracy e-modules are effective instructional media for improving students' conceptual understanding of environmental issues. However, the results also highlight that cognitive improvement alone is insufficient to ensure behavioural transformation. To maximize the effectiveness of ecoliteracy interventions, learning innovations should be accompanied by continuous habituation practices and the cultivation of a supportive school culture. Integrating environmental routines, providing adequate facilities such as separated waste bins, and embedding sustainability values into daily school activities are essential steps to ensure that environmental knowledge is translated into consistent pro-environmental behaviour.

CONCLUSION

Based on the findings of this study, it can be concluded that the use of an ecoliteracy e-module has a positive impact on improving students' understanding of environmental issues. The pretest and posttest results showed a statistically significant increase in scores, with an average gain of 19.20 points, indicating that the e-module effectively enhanced students' conceptual knowledge. However, although students' understanding improved, behavioural changes related to waste management and the reduction of single-use plastics still varied considerably. While some students were able to apply the concepts consistently, others experienced difficulties in translating knowledge into sustained pro-environmental behaviour. These findings suggest that although the ecoliteracy e-module is effective in increasing cognitive learning outcomes, behavioural implementation requires continuous reinforcement and supportive environmental conditions.

In light of these findings, several recommendations can be proposed. Schools and teachers should strengthen environmental behaviour through structured habituation programs, provision of supporting facilities such as separated waste bins, and the integration of project-based activities that allow students to apply ecoliteracy concepts in real-life contexts. Policymakers and educational institutions are encouraged to support ecoliteracy initiatives by providing accessible digital learning resources and adequate environmental infrastructure, particularly for schools with limited facilities. For future researchers, it is recommended to employ more rigorous research designs, such as quasi-experimental or true experimental approaches with control groups, in order to obtain stronger causal evidence regarding the effectiveness of ecoliteracy e-modules. Longitudinal studies are also suggested to examine the sustainability of behavioural change over time and to identify additional factors influencing learning outcomes. With collaborative support from educators, institutions, and policymakers, students are expected to develop into environmentally responsible individuals capable of applying ecoliteracy values in their daily lives.

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