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## Developing a Transformative E-module with Reflective Video Tasks on Waste Management to Enhance Environmental Sensitivity

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**Abstract:** This study seeks to create a transformational project-based E-module featuring reflective video activities centered on local waste management challenges to foster environmental awareness among high school students in Depok, Indonesia. The module was tested with 10<sup>th</sup> grade students in a senior high school in Depok using the ADDIE model and a mixed-method approach. The e-module called "e-ling" has both asynchronous and synchronous functionalities and uses real-world waste management concerns as project-based activities. To see if the module was possible and useful, researchers used expert validation sheets, environmental sensitivity scales (before and after tests), and questionnaires for students and teachers. Expert evaluation in pedagogy, media, content, and language got an average score of 84.28%. Student and teacher answers showed that the material was very good (96% and 90%, respectively). Effectiveness testing showed that students' environmental sensitivity got a lot better, with an N-Gain score of 0.53 (moderate) and an average posttest score of 300 (high). These results indicate that the E-modul module is both viable and efficacious in improving students' environmental awareness, particularly with urban waste management issues in Depok.

**Keywords:** Transformative E-Module, Reflective Video, Environmental Sensitivity.

### 1. Introduction

Global concerns of greater urgency to solve are environmental damage and climate change. From unpredictable weather patterns with some regions experiencing rainy seasons to others suffering through severe droughts, to rising temperatures on land and at sea, these symptoms have been particularly felt lately. A paper [Lindsey & Dahlman \(2024\)](#) claims that with an average temperature increase of 1.4°C both on land and at sea, 2023 has been the warmest year on record. The [IPCC \(2021\)](#) also noted that floods and storms are getting more frequent due to climate change. Studies by [Fatawa et al. \(2023\)](#) reveal that dry spells are getting longer and present rainfall patterns are unpredictable. Changes in the rainy season, the length of the dry season, floods, whirlpools, and other aspects define climate change in Indonesia. Methane gas from landfills and other waste sites also contributes to global warming, in addition to the growth of greenhouse gases (GHGs) in the atmosphere. In academic terms, waste is the material left over after an item has served its purpose and is subsequently thrown away.

[Sejati \(2009\)](#) says that waste is everything that is thrown away or disposed of after a person or natural event has happened and is no longer needed. This term is a good starting point for understanding what waste is. It gives a conceptual underpinning, but the context of waste management is always changing to keep up with social and environmental developments. Recent research shows that waste has become a far more complex global issue than it once was, shaped by steady population growth, rapid urban expansion, and the mounting pressures of climate change ([Rubini et al., 2023](#)).

As the population increases, the volume of waste inevitably rises as well. [Lindsey & Dahlman \(2024\)](#) note that in many low- and middle-income countries, most waste is still managed through open dumping or loosely regulated burning. The [IPCC \(2021\)](#) also emphasizes that human actions, such as burning fossil fuels, clearing forests, and running industrial processes, continue to drive climate change. One point that often receives less attention is methane (CH<sub>4</sub>), which has a substantially higher warming effect per unit mass than carbon dioxide (CO<sub>2</sub>). [Saunois](#)



et al. (2020) reported that methane emissions contribute significantly to the global greenhouse effect, and increasing concentrations of this gas enhance the absorption of longwave radiation in the atmosphere, further warming the Earth.

As the population rises including in Indonesia waste has grown to be a constant environmental issue everywhere. Following India, Nigeria, China, and Brazil (Lindsey & Dahlman, 2024), Indonesia is the fifth biggest producer of plastic garbage to the ocean worldwide. The Republic of Indonesia's Ministry of Environment and Forestry (2023) lists Central Java, East Java, and West Java as the provinces with the greatest trash levels over the past three years (2019–2021). Depok City is one of the West Java cities today dealing with waste-related environmental problems.

Comprising 2,056,335 people distributed over 11 districts, Depok City is a metropolis (BPS Depok City, 2020). Since Depok City borders both Banten Province and DKI Jakarta Province, it is a showcase of West Java Province. The people of this city originate from many ethnic groups, including Betawinese, Sundanese, Javanese, and others, therefore creating a varied population. Being a city that supports the capital area, the activities of its people lead to different difficulties like garbage and environmental issues.

Garbage buildup is causing serious land problems in the city of Depok at now. While the capacity of the Cipayang final disposal site (TPA) is just 200 tonnes (Kisar., 2022), the Depok citizens produce almost 1,200 tonnes of garbage almost every day. This TPA therefore has exceeded its waste overflow capacity. Mostly, domestic, industrial, and market trash contributes to the total garbage generated. Apart from creating bad smells, the accumulating trash at the TPA causes decomposing garbage that produces methane gas, a greenhouse gas. Additionally included in the TPA are dangerous poisons derived from nearby electronic garbage.

Laws pertaining to waste, efficient waste use technology, and also outreach or education will help to minimise environmental damage resulting from trash. The perspectives of students with environmentally conscious nature can be greatly shaped by their education. Caymaz (2020) says that educating students from kindergarten through university at all educational levels will help to improve sensitivity and awareness; ideas, levels of knowledge, and alternative concepts about global warming should be defined; hence, an appropriate learning environment should be organised. Since it is a fundamental factor influencing students' attitudes and behaviours towards environmental issues, environmental sensitivity itself is an important prerequisite in environmental education (Hungerford & Volk, 1990). According to Metzger & McEwen (1999), environmental sensitivity is an affective dimension connected to an individual's emotional connection to nature that inspires concern and ecologically friendly activities. Before they act to save the environment, this becomes the main basis and a knowledge bridge for a person since not necessarily someone with good information about the environment will act in an environmentally caring manner without a feeling of environmental sensitivity.

Human lack sensitivity to the surroundings influences the environmental damage resulting from waste. Environmental sensitivity increases the inclination to act via knowing of environmental problems (Susilowati et al., 2020). According to Putri et al. (2022), the intention to act is directly influenced by environmental sensitivity; so, behaviour will directly follow from this influence. Every person reacts differently to situations that take place in their surrounds. People react to environmental problems in different ways, and a lot of this depend on what kind of knowledge they already have and how they turn that knowledge into real actions.

Good environmental education can help students build better pro-environment thinking and behavior. But the low awareness level among many high school students is still a problem that need to be solved. This shows that old teaching methods are not strong enough anymore to build deep environmental values. Even if environmental lessons can shape student behavior a bit, making long-term sustainable habits need more than just teaching the content. Djuwita et al. (2019) say that schools must make more serious effort to grow these values and help students practice them daily. But many studies still show that students' environmental sensitivity is low, meaning the current way of teaching is not working well. So new learning strategies are needed, especially ones that are more reflective and based on real issues, like letting students see actual waste problems in cities (Ibnu, 2023).

Survey results from SMAN 5 Kota Depok show students mostly know about environmental risks around them. Many can explain that too much trash is bad for the ecosystem and that burning waste can damage the air. But this understanding doesn't really show in their everyday behavior. Only few students actually act based on what they



know. In class, the knowledge is there, but it rarely becomes real behavior. This gap shows the need for a method that link what students know with what they actually do. Project-based learning is suggested as a better way to close this gap and help students use environmental knowledge in real life.

Almulla (2020) also found that even though students know a lot about environmental issues, their attitudes and daily habits still don't match that knowledge. Luque-González et al. (2025) found similar patterns in university students, showing that Project-Based Learning (PBL) helps them engage deeper with SDGs. Their results support the idea that hands-on projects are important for turning environmental knowledge into real action.

As information and communication technology grows, new ways to improve environmental education appear. Project-based electronic modules can make students more engaged and help them follow how environmental issues change over time. Adding video inside these modules can also make the learning feel more active and interactive, which may help students pay more attention to environmental problems.

Logan (2021) says that e-learning modules have an important role in raising student engagement and learning results. Martínez-García et al. (2023) also point out that e-learning research keeps growing, and electronic modules continue to push new ideas in digital learning. Husamah (2025) discusses how digital learning tools in environmental education can increase student participation, even though there are still problems like limited resources and weak infrastructure. But Akpen et al. (2024) remind that online learning can also reduce interaction, make students feel isolated, and lower active participation, so more strategies are needed to keep it effective.

Based on author observations at SMAN 5 Depok, 93% of students require additional learning resources to complement their course of learning. Of the students, 97.8% require individually comprehensible extra learning materials. Although many students, 51.1%, have never utilised electronic modules, 88.9% of them want to know and try learning with application-based or web-based E-modules.

By means of the optimisation of learning resources, including instructional materials, one can raise the quality of education. Knowledge, skills, and attitudes students need to acquire will help them to reach the designated learning objectives and fundamental competences. One type of instructional tool employed is modules of materials. Modules provide the material contextually, which helps students to grasp the learning and lets them learn anywhere and anytime.

While these modules are merely regular modules, the current teaching materials, released by the Ministry of Education used by schools in biology learning at the high school level, are what the current conditions or when learning is conducted remotely (online) demand electronic modules (E-modules). E-modules combine computer and print technologies for educational purposes. Print modules can be converted into electronic forms, hence defining electronic modules or E-modules. Print modules and E-modules are essentially the same, however their physical presentation methods change only.

Lessons in biology offer more fascinating and contextual practical activities. Still, the current instructional tools lack project assignments. Cooperative and collaborative project-solving abilities are often sought for in the workplace of the twenty-first century. Project-based electronic modules have been prompted by the shortcomings in biology textbooks, issues in the learning process, and evolution of information technology. E-modules are attempts to translate digital from print instructional tools. Given the present situation, where students more commonly read on cellphones, e-modules have become indispensable in the digital world. This e-modules have benefits over printed modules. Nurdin et al. (2025) stated that the integration of technology in biology learning not only enhances conceptual understanding but also enables personalization and the interactive exploration of real environmental issues. Adding reflective movies to project-based e-modules makes pro-environmental attitudes even stronger and helps close the gap between how individuals know and how they act by making learning experiences more meaningful.

Designed to give in-depth knowledge about environmental changes, this research intends to create a transforming electronic module with reflective video assignments on waste management based on the description given above, aimed to increase environmental sensitivity among high school students. The results of this study should greatly aid in the development of more effective waste management strategies that enhance environmental awareness among high school students in Depok, hence supporting their development.



## 2. Methods

This activity is to create a transforming electronic module including reflective video activities on waste management in order to improve environmental sensitivity among Depok high school students. Combining qualitative and quantitative research techniques, this kind of study employs a mixed method. Comprising five stages, the research development design uses the ADDIE model:

- a. Analysis: Identifying problems and development needs
- b. Design: detailing the product or module design process being developed
- c. Development: Creating prototypes and revisions
- d. Implementation: Applying the E-module product in schools
- e. Evaluation: Testing the effectiveness of the developed E-module product.

After establishing the development framework, the next step is to determine the research subjects to be involved in the trial of the e-module. Students and teachers at SMAN 5 Kota Depok from July 2023 to July 2024 were the subject of the study. With data gathered via pre-tests and post-tests, the instruments employed include a questionnaire measuring the efficacy of the E-module from the viewpoints of students and teachers. The teachers will also send a questionnaire following the E-module usage. Tenth grade students of SMAN 5 Kota Depok make up the population of this study. This study involved 35 tenth-grade high school students as the subjects for the e-module trial. The sample size was determined using purposive sampling, considering that the selected class represented the diversity of the population in terms of both academic achievement and socio-economic background. Out of a total of 220 students, this class was chosen because its average academic performance was comparable to that of the overall population, thus making it representative for the purposes of the initial trial. Moreover, the number of 35 students aligns with the minimum sample size requirements in development research based on the ADDIE model, in which the primary focus is to test the effectiveness of the product on a limited scale before replication with a larger population.

Data analysis was conducted using the following methods:

- a. Product eligibility analysis to determine the accuracy, effectiveness, and attractiveness level of the resulting E-modules validated by [Lynn \(1986\)](#); [Zamanzadeh et al. \(2015\)](#).
- b. Teacher and student response analysis using a [Likert scale \(Likert, 1932; Joshi et al., 2015\)](#).
- c. Effectiveness analysis using the N-Gain score ([Hake, 1998; Navarrete et al., 2024](#)).

Validation by media professionals, language experts, learning experts, and content experts guarantees the authenticity of the product by means of validation and revisions. These experts answer questionnaires to get validation data that will help to evaluate the strengths and shortcomings of the produced good. Suggestions for improvement are developed to cover the found shortcomings. Based on the results of the validation process, the process of product revision seeks to enhance and polish the model thereby enabling more efficient usage of the product.

## 3. Results and Discussion

This study is a mixed method type. This study applies the research and development (RnD) approach using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The stages below help to define the phases of the project-based learning e-module augmented with reflective videos:

### 3.1 Analysis

Starting from looking at the gaps, deciding the learning objectives, verifying possible users, finding resources, deciding the delivery method, and lastly writing the project plan, an analysis is carried out to fully understand the issues connected to the necessity of development. 98.9% of students enjoy studying via media; 97.8% of them need learning that they may study on their own; and 88.9% of them prefer to use modules or teaching tools using



applications or websites. The data gathered relies on environmental sensitivity surveys used at SMAN 5 Depok. According to the analysis findings, pupils' environmental sensitivity remains really poor. This is so because 51.1% of students have never used electronic modules including more interesting information to generate products from environmental change learning outcomes, whereas students only learn conventionally using the given textbooks. Thus, design of project-based learning calls for efforts.

Finding the potential delivery system marks the next stage in the analysis. The delivery system is tailored to the teaching module or implementation strategy of learning. The delivery has to be orientated on reaching the learning goals. The following table shows the development of learning techniques depending on the learning objectives established in the preceding analysis stage: Developing a project management strategy is the last step of the research and is essential to guarantee timely completion of the project. Management can be separated into numerous stages tailored to the specified time goal.

### 3.2 Design

The next stage is to adjust the basic competencies and learning objectives with the previous analysis stage, create a flowchart, draft the product, produce the product, and determine the testing strategy as shown in figure 1.

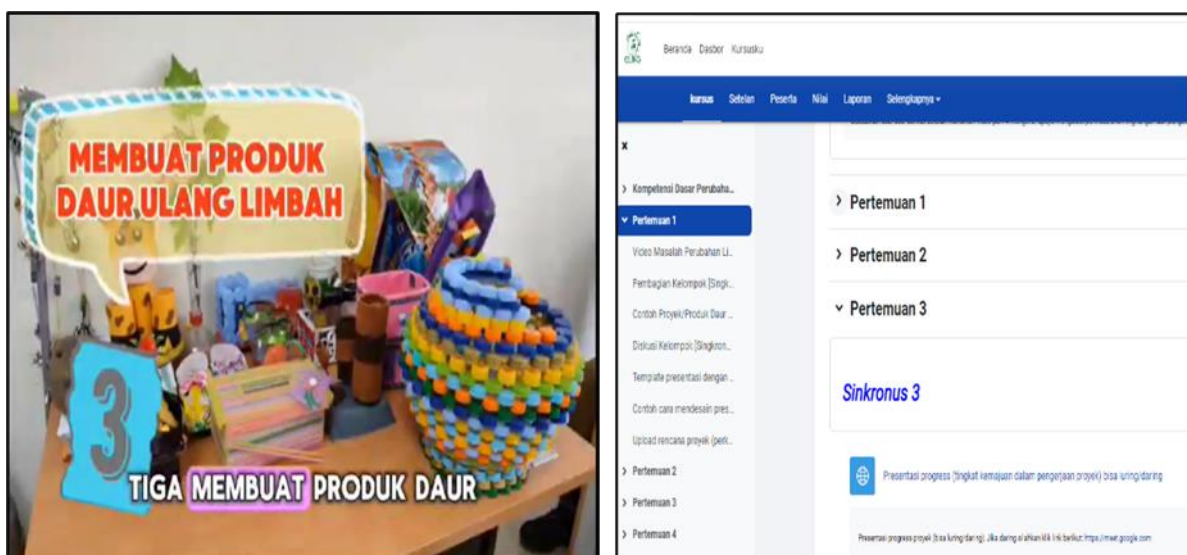


Figure 1. Reflective Video and E-Ling Project Design

### 3.3 Development

Based on project work to increase environmental awareness, the content is developed under the notion of an electronic module for environmental change (E-Ling) which combines text, images, and videos in storyboard form to support project-based learning (PjBL) to be implemented effectively and achieve the desired objectives. Developed in line with the PjBL syntax, which comprises of stages of planning, implementation, reporting, and evaluation both at the individual and group levels, the E-Ling idea based on PjBL follows Along with the e-module design stage, the phases of product development consist of the planning and website and application design. To support its implementation, the e-module was not only designed as a learning content resource but also integrated into a specially designed digital platform.

The e-module was developed and implemented using the Moodle platform, which was customized to meet the needs of project-based learning. The customization included the integration of interactive web- and application-based content, the embedding of reflective videos, and the provision of online discussion forums. The system includes features like progress tracking, automatic feedback, and mobile access, so students can review the material and continue learning whenever they have time. From a technical perspective, the system's backend was designed to record user analytics data, including session duration, task completion rates, and frequency of interactions with the materials. These analytics not only supported the monitoring of student engagement but also served as an additional source for evaluating the effectiveness of the e-module in enhancing environmental sensitivity.

Development of a Moodle-based website will be simpler for developers. At this point, designers choose Moodle's activity templates catered to the learning needs, thereby preparing the layout that will be loaded with several menus and content. Designed to provide an interactive and easily available online learning experience, Moodle also known as Modular Object-oriented Dynamic Learning Environment is a web-based platform. This software lets one create and run online courses with several tools supporting efficient learning. Figure 2 illustrates Data input, information, and images including the E-Ling logo are now handled to be shown in line with the needs of the application on the developed layout from the last stage.



Figure 2. E-Ling Development

### 3.4 Implementation

The implementation is conducted for students of SMAN 5 Kota Depok by providing E-Ling in the study of environmental changes for a total of 4 meetings according to the lesson plan, and students are asked to study independently with the teacher acting merely as a facilitator who monitors and directs the course of learning.

### 3.5 Evaluation

Evaluation is carried out to collect data that will be used to identify how to enhance learning in alignment with the learning objectives to be achieved. Assessment of the PjBL-based e-module by students and teachers as users is used as an evaluation tool for product development. Thus, after revisions from all stages of assessment, a final product of the PjBL-based e-module will be produced.

#### 3.5.1 Product Eligibility Analysis

Expert assessments help one to determine whether the electrical module product is feasible. The phases of eligibility study aim to ascertain the degrees of accuracy, effectiveness, and attractiveness of the project-based electronics supported by a film on environmental changes. Table 1 below shows the analytical results of the material expert: 92.33%; the language expert: 80%; the learning expert: 84.71%; the media expert: 86.33%.

Table 1. The expert assessment analysis's findings

No.	Experts	Percentage of Eligibility %	Qualifications
1	Language	92,33	Good
2	Learning	80	Good
3	Material	84,71	Good
4	Media	86,33	Good

### 3.5.2 Analysis of Student and Teacher Responses

The results of the teachers' responses regarding the project-based electronic module equipped with environmental change video materials can be seen in the following table 2.

**Table 2.** Student and teacher responses

Respondent	Result	Description
Students	93,18 %	Students' responses are very good towards the E-Ling based teaching materials.
Teachers	90 %	Teachers' responses are very good towards the E-Ling based teaching materials.

The responses of the students to this E-Ling show that students 1) welcome technological innovation. A high percentage shows that students are ready to apply this technology during their educational experience. 2) Because of its multimedia and more interesting accessibility, which helps students grasp the content, E-Ling can draw their attention and appeal. 3) Particularly in relation to environmental change, the content offered probably relates to the interests and requirements of the students. 4) E-Ling shows how adaptable it may be to improve students' comfort and efficiency of studying anywhere. The teacher's responses to E-Ling follows then: 1) that E-Ling is a creative learning tool recognised as an innovation in teaching through this media, which is open to changes in learning that employs technology, so improving the learning process. 2) E-Ling offers variations in learning and helps to increase the quality of education, therefore facilitating teachers' explanations of ideas of environmental changes. 3) Using E-Ling, teachers can help students to learn on their own initiative since E-Ling students can study on their own. Since it gives teachers and students quick access, this device is really unique. Environmental change learning resources are available online or on downloads to cell phones. Learning therefore becomes more interesting and adaptable in step with the developments in mobile technology.

Furthermore, when analyzed from the technical perspective of e-module usage, the integrated technological features demonstrated a significant contribution to these outcomes. Data analysis indicated that the technology embedded within the e-module directly contributed to enhancing students' environmental sensitivity. For example, the reflective videos helped students slow down and think deeper about environmental issues, while the progress-tracking tools made it easier for teachers and researchers to see how active students were. The data also showed a pattern: students who spent more time on the reflective parts usually had bigger improvement in their environmental sensitivity. This suggests that the e-module's technology is not just for delivering the lessons but also supports the teaching goals directly. Consequently, this study offers a novel contribution to the field of project-based learning through the integration of technological architecture, interactive features, and user analytics, which have rarely been explored in depth in previous studies.

Based on responses from teachers and students, the school still needs work to improve the ideas and research that have been carried out including creating electronic modules so that students may study how to address social and environmental issues sustainably in real situations. Although the link between creativity, innovation, and sustainability is getting ever closer, according to [Brem et al. \(2020\)](#), more study is still needed as well as fresh ideas and methodologies to handle social and environmental problems. The remark of [Elegbede et al. \(2023\)](#) that education in the future is predicted to concentrate on environmental preservation and the development of a just society ecologically and socially by responsible behaviour known as sustainable education strengthens this. [Hoti et al. \(2024\)](#) which incorporates entrepreneurship into the final year engineering projects to help students understand how their technical skills can be applied in real-world scenarios.

### 3.5.3 Analysis of the Effectiveness of E-Ling

Testing the effectiveness of project-based electronic modules equipped with video materials on environmental changes in increasing students' environmental awareness was carried out by analyzing the N-Gain scores. The results can be seen in the following table. 3.

**Table 3.** N-Gain Calculation

Experimental	133,32	159,19	530	Moderate
Control	74,45	130,30	240	Low



E-Ling underwent N-Gain's effectiveness test as well. This aims to ascertain whether the created product significantly raises environmental sensitivity among students or not. Because of the conventional learning, the control class exhibited low outcomes while the experimental group showed moderate ones. Adjusted against the maximum increase, N-gain is a gauging of the improvement in student learning outcomes from pre-test to post-test. It offers evidence of the value of education. After adopting E-Ling, a score of 530 for the experimental group revealed a notable increase in learning results. The results show that the E-Ling module helped students in the experimental group get higher learning gains. The control group only reached a score of 240, which is still lower than the students who used the module. This means that traditional teaching methods were not as effective in improving the learning outcomes.

Based on Hake's (1998) category, the N-Gain score of 0.53 is considered in the medium level.

N-Gain < 0.3	=	Low
$0.3 \leq \text{N-Gain} \leq 0.7$	=	Medium
N-Gain > 0.7	=	High

So the improvement falls in the medium category and is statistically meaningful. This shows that the E-Ling module is more effective for improving students' environmental awareness compared to the conventional method used in the control group.

The N-gain analysis shows that students using E-Ling achieved better learning results than the control group. This doesn't mean E-Ling is always the best for all situations, but it shows it works well for this study. Zuhriyah (2021) states that engaging video material can improve students' understanding of environmental topics, and Abude (2021) found that modular distance learning also supports student performance. These findings together show that well-designed digital and modular tools can improve learning when used the right way. It is a flexible and effective way to teach, especially in remote places. These results indicate that learning with e-modules can help students study outside of school hours and will certainly enhance their understanding of environmental changes.

The 2019 Ibe and Abamu study indicates that using audio-visual media in science education can raise student performance and interest. The results of this study match our observations and show that project-based e-modules including videos and information technology are rather successful in increasing student involvement in learning about environmental issues. Consequently, including the usage of audio-visual media in the classroom is rather crucial for curriculum designers since it helps students to be more active and enhances their knowledge. The research by Subari et al. (2022) also about e-modules states that the results of the effectiveness test show that the class using the e-Module on ecology and environmental changes with a guided inquiry approach has higher scores compared than the class that does not use the e-Module, thus the use of e-Modules equipped with images, animations, and videos can help students in understanding the material and is quite effective in improving student learning outcomes.

After that, data analysis was carried out using the t-test (Independent Sample t-test) to determine the difference between the experimental class and the control class with the following calculation results:

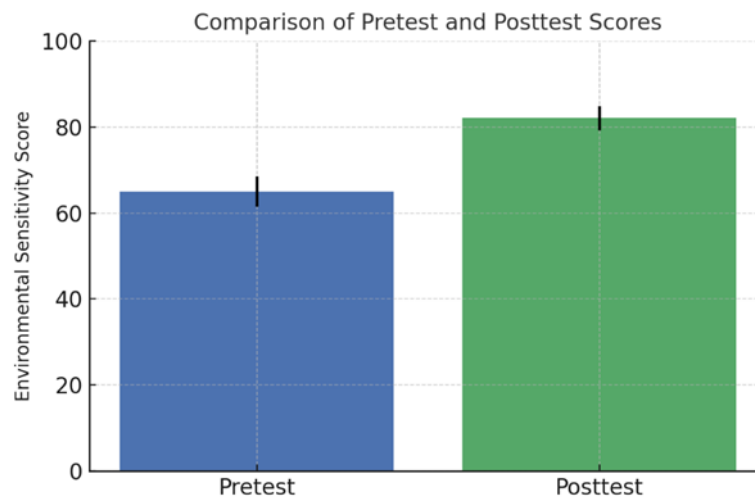
**Table 4.** t-test calculation result

Model	F	Sig.	t	df	Sig (2-tailed)	Mean difference
Environmental Sensitivity	50,977	0,000	10,656	304	0,000	11,50175
			10,020	199,196	0,000	11,50175

The results of the analysis above, using SPSS 26, show a t-test value with Sig 0.000 < 0.05, indicating a significant difference between the experimental class and the control class that used project-based electronic modules equipped with video materials on environmental changes.

After showing the N-Gain and t-test findings, additional visualizations are needed to make the differences in learning outcomes before and after the E-Ling module clearer.





**Figure 3.** Comparison of Pretest and Posttest Scores on Environmental Sensitivity

Figure 3 show that the posttest score go much higher than the pretest score, so it kind of tell that the project e module E Ling, together with the reflective video, really helping students become more aware about environment. This also match with the N Gain number and the independent t test result that already point the same direction, that E Ling create learning improvement that can be seen clearly.

The study also check the size of the impact by using Cohen effect size. This analysis is used so we can know how strong the project based e module with the video material actually change students environmental awareness. The value that was calculated then compared again with the standard guideline that Cohen already propose. The table 5 below is showing the ES value and how they are usually explained in research.

**Tabel 5.** The results of the calculations interpret the significance of the large influence

ES	Percentage	Category
1,2	88	Large

Based on the table, the effect size that appear is 1.2, and this actually above the usual limit that Cohen say is large effect. Because of this, it can be understood that the project module that include video bring very big and meaningful change in how students improve their environmental sensitivity. In real practice, this mean the intervention shift the student performance more than one standard deviation, which make it very strong when compared to more traditional teaching style.

To get the ES value, the calculation use Cohen d, which is the difference of two means divided by the pooled standard deviation (Cohen, 1988) or interpreting it, the study still follow the usual guideline where around 0.2 is small, 0.5 is medium, and 0.8 or above is large effect.

0.2 = small effect

0.5 = medium effect

0.8 or higher = large effect

The result show that the Cohen d fall inside the large effect range, so the project based e module not only create significant difference but also give practical improvement that is quite big for students environmental awareness. This give strong support that tool like e module with project basis can bring real benefit for environmental learning.

The experiment, including the feedback from the teacher and students, show that E Ling bring noticeable improvement in environmental awareness. The effectiveness test show ES value 1.2, which mean the module have strong impact toward students sensitivity about environmental issues. With this evidence, E Ling can be used as a strong biology learning material, especially in situation that need high environmental understanding.

These findings also similar with earlier research that found project based learning and technology based material often increase student engagement and learning performance. Hujjatusnaini et al. (2022) reported that PjBL make students develop higher order thinking and the important 21st century skills, which is similar with how E Ling work through deeper task process. Rubini (2023) show that climate change e module also improve ecological literacy, meaning digital content can strengthen understanding of environmental concept. Good student responses in Villanueva (2022) home based e module study and the improved scores in El-Sabagh (2021) electronic learning research also support the idea that digital modules help students learn better than regular teaching.

E Ling make use of Moodle system, which fit well with the set up of Project Based Learning. Garbarova et al. (2023) explain Moodle allow teacher to combine things like assignment, quiz, forum, questionnaire, and resource into one connected project flow. This really matter because PjBL need long interaction, repeated feedback, and structured teamwork, and Moodle help make these parts run smoothly. Almulla (2020) also mention that when students handle environmental tasks in project form, their attitude and behavior start to change because they must deal with real problem and create real solution. So in this case, Moodle is not only a teaching platform, but a tool that support the whole project cycle where the behavior improvement can happen.

Study about reflective video also show similar pattern, where the important part is not only the video but the reflection process after watching it. Hsu et al. (2022) show that video learning with reflective questions help student thinking become more critical because they need to question assumption and evaluate the impact of their idea. E Ling follow the same approach. The reflective video there push students to look at real waste management issues and think about their own responsibility. Lepp 2023 also show that guided video reflection can improve students metacognitive skill. For high school students, this kind of practice is very helpful because it support not only understanding but also environmental sensitivity.

The technology part also play key role. Hajj-Hassan et al. (2024) found that interactive video and simulation work well because students must respond, predict, and update their understanding while they learn. This pattern show why E Ling technology matter. The interactive sections do not only make the module look modern, but actually support the thinking process that relate directly with environmental awareness. So the technology inside E Ling is a planned learning method, not only decoration, and it help shape better sustainable attitude in students.

Richter & Stoetzel (2022) found that both normal real life video and VR can cause deep reflection in teacher training, and the main reason is the design of the learning task, not the technology. This idea also fit with E Ling, because the reflective video that use real life situation still effective since the depth of thinking come from the structure of the reflection, the challenges students face, and the way the task is guided. So good reflection does not always need advanced VR; a well prepared real life video already can give the same effect.

Nickl et al. (2022) stressed that the qualities of the learner and how they interact with videos have a big effect on how well they learn. This research emphasizes the significance of examining students' engagement patterns with videos in E-Ling (e.g., viewing length or reflective replies) as markers of the module's efficacy.

This study, however, has numerous limitations. To begin with, the trial sample was not very big (35 students) and only lasted for four sessions, thus the results should not be taken too seriously. Second, E-Ling works best when you have access to the internet and a device, which may not be the case in many schools or areas. Third, for the best results, teachers need to know how to use digital-based modules, therefore educating teachers is very important for helping modules work well. These limitations present opportunities for future research involving larger samples, longer implementation periods, and enhanced infrastructure and teacher training support.

Based on the results of the experimental trials and responses from both students and teachers, it can be concluded that the electronic project-based module equipped with video materials on environmental changes is effective and has an impact in enhancing students' environmental sensitivity, therefore its use in biology learning in high schools can be recommended.

With a score of 1.2, the E-Ling product's efficacy test based on ES table above results shows that E-Ling significantly increases environmental sensitivity of students. This corresponds to the goal of E-Ling to act as a tool to increase the efficiency of learning, so it can be advised as an e-module for biology education in high school.



This research interprets that the electronic environmental change module (E-Ling) developed can significantly enhance student learning. The same was also conveyed by Rubini (2023) in her research results, stating that students' ecological literacy increased after studying climate change with the electronic module. Students also gave very positive responses to the use of this teaching material.

Learning with E-Learning can also encourage effective learning that can be done anywhere according to the students' conditions. According to Villanueva's research (2022), students have very high engagement in home-based learning activities or with e-moduls, and their learning achievements are generally very satisfactory. Based on these results, project-based learning models with e-moduls in Indonesia need to be recommended so that students are trained to think critically and behave well towards the environment. El-Sabagh (2021) in his research shows that the group using electronic learning is significantly superior compared to the control group. This indicates that the electronic learning environment has the potential to enhance student engagement in the teaching and learning process.

The use of this E-Ling employs features developed based on Moodle, where Moodle has advantages for electronic modules according to learning needs such as adapting learning to project-based learning (PjBL) syntax. According to Garbarova et al. (2023), in Moodle, courses are created, and within them, students enrolled in a specific class can access various assignments needed to complete that course (subject). The abundance of tools that teachers can use in their classrooms is one of the benefits of Moodle. A place to submit assignments, exams, polls, questionnaires, dictionaries, forums, and other tools can be created with learning materials. Educators can submit documents, books, URLs, and other resources to this environment.

The implications of this research finding are consistent with previous literature indicating that E-Ling can improve learning outcomes through its higher interactivity and more flexible access to learning materials. The limitations of this study, although the sample size is quite large, further research with a more diverse population is needed to confirm these findings and the duration of the E-Ling product could be conducted over a longer period to determine the effectiveness of its long-term use.

## 4. Conclusion

Overall, the result show that E Ling e module give strong improvement toward students environmental sensitivity, especially about waste problem in Depok City. The module design combine local context material with digital tool that make students analyze direct issues and think about their personal role. This combination, more than the digital form alone, is what push the behavior change. Because of this, the study support that contextual and technology supported material can help improve environmental attitude and actions among high school students.

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### Author Contributions

Deden Ibnu Aqil: Conceptualization, Investigation, Methodology, Writing - Original Draft. Hafid Abbas: Conceptualization, Investigation, Validation. I Made Astra: Conceptualization, Formal analysis. Rendika Vhalery: Conceptualization, Writing - Review & Editing. All the authors read and approved the final version of the manuscript.

### Ethical Approval

This study was reviewed and approved by postgraduate leadership of Jakarta State University with letter number 4909/UN.49.6Ps/LT/2024 and principle of State Senior High School 5 Depok City with the letter number 423.5/811/Kur-SMAN5-DPK/V/2024. Informed consent was obtained from all participating students, and formal permission was granted by the school prior to data collection.

### Does this article screen for similarity?

Yes

### Conflict of Interest

The authors have no conflicts of interest to declare. There is also no financial interest to report. The author certifies that the submission is original work and is not under review at any other publication.

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