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Development of a project-based e-module on *Salacca sumatrana* conservation to enhance students' creativity and ecoliteracy

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ABSTRACT

This study aims to develop a project-based electronic module on the conservation of *Salacca sumatrana*, a local biodiversity resource in South Tapanuli. The ADDIE model development process was assessed for effectiveness using a quasi-experimental non-equivalent control group pre-test-post-test design. Participants consisted of 84 students from high schools in South Tapanuli. The research instruments included expert validation sheets, practicality questionnaires, TTCT-based creativity tests, and ecological literacy instruments measuring students' knowledge, attitudes, and skills. The expert validation results showed very good feasibility (98%). The teachers' practicality assessment reached 93.5%, categorizing the e-module as very practical. The effectiveness test results showed that the e-module had a moderate effect on creativity (Cohen's d = 0.45) and a large effect on ecological literacy, with a significant improvement in students' understanding of ecosystem threats (increasing from 58% to 96%) and biodiversity concepts (increasing from 60% to 82%) based on pre-test and post-test comparisons. A t-test revealed a statistically insignificant difference between the experimental and control groups for creativity ($p = 0.080 > 0.05$), though the moderate effect size (0.45) indicates practical educational impact. Practicality trials showed high student acceptance, with scores ranging from 82.20% to 92.69% across schools. These findings indicate that the project-based e-module is a feasible, practical, and effective learning resource for fostering students' creativity, ecological literacy, and ecological responsibility, as well as supporting local biodiversity conservation and promoting sustainable education.

Keywords: Creativity, ecoliteracy, local potential, project-based learning, *Salacca sumatrana*

INTRODUCTION

21st-century education demands a transformation of learning that not only transfers knowledge but also shapes students' critical thinking, creativity, and global awareness competencies (Licona, 2022). Amidst these demands, the Indonesian education system still struggles with the challenge of integrating contextual and relevant learning experiences with the real needs of society while equipping students with adaptive life skills (Rahmat & Siregar, 2021). Failure to bridge this gap risks producing a generation that is cognitively capable but lacking in empathy and weak in understanding the realities of their surroundings.

Indonesia is one of the megabiodiversity countries with widespread conservation areas, but various studies report an alarming trend of declining species populations (Ardoin et al., 2020). Environmental damage due to anthropogenic activities continues and intensifies despite formal conservation efforts that began in the 1970s (Dictionary, 2024). This condition indicates a misperception between the conservation knowledge taught and the resulting pro-environmental behavioral changes. Therefore, sustainable and transformative educational interventions are a necessity, not merely to increase knowledge, but to dismantle

existing perspectives and shape new attitudes towards nature.

This crisis is clearly reflected in the local context of South Tapanuli. Observations and interviews at four schools (SMA Negeri 1 Angkola Barat, SMA Negeri 1 Angkola Timur, SMA Negeri 1 Angkola Selatan, and SMA Negeri 1 Sipirok) revealed two main issues. First, students' creativity in solving environmental problems is still low, especially when faced with issues of local potential conservation. In this study, student creativity is defined as the ability to generate original ideas in response to environmental issues related to the conservation of local potential (Suryani & Mulyani, 2021). Second, ecoliteracy is defined as the ability of students to understand ecological principles and demonstrate concern and concrete actions in preserving ecosystems (Murray & Poto, 2024). The level of ecoliteracy is alarming: only 55% of students have an adequate understanding of environmental concepts, 44% demonstrate attitudes and skills in analyzing human-nature relationships, and most worryingly, 50% of students still litter. These figures are not merely statistics but an alarm that biology education has failed to transform ecological knowledge into behavioral awareness.

The root of this problem lies in three issues. First, learning is still dominated by a shallow memorization paradigm. The strategy of memorization, which is synonymous with mechanical repetition, has been proven to have a much lower effect on meaningful learning outcomes compared to the constructivist approach (Biggs & Tang, 2023). Second, the teaching materials used are still limited to conventional textbooks that present material in a generic, abstract manner, detached from the context of the students' lives. As a result, the objects being studied cannot be observed directly, interest in learning is eroded, and conceptual understanding is not internalized (Rutten et al., 2020). Third, the inaccuracy of the learning design has an impact on the low levels of creativity and ecoliteracy. These three issues are interrelated and require comprehensive intervention.

In response to these challenges, the development of project-based e-modules utilizing the local potential of *Salacca sumatrana* (Salak Sidimpuan) is proposed as an integrative solution. Electronic modules were chosen for their advantages in providing learning flexibility, facilitating independent learning, and accommodating the diversity of learners' learning styles (Wang et al., 2021). More than just a digital medium, e-modules designed with a project-based learning (PjBL) approach are capable of combining interactive multimedia, authentic case studies, and collaborative activities into a single learning system (Purnamasari et al., 2022; Sapitri et al., 2024; Sapitri & Tambunan, 2025). Articulate Storyline was chosen as the development platform because of its ability to create interactive narratives where students can explore the ecological consequences of their decisions in conservation project simulations (Daryanes et al., 2023).

Theoretically, the effectiveness of this approach has been widely proven. Digital PjBL involving authentic community-based projects significantly enhances learners' creativity and science-environment literacy (Krajcik & Shin, 2023). E-modules that integrate local wisdom into a scientific context have proven effective in fostering creative thinking and environmental literacy (Putri & Nisa, 2025; Setyorini et al., 2022). In the field of conservation, project-based learning encourages students to actively engage as problem solvers, rather than merely recipients of information (Ballouard et al., 2013; Kokotsaki et al., 2016). However, the implementation of this approach is still very limited, not because of its pedagogical weaknesses, but because of the scarcity of teaching materials that specifically design biodiversity-based conservation projects into a structured digital format (Dalida et al., 2018; Tarigan & Kudadiri., 2024).

The urgency and novelty of this research,

Salacca sumatrana, an endemic fruit of South Tapanuli that has ecological value as a guardian of ecosystem balance and economic value as a leading commodity, is now threatened with extinction due to massive land conversion (Lubis et al, 2024; Rahayu & Pratama, 2021). Ironically, this biological wealth is barely touched upon in school curricula, even though the local context that is close to the lives of students has tremendous pedagogical potential (Rahmadi & Hayati, 2021). Recent research confirms that integrating authentic local projects into e-modules remains a critical design challenge that has not been adequately addressed by empirical research (Lin & Chen, 2024). In other words, some gaps need to be addressed: (1) practically, there are no digital teaching materials that explicitly design learning about conservation based on local endemic species, and (2) empirically, there are still few studies evaluating the simultaneous impact of such interventions on students' creativity and ecoliteracy.

Current educational efforts, while acknowledging the importance of conservation, tend to be theoretical and fail to translate ecological knowledge into measurable agency and behavioral change (Lubis et al., 2023; Susanti et al., 2026; Tambunan., 2018). Furthermore, there has been no research that simultaneously develops and evaluates project-based e-modules specifically focused on the conservation of *Salacca sumatrana* and measures its impact on two critical variables at the same time. In fact, the ability to compare traditional knowledge with scientific findings, design local potential conservation models, and shape environmentally conscious character are essential competencies mandated by the 21st-century education framework (Lubis & Baidury, 2025; Mistry & Berardi, 2016). The contribution of this research has a long-term impact in terms of academics, which can improve science literacy for the learning process.

This study aims to develop a project-based e-module for the conservation of the local potential of South Tapanuli *Salacca sumatrana* that is feasible, practical, and effective in increasing the creativity and ecoliteracy of students. The problem formulation in this study is the feasibility, practicality, and effectiveness of a project-based e-module for the conservation of the local potential of South Tapanuli *Salacca sumatrana* as a medium for high school biology learning.

21st-century education demands the development of learning that does not merely transfer knowledge textually, but also shapes students' competencies in critical thinking, creativity, collaboration, and global awareness as provisions for facing increasingly complex life challenges (Licona, 2022). However, the education system in Indonesia still faces challenges in integrating learning that is relevant to the needs. Indonesia has quite a number of conservation areas, but various studies show that the number of rare animal species is declining (Ardoin et al., 2020). Environmental damage caused by human activities continues and is increasing despite conservation efforts that have been carried out since 1970 (Masihu & Agustyn, 2021). Therefore, it is necessary to provide knowledge and insight about conservation to the current generation in a sustainable and continuous manner so that their understanding can change their way of thinking and attitude towards the environment.

Observations and interviews were conducted in four schools in South Tapanuli, namely SMA Negeri 1 Angkola Barat, SMA Negeri 1 Angkola Timur, SMA Negeri 1 Angkola Selatan, and SMA Negeri 1 Sipirok. It was found that the creativity of students is still low, as evidenced by the lack of ideas for solving environmental problems related to local conservation potential. The ecological literacy or ecoliteracy of students is still low. This is evidenced by the fact that 55% of students understand environmental knowledge, while 44% of students have the attitude and skills to analyze the relationship between humans and nature. Students still have the habit of littering (50%).

This problem is caused by 1) learning that still focuses on memorization, making it difficult for students to remember and understand. Memorization-based learning strategies have a much lower effect on learning outcomes (Biggs & Tang, 2023). 2) The teaching materials used are still limited to textbooks that contain general and abstract material. This results in students having little interest in studying because the objects being studied cannot be observed directly (Rutten et al., 2020). 3) The learning activities implemented are still inappropriate as evidenced by the low creativity and ecoliteracy character of students.

E-modules containing real-world project-based learning activities that utilize the local potential of *Salacca sumatrana* can be used as a solution to problems. Electronic modules are a solution because they provide flexibility in learning and facilitate independent learning (Zhang & Hwang, 2023). Project-based conservation electronic modules can combine multimedia, local case studies, and collaborative activities (Purnamasari et al, 2022; Sapitri et al., 2024). Digital PjBL involving authentic community-based projects significantly increases students' creativity and science-environment literacy (Krajcik & Shin, 2014). E-modules based on local potential (in the context of their local culture and environment) effectively improve students' creative thinking and environmental literacy in science learning (Putri & Nisa, 2025; Setyorini et al., 2022).

E-modules developed using the Articulate Storyline application present local cases, such as threats to endemic species, in the form of interactive narratives where students can explore the various consequences of their choices in a conservation project. Articulate Storyline creates a distinct interactive learning experience (Daryanes et al., 2023). Conservation projects through the application of project-based learning have been proven effective in improving conceptual knowledge (Kokotsaki, et al., 2016). In the context of conservation, project-based learning can encourage students to actively engage in solving environmental problems (Ballouard, 2013). However, its implementation is still limited due to the lack of appropriate teaching materials.

Integrating the conservation of the local potential of South Tapanuli *Salacca Sumatrana* into project-based e-modules can be an innovative solution to raise environmental awareness while developing the expected skills, namely the ability to compare traditional knowledge with scientific findings and design local conservation models (Mistry & Berardi 2016). Character is directed at shaping students' behavior in conserving local potential (Lubis et al., 2023; Susanti et al., 2026; Tambunan., 2018). On the other hand, environmental issues and the loss of biodiversity require an educational approach that educates students about conservation (UNESCO, 2020). One example of local potential that has not been optimally utilized in learning is *Salacca Sumatrana* (Salak Sidimpuan), which has high ecological and economic value but is threatened with extinction due to land conversion (Rahayu & Pratama, 2021).

Recent research highlights a critical gap between the potential of technology-enhanced PjBL and its practical application in fostering cognitive and pro-environmental behavioral competencies. PjBL can engage students in solving environmental problems, but there is a scarcity of teaching materials that integrate the context of local biodiversity with digital pedagogy (Dalida et al., 2018; Tarigan et al, 2025. This article explicitly analyzes the design of digital modules for environmental literacy. Research shows that although e-modules offer technical flexibility, the majority of available content is generic and does not provide a framework that guides students from understanding local ecology to creative action. This study directly supports the claim that the integration of authentic local projects into e-modules remains a critical design challenge (Lin & Chen, 2024). Although Indonesian education policy mandates character and competency

development, the curriculum often fails to utilize endemic species as a learning context (Rahmadi & Hayati, 2021). *Salacca sumatrana*, an endemic plant of South Tapanuli with high ecological and economic value, is a concrete example of this disconnect. Despite being threatened by habitat loss (Lubis et al., 2025; Harsono & Hartana, 2002; Harsono, 2021), it is rarely used as a learning resource. Current educational efforts, while acknowledging the importance of conservation, often remain theoretical and fail to translate knowledge into real student agency and behavioral change (Colombo et al., 2023). The contribution of this research has a long-term impact in terms of academics, which can improve science literacy for the learning process; in terms of culture, which can preserve the traditional knowledge of *Salacca sumatrana.* Therefore, this study aims to address this double gap by developing and evaluating a project-based e-module focused on the conservation of *Salacca sumatrana*. This research specifically investigates how this context-based and technology-mediated intervention can simultaneously improve two critical 21st-century outcomes: student creativity and ecoliteracy.

The research questions in this study are: How can the development, feasibility, practicality and effectiveness of project-based e-modules for the conservation of the local potential of *Salacca sumatrana* in South Tapanuli be used as a medium for high school biology learning?.

METHOD

This development research aims to produce a valid, practical, and effective project-based electronic module to enhance students' creativity and ecological literacy in the context of conserving *Salacca sumatrana*, an endemic plant of South Tapanuli. This research adopts the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model (Branch, 2020). ADDIE is used because it is more procedural, showing clear and careful steps in producing a product. The effectiveness test uses a nonequivalent control group quasi-experimental design that uses naturally formed experimental and control groups, conducting pre-tests and post-tests on both groups (Creswell & Creswell, 2018).

This design was chosen because researchers could not randomize or assign students to groups, given the naturally formed classroom situations in schools. Effectiveness was assessed using a quasi-experimental pretest-posttest design with non-equivalent control groups. The population consisted of students from SMA Negeri 1 Angkola Barat and Sipirok, South Tapanuli Regency, North Sumatra. The research sample was determined using purposive sampling, based on the consideration that the selected schools represented the required characteristics of having nearby salak plantations. SMA Negeri 1 Angkola Barat class X1 was the control group, and SMA Negeri 1 Angkola Barat class X4 was the experimental group, with 32 students in each group for the implementation stage. The number of students in the small-scale practicality test was 5, and in the large-scale test, it was 15. The small-scale test was conducted at SMA 1 Angkola Timur, and the large-scale test was conducted at SMA 1 Angkola Selatan.

The research was conducted from March to October 2025. The research instruments included interview sheets, a creativity test (5 essay questions based on TTCT assessing fluency, flexibility, originality, and elaboration), and observation sheets. The research instruments consist of a creativity test with a 4-aspect rubric (fluency, flexibility, originality, elaboration) (Aca et al., 2023) and an ecoliteracy test that measures knowledge, attitudes, and skills (Matlack et al., 2023).

The content of the instruments was validated by three experts using the Content Validity Ratio (CVR), while reliability was tested using Cronbach's Alpha (ecoliteracy).

The module product was validated by experts (subject matter, media, and language experts) using a 1–5 Likert scale, while practicality was tested by two biology teachers. Data analysis was performed using SPSS 26 with prerequisite tests for normality (Shapiro–Wilk) and homogeneity (Levene's Test), followed by a paired sample t-test to test for significance of improvement. The effectiveness of the intervention was measured using Hake's normalized N-Gain.

Table 1. Reseach procedure

The ADDIE Model	Main Activities and Output
Analysis	1. Needs Analysis (Observation & Interviews – 4 Schools) 2. Curriculum Mapping (Learning Outcomes & Objectives) 3. Learner Characteristics Analysis 4. Local Potential Study: Ecological & Economic Value of *Salacca sumatrana* Output: Initial Needs Analysis Document
Design	1. E-Module Storyboard Design (Articulate Storyline) 2. Creativity Test Design (Fluency, Flexibility, Originality, Elaboration) 3. Ecoliteracy Instruments (Knowledge, Skills, Behavior) 4. Conservation Project Planning Output: Storyboard, Draft Instruments, Project Blueprint
Development	1. Prototype Development (Version 1) 2. Expert Validation (Subject Matter, Media, Language Experts) 3. Revision Prototype 2 4. Small Group Trial (5–10 Students) 5. Final Revision Prototype 3 Output: Validated E-Module
Implementation	1. Large Group Trial (32 Students – 2 Schools) 2. Experimental vs Control Class Implementation 3. Pre-test & Post-test Data Collection Output: Practicality & Effectiveness Data
Evaluation	1. Formative Evaluation (Continuous Improvement) 2. Summative Evaluation (Statistical Effectiveness Analysis) 3. Final Product Refinement Output: Valid, Practical, and Effective E-Module

RESULTS AND DISCUSSION

1. Analysis stage

The analysis stage is the initial foundation in product development, which aims to identify the needs, problems, and potential that form the basis for the development of the e-module. At this stage, the researchers conducted an analysis of learning needs, curriculum analysis, analysis of student characteristics, and analysis of local potential. The needs analysis was conducted through observation and interviews at four schools (SMA Negeri 1 Angkola Barat, SMA Negeri 1 Angkola Timur, SMA Negeri 1 Angkola Selatan, and SMA Negeri 1 Sipirok). The results of the analysis revealed two main problems, namely (1) students' creativity in solving environmental problems is still low, and (2) students' ecoliteracy is in a concerning category (only 55% understand environmental concepts, 44% have the skills to analyze human-nature relationships, and 50% still litter). These findings indicate the need for learning interventions that not only transfer knowledges but also shape pro-environmental awareness and behavior. The curriculum analysis focused on biodiversity material in the 10th grade of senior high school. The identification of learning outcomes and learning objectives shows that biodiversity material has great potential to be linked to the local context, but so far it has been presented in a generic and abstract manner in textbooks. This makes it difficult for students to understand

because the objects being studied cannot be observed directly (Fitriani et al., 2020). An analysis of local potential was conducted through literature studies and field observations of *Salacca sumatrana* (Salak Sidimpuan), an endemic plant of South Tapanuli that has ecological value as a guardian of ecosystem balance and economic value as a leading commodity, but is threatened with extinction due to land conversion (Bachman et al., 2024). This local potential has not been optimally utilized in learning, even though the local context that is close to the lives of students has tremendous pedagogical potential to increase the relevance and meaningfulness of learning (Kamila et al., 2024). Thus, the analysis stage resulted in the formulation of the need to develop a project-based e-module that integrates the conservation of *Salacca sumatrana* as a solution to enhance students' creativity and ecoliteracy.

2. Design stage

The design stage involves the systematic design of products and research instruments before entering the development stage. At this stage, researchers design e-module storyboards, compile research instruments, and design conservation project activities. The design of the e-module storyboard is carried out by determining the navigation structure, layout, project-based learning flow, and multimedia integration using the Articulate Storyline application. The researchers collected materials, images, videos, and other supporting components, as well as installing applications, editing the template system on the slides, setting up slide navigation, and designing the background (Rusman & Wahyudi, 2023). Articulate Storyline was chosen for its ability to create interactive learning experiences through narratives and simulations that allow students to explore the consequences of each decision in a conservation project (Daryanes et al., 2023). The research instrument design included a creativity test adapted with four indicators: fluency, flexibility, originality, and elaboration. Each response was assessed using a 0-4 scale rubric. The ecoliteracy instrument included dimensions of pro-environmental attitudes and behaviors. Expert validation questionnaires were administered to subject matter, media, and language experts, as well as practicality questionnaires for teachers and students. The conservation project activities are designed to actively involve students in solving real environmental problems, such as identifying threats to the *Salacca sumatrana* habitat, designing conservation models, creating educational content, and taking real environmental. This project approach aims to develop creativity while shaping ecoliteracy character through direct experience.

3. Development stage

This stage produced a prototype e-module that was ready for implementation. Initial product development (prototype 1) was carried out by turning the storyboard into an interactive e-module using Articulate Storyline. The product was equipped with videos, images, interactive narratives, and conservation project guidelines that integrated the local potential of *Salacca sumatrana*. Expert validation was carried out by six experts, consisting of two subject matter experts, two media experts, and two language experts, using a 1-5 Likert scale instrument. The validation results showed a percentage of 98% in the excellent category, indicating that the e-module was suitable for testing. The e-module is considered feasible because the assessment of the content, material, and language aspects received a good score (Diani & Syarlisjiswan, 2021). However, there are several suggestions for improvement from the experts as shown in the Table 2.

The product (prototype 2) was revised based on expert input. Next, a small group trial was conducted with 5 students from SMA Negeri 1 Sipirok and SMA Negeri 1 Angkola Barat. The small group trial results obtained scores of 82.20% (Sipirok) and 85.31% (Angkola Barat),

which were categorized as very good. The students provided suggestions for improvement regarding the slightly broken images and the need to simplify navigation. The researchers made improvements according to these suggestions to produce prototype 3.

Table 2. Validator improvement suggestions

No	Validator	Aspects Evaluated	Suggestions for Improvement	Revision
1.	Subject matter expert	Alignment of learning outcomes (CP) with the material	Learning Outcomes should be more focused on the material being discussed and should not display all LOs in the curriculum.	Simplify and select LOs that are directly relevant to the learning topic to make them more specific and targeted.
2.	Media expert	Design and layout	Change the font to *Times New Roman* to make it more formal and in line with academic standards.	Change all fonts to Times New Roman.
		Text layout	Avoid using centered text throughout the material as it hinders readability.	Set the main text to left-right justified for easier reading.
		Practice question	There are still repetitions in the exercise section.	Revise and remove repetitive questions to make them more varied and effective.
		User guide	Instructions for using the learning media need to be added so that users can easily understand them.	Add a "Media Usage Instructions" section at the beginning of the product.
3.	Language Expert	Readability and consistency of terms	Improvements are needed in terms of readability and consistency in the use of terminology in the material.	Revise sentences to make them more effective and communicative, and standardize the terms used.

The large group trial involved 30 students (15 from each school) to assess the practicality of the e-module on a broader scale. The large group trial results obtained scores of 84.23% (Sipirok) and 92.69% (Angkola Barat), with a very good category. The practicality test by biology teachers at SMA Negeri 1 Angkola Barat showed a percentage of 93.5% in the very practical category. At this stage, no significant revisions were found, so prototype 3 was declared ready for implementation.

The developed e-module has proven to be useful as a tool for students and teachers in the learning process, creating an interesting and easy-to-understand learning atmosphere (Rohmatin et al., 2022). The use of interactive multimedia and authentic local contexts makes learning more meaningful and relevant to the lives of students. The results of the assessment validation are summarized in Figure 1.

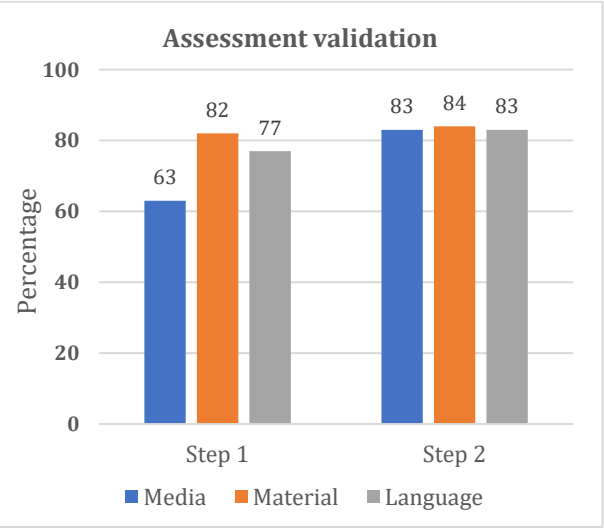

Figure 1. Validation results

The results of the practicality test and review by biology teachers at SMA Negeri 1

Angkola Barat showed that the practicality of the teaching materials was very good, with a percentage of 93.5%. The e-module developed obtained a very good validity level, with a percentage of 98% in the Very Practical category. A small group trial was conducted with students from class X1 SMA Negeri 1 Sipirok and 5 students from SMA Negeri 1 Angkola Barat. From the small group trial, a questionnaire was given to students in the form of feedback and suggestions regarding the media developed by the researcher. From the small group trial, a questionnaire was given to students in the form of feedback and suggestions regarding the e-module developed by the researcher. Based on the results of the small group trial, the overall score obtained was 82.20% for SMA Negeri 1 Sipirok and 85.31% for SMA Negeri 1 Angkola Barat, so it can be concluded that the media is categorized as very good. However, there were several suggestions and improvements from the students, namely that the Learning Outcomes still displayed all LOs in all materials, and there were still some slightly broken images, so the researcher made the improvements according to the suggestions.

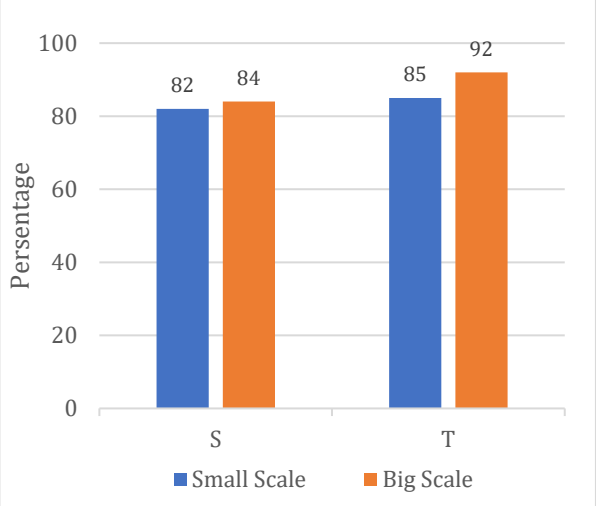

Figure 2. Practicality test results
Explanation:
S = SMA Negeri 1 Angkola Selatan
T = SMA Negeri 1 Angkola Timur

A large group trial was conducted involving 15 students from SMA Negeri 1 Sipirok and 15 students from SMA Negeri 1 Angkola Barat. From the large group trial, a questionnaire was given to students in the form of feedback and suggestions regarding the media developed by the researcher. Based on the results of the large group trial, the overall score for SMA Negeri 1 Sipirok was 84.23%, and for SMA Negeri 1 Angkola Barat was 92.69%. It can be concluded that the project-based e-module for the conservation of the local potential of South Tapanuli *Salacca sumatrana* is categorized as very good. The large group trial ran smoothly, and no revisions were made. The results of the questionnaire are shown in Figure 2.

4. Implementation stage

Implementation of e-modules in a real learning setting to test the effectiveness of the product in enhancing students' creativity and ecoliteracy. The implementation was carried out in two schools: SMA Negeri 1 Sipirok as the control class (32 students) and SMA Negeri 1 Angkola Barat as the experimental class (32 students), with a period of 8 weeks in the odd semester of the 2024/2025 academic year. The design used was a nonequivalent control group design with pretest and posttest in both groups (Creswell & Creswell, 2018).

Creativity test results

Creativity was measured using the Verbal Creativity Test adapted from the Torrance Tests of Creative Thinking (TTCT). This instrument consists of 5 open-ended questions that measure 4 indicators: (a) Fluency, (b) Flexibility, (c) Originality, and (d) Elaboration. Each response is assessed using a 0-4 scale rubric. The instrument has been validated by two subject matter experts and has an inter-rater reliability coefficient of 0.85. Data collection techniques were carried out through a 60-minute written pretest and posttest. In the field test, the product was tested on students at SMA Negeri 1 Sipirok as the X1 control class and SMA Negeri 1 Angkola Barat as the X4 experimental class, with 32 students in each class. The product was tested by

administering a pretest and a posttest. In the control class, the pretest was administered before teaching the material in general, using a textbook. The posttest was administered after the learning process using the textbook. In the experimental class, the pretest was administered before learning using the e-module, and the posttest was administered after learning using the e-module.

The aim was to observe the increase in student creativity before and after using the e-module, as well as to determine the suitability of the learning media in the learning process. Creativity was tested using a student creativity test. The results of the module effectiveness test were measured by comparing the pretest and posttest scores on the variables of creativity and ecoliteracy. The learning process in the control class did not use the developed e-module. The treatment in the experimental class.

The creativity test results were analyse by comparing the post-test scores between the experimental and control groups using the Independent Samples t-test. Previously, prerequisite tests for analyse were conducted, namely, normality and homogeneity tests.

Normality test results

The normality test (using Shapiro-Wilk) on the post-test data showed that both groups were normally distributed (experimental class p = 0.382 > 0.05; control class p = 0.242 > 0.05).

Table 3. Normality test results

Tests of normality						
	Kolmogorov-Sminov[1]			Shapiro-Wilk		
	Statistic	Df	Sig	Statistic	Df	Sig
Control	0.145	32	0.097	0.957	32	0.242
Experiment	0.138	32	0.128	0.965	32	0.382
a. Liliefors Significance Correction						

Based on Table 3, the normality test results for the experimental class using the Shapiro-Wilk test yielded a significance value of 0.242 (p > 0.05), indicating that the data were normally distributed.

Homogenity test results

Variance is used to determine whether two samples have homogeneous variance or not. One statistical technique used to explain group homogeneity is Levene's variance test, where if the Sig. value is > 0.05, the data is considered homogeneous. The results of the homogeneity test can be seen in Table 4.

Table 4. Homogeneity test results

Test of homogenety of variances					
		Levene statistic	Df1	Df2	Sig
The influence of moduls in incre-asing creativity	Based on Mean	0.993	1	61	0.323
	Based on Median	0.837	1	61	0.364
	Based on Median and with adjusted df	0.837	1	46.033	0.365
	Based on trimmed mean	0.835	1	61	0.365

Based on Table 4, the results of the homogeneity test (using Levene's Test) show that the variance of the data for the two groups is homogeneous (p = 0.323 > 0.05). With a significance value of 0.323 > 0.05, it can be said that the data is homogeneous.

Statistical analyse test results

Based on the results of the statistical analyse test (Table 5), the average post-test creativity score of the experimental group (31.00 ± 3.935) was higher than that of the control group (28.65 ± 6.333).

Table 5. Table of means and standard deviations

	Group statistics				
The influence of moduls in increasing creativity	Variable	N	Mean	Std Dev	Std. Er Mean
	Experiment	32	31.00	3.935	0.696
	Control	31	28.65	6.333	1.137

Hypothesis testing was used to compare the experimental class and the control class using the independent samples t-test. The t-test was used to test the significance of the difference in class influence averages. This test was used to test the influence of independent variables on

dependent variables. Prior to hypothesis testing, the following hypotheses were formulated:

Null hypothesis (H_0): There is no significant difference in creativity between students who learn using the project-based e-module and those who learn using conventional textbooks.

Alternative hypothesis (H_1): There is a significant difference in creativity between students who learn using the project-based e-module and those who learn using conventional textbooks.

The decision-making criteria based on the significance value (Sig.) are as follows:

1. If Sig. < 0.05, then H_0 is rejected and H_1 is accepted (indicating a significant effect of the e-module on students' creativity).
2. If Sig. ≥ 0.05, then H_0 is not rejected and H_1 is rejected (indicating no significant effect of the e-module on students' creativity).

The results of the hypothesis test can be seen in Table 6.

Table 6. Hypothesis test result

	Independent samples test								
The influence of moduls in increasing creativity	**Levene's Test for Equality of variances**		**t-test for equlity of means**						
		F	**Sig**	**t**	**Df**	**Sig (2-talled**	**Mean Difference**	**Std Error Diference**	**95% Confidence Interval**
	Equal variances assumed	0.993	0.323	1.779	61	0.080	2.355	1.324	-0.292 - 0.5002
	Equal variances non assumed	-	-	1.766	49.885	0.083	2.355	1.333	-0.323 - 0.5033

Based on Table 6, the results of the hypothesis test using a two-tailed t-test show a significance value of p = 0.080. With a confidence level of 95% (α = 0.05), this result is not statistically significant (p > 0.05).

To provide a more comprehensive picture of the magnitude and reliability of the observed differences, the effect size and confidence interval are reported:

1. Effect Size (Cohen's d):
   The effect size was calculated using the pooled standard deviation.

$$d = \frac{M_{eks} - M_{ktrl}}{SD_{pooled}} = \frac{31.00 - 28.65}{5.272} = 0.45$$

   Cohen's d value = 0.45 falls into the small to moderate effect category (according to Cohen's criteria: 0.2 = small; 0.5 = moderate). This indicates that the use of e modules has a positive impact that is practically significant. 95% Confidence Interval (CI) for the Mean Difference.

2. The 95% confidence interval for the mean difference (experimental - control) is

$$95\%\ CI = (2.35 \pm 2.636) = [-0.286, 4.986]$$

   CI Interpretation: We can be 95% confident that the true mean difference between the two groups lies between -0.286 and 4.986. Since this interval includes zero (0), it reinforces the findings of the two-tailed significance test that the statistical evidence is not yet strong enough to state that there is a definite (significant) difference in the population.

Ecoliteracy test results

Ecoliteracy was measured using an instrument developed based on three domains: knowledge, attitude, and skills. The instrument consisted of tests and questionnaires with specific scales adjusted to each aspect measured. The details of each domain are as follows:

1. Knowledge, comprising two sub-aspects: (a) ecosystem threats, and (b) biodiversity.

Each was measured through multiple-choice or short-answer tests with scores ranging from 0 to 100.

2. Attitude, describing students' active participation in environment-related activities. This aspect was measured through observation sheets using a Likert scale of 1–4. Its sub-aspects included: presenting project results and creating video content on environmental preservation.
3. Skills, measuring students' real actions in environmental conservation efforts. The instrument used was an observation sheet. The sub-aspects included: cleaning the surrounding area and conducting salak plant nursery activities.

Each action was assessed based on frequency or quality of implementation using a scale of 0–100. The data obtained from pretest and posttest were then statistically analyzed. Ecoliteracy data were analyzed using the Wilcoxon Signed-Rank Test because the data were not normally distributed (based on the initial normality test). The following table presents the percentage increase from pretest to posttest for each aspect, complete with Z-values, p-values, effect size (r), and 95% confidence intervals for the median, as shown in Figure 3.

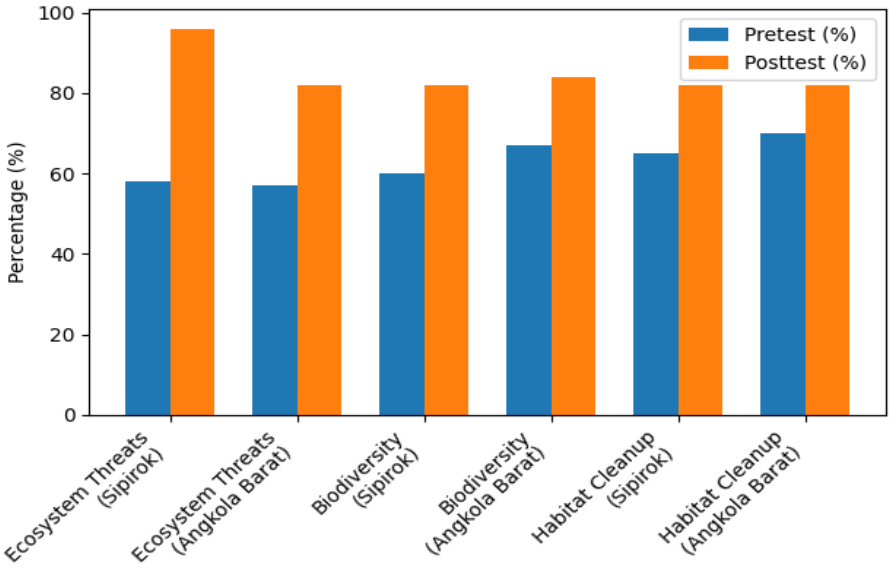

Figure 3. Pretest and posttest comparison of ecoliteracy

The graph shows a consistent increase in all ecoliteracy indicators after the implementation of the learning process. In the ecosystem threats indicator, the most notable increase occurred at SMA Negeri 1 Sipirok, where scores rose from 58% in the pretest to 96% in the posttest. An increase also occurred at SMA Negeri 1 Angkola Barat, from 57% to 82%. This indicates that the implemented learning was able to significantly enhance students' understanding of threats to ecosystems. In the biodiversity indicator, both schools also showed clear improvements. At SMA Negeri 1 Sipirok, scores increased from 60% to 82%, while at SMA Negeri 1 Angkola Barat, they rose from 67% to 84%. This increase demonstrates that students gained a better understanding of the concept of biodiversity and the importance of its preservation. Meanwhile, in the real action aspect through habitat clean-up activities, there was an increase from 65% to 82% at SMA Negeri 1 Sipirok, and from 70% to 82% at SMA Negeri 1 Angkola Barat. This improvement indicates that the learning process not only enhanced students' knowledge but also encouraged their involvement in concrete actions to protect the environment. Overall, the graph shows that posttest scores for all indicators were higher

than pretest scores, indicating that the implemented learning intervention was effective in improving students' ecoliteracy.

5. Evaluation stage

The evaluation stage consists of formative and summative evaluations. Evaluation is conducted continuously at each stage of development. Summative evaluation is conducted through effectiveness data analysis to assess the success of the product in achieving its objectives. For the creativity variable, although the hypothesis test results showed no statistically significant difference ($p = 0.080 > 0.05$), the effect size of 0.45 indicates a small to moderate practical impact. This shows that the e-module has the potential to increase creativity, but further research with a larger sample or longer intervention duration is needed to achieve statistical significance. For the ecoliteracy variable, the test results show a statistically significant increase with a large effect size on all aspects measured.

These findings confirm that the *Salacca sumatrana* conservation project-based e-module is effective in improving students' ecological knowledge, process skills, and pro-environmental behavior. This is supported by previous research, which demonstrated a substantial increase in students' creative thinking skills (mean scores increased from 43.23 to 86.97) with an N-gain of 0.80 (high effectiveness). This proves that the integration of local values in e-modules is highly effective (Firnanda et al., 2025). Furthermore, Lubis & Baiduri (2025) reaffirm that the conservation-based e-module on *Salacca sumatrana* not only enhances creativity but also strengthens students' local conservation awareness, as it employs an authentic context close to their daily lives.

Based on the evaluation results, it can be concluded that the project-based e-module for the conservation of the local potential of South Tapanuli *Salacca sumatrana* is feasible, practical, and effective for use in the learning process. This product has been proven to significantly improve the ecological literacy of students and shows the potential for a positive impact on creativity, although further exploration is still needed.

CONCLUSION

This development research has produced a project-based e-module on the conservation of the local potential of *Salacca sumatrana* that is valid, practical, and effective in improving the creativity and ecoliteracy of high school students in South Tapanuli. Through the systematic ADDIE model, the product was developed based on actual needs analysis and obtained excellent validation from subject matter, media, and language experts (98%), as well as practicality tests by teachers and students which reached the very practical category (93.5%). Empirically, the e-module proved effective in significantly improving students' ecoliteracy with a large effect size on all aspects of knowledge and environmental real action. Regarding the creativity variable, although the statistical test results showed an insignificant difference ($p = 0.080 > 0.05$), the moderate effect size ($d = 0.45$) indicates a potential positive impact that requires further investigation. The practical implication of this research is the availability of an innovative learning model that integrates technology, project pedagogy, and local biodiversity conservation, while simultaneously supporting education that builds students' emotional attachment and responsibility towards their environment. This product is worthy of adoption and dissemination as an alternative contextual teaching material on biodiversity topics at the high school level.

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