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Creating an E-Module on Environmental Pollution Based on *Tegal Deso–Okol* Local Wisdom: Can It Enhance Students' Creative Thinking Skills?

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Abstract: This study aims to develop a valid, practical, and effective learning e-module based on the local wisdom of Gresik (Tegal Deso–Okol) for environmental pollution content to enhance students' creative thinking skills. The research employed a Research and Development (R&D) method integrating the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) with a project-based learning (PjBL) framework. Sixty students from a senior high school in Gresik tested the e-module. Evaluation instruments included validation sheets, student questionnaires, performance rubrics, and learning outcome tests. The validation sheets assessed the feasibility of the e-module, the questionnaires measured practicality, and the performance rubrics evaluated project implementation and presentation. Data were analyzed using descriptive statistics, supported by qualitative feedback to refine the final product. The e-module demonstrated high reliability (92.70) and strong validity (3.77). Its practicality reached 91.67% in Class A and 95.83% in Class B. Students' creative thinking skills improved substantially, with mean scores increasing from 43.23 to 86.97 in Class A and from 50.47 to 90.01 in Class B. The student response rate (97.5%) and the N-gain score (0.80) also indicate high effectiveness. Overall, integrating cultural values into learning activities through this local-wisdom-based e-module effectively supports the development of students' creative thinking skills.

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Introduction

Higher-order thinking skills (HOTS), which are crucial for educators to execute education in the twenty-first century, include creative thinking abilities (Nesri & Kristanto, 2020). Fluency, creativity, adaptability, and elaboration are signs of creative thinking (Torrance, 2024). A learning e-module is a useful teaching strategy for tackling issues associated with poor levels of creative thinking abilities (Turnip et al., 2021). Projects or activities are fundamental to the learning process according to the PjBL paradigm. (Handayani and others, 2019).

Previous studies on e-modules and digital learning media have generally focused on improving conceptual understanding or learning outcomes but have not optimally addressed the growth of innovative thinking abilities, particularly in terms of integrating contextual, cultural, and project-based elements. Although recent studies, such as Haka (2024), have explored local-wisdom–based e-modules, the focus has remained on feasibility and student response rather than creativity enhancement. Similarly, Faizah (2025) highlights the potential of PjBL for strengthening sustainability values but does not specifically link the model to creative thinking development. The *Tegal Deso–Okol* context is uniquely relevant because it

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embodies distinctive environmental management values practiced by the Gresik community, providing an authentic and culturally grounded example for understanding environmental pollution, and making it particularly suitable for developing creativity through a PjBL-based e-module.

Students' ability to think creatively about environmental contamination can be enhanced by using a science module based on PjBL, according to research by Minati (2023). The local context and environmental issues that are pertinent to students' everyday lives are often overlooked in today's media, which makes it more difficult for them to engage pupils in the learning process and grab their attention (Suriya et al., 2020). The many forms of environmental contamination and their effects on ecosystems and human life are covered in the content (Muadifah, 2019). Students in the tenth grade are urged to comprehend how composting straw might help with environmental conservation initiatives. Understanding biological concepts can be enhanced by local knowledge (Dewi et al., 2021).

Using local wisdom in the classroom, such as *Tegal Deso-Okol*, can greatly enhance students' comprehension of the course topics (Mudatsir et al., 2022). The community uses straw (*damen*) to make *Okol*, which is alternated between two warriors. Instead of being recycled, the straw used as an *Okol* foundation is typically burned to ashes. In Gresik, East Java, Indonesia, leftover tumpeng and agricultural goods that are turned into gunungan frequently generate waste and turn into organic trash during the execution of *Okol* local wisdom activities and *Tegal Deso*. Both actually have a lot of potential to be transformed into something more beneficial. According to these results, straw waste from *Okol* activities and organic waste from tumpeng leftovers and agricultural goods in *Tegal Deso* local wisdom may be recycled as organic fertilizer using composting techniques. One sustainable way to handle organic solid waste is through composting (Manea et al., 2024).

The students better comprehend and apply the knowledge they acquire in practical settings, the learning e-module includes case studies and projects pertaining to regional environmental challenges (Ambarita, 2020). According to the above definition, creating an e-learning module on environmental degradation based on local knowledge (*Tegal Deso-Okol*) of Gresik is a viable approach that should foster students' capacity for original thought. This project aims to provide a legitimate, practical, and effective learning e-module for environmental pollution content based on the local knowledge of *Tegal Deso–Okol* in Gresik in order to improve students' capacity for original thought. The novelty lies in integrating a specific local tradition into a digital module, not only as cultural enrichment but also as a pedagogical stimulus to enhance creativity, which is rarely explored in science learning. This study also introduces a model for digitizing local wisdom in an interactive format relevant to modern education. The findings contribute theoretically by demonstrating how cultural context can support higher-order thinking, and practically by producing a validated e-module that supports meaningful, contextual, and creativity-oriented learning while helping preserve local wisdom and reinforce 21st-century competencies.

Research Method

This study employed a research and development (R&D) method using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) combined with a Project-Based Learning (PjBL) model. The ADDIE framework (Marrison, 2020) serves as a standard model for technology-based education. Analysis, design, development, implementation, and evaluation are the five phases of the ADDIE instructional system design paradigm, it provides a series of iterative processes to produce effective instruction and training (Al-Momen et al., 2016). The PjBL model has the following stages: (1) problem

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solving and project selection; (2) project organization; (3) implementing the project schedule; (4) teacher monitoring and project progression; (5) creation of project analysis conclusions; and (6) evaluation of project procedures and outcomes. The development research process shown in Figure 1 is as follows.

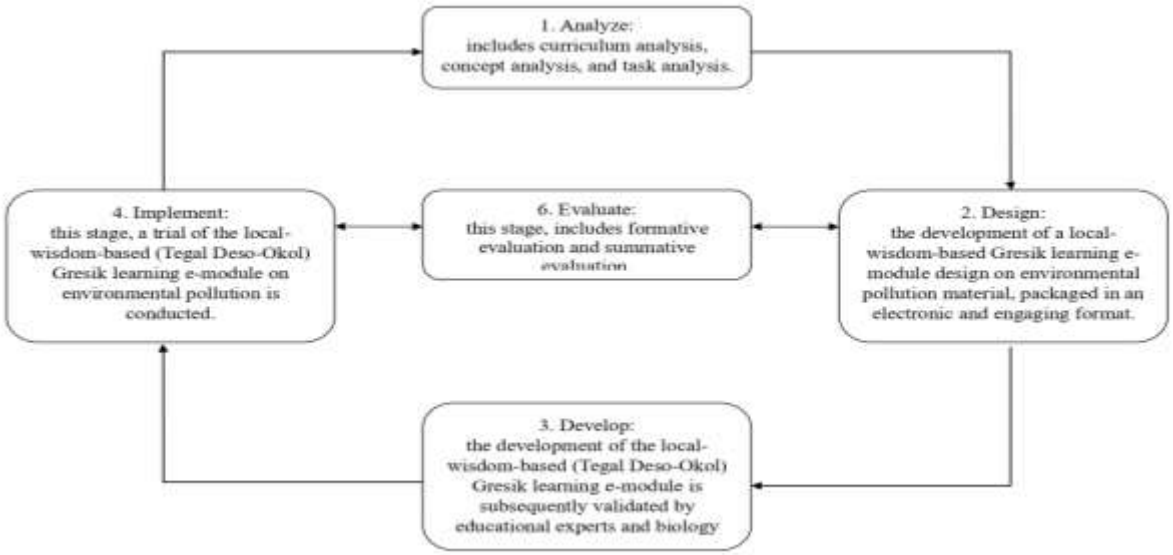


Figure 1. Research Stages Design based on the ADDIE Model

The study employed three research instruments: (1) a validity sheet evaluated by two biology subject teachers and two expert lecturers; (2) an effectiveness sheet based on student learning and responses; and (3) a practicality sheet based on observations from two observers. The learning outcomes from the e-module learning based on local knowledge (*Tegal Deso-Okol*) Gresik, which were acquired through posttest sheets on the subject of environmental pollution, served as the basis for the efficacy test.

The following methodologies were used to validate, implement, and evaluate the data analysis techniques for the e-module learning based on Gresik's local knowledge of environmental contamination (*Tegal Deso-Okol*):

(1) Analysis of validity. In order to validate the developed e-module, each evaluated aspect, such as presentation components, content, language, the e-module's relevance to creative thinking skills, and the e-module's suitability for learning based on local wisdom (*Tegal Deso-Okol*) Gresik on environmental pollution material, was given a score between 1 and 4. The E-module learning can be deemed theoretically feasible if the average score is at least 2.51 (Shiyamsyah et al., 2024).

(2) Analysis of practicality. The applicability of the e-module learning based on local knowledge (*Tegal Deso-Okol*) Gresik on environmental pollution content was assessed using a data analysis technique that entailed analyzing students' behaviors during the learning process based on many predetermined parameters. "Yes" received a score of 1, while "No" received a score of 0. The e-module learning can be deemed realistic if the percentage is at least 71% (Yunianti, 2018).

(3) Effectiveness analysis. The effectiveness analysis was conducted using student response data and posttest results. Student responses were assessed through “Yes” or “No” answer sheets, and the e-module was categorized as effective if the percentage reached ≥ 71%. Learning mastery was measured through posttests, and students were deemed to have attained mastery if they met the biology learning indicators with a minimum percentage of ≥ 71%. The overall effectiveness was then analyzed using the Normalized Gain (N-

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Gain) score and classified according to standardized evaluation criteria., as shown in the Table 1.

Table 1. Criteria for Normalized Gain Scores

Gain Increase Criteria	Nominated Score
g-Tall	$g \geq 0.7$
g-/ Keep	$0.7 > g \geq 0.3$
g-Low	$g < 0.3$

(Hake, 1998)

Results and Discussion

An e-learning program with environmental contamination content that is based on local knowledge (*Tegal Deso-Okol*) Gresik was created by the research conducted between February and June of 2025 in order to develop high school students' capacity for valid, useful, and effective creative thought. Based on local knowledge (*Tegal Deso-Okol*) in Gresik, East Java, this study created an e-module that teaches pupils how to think creatively about environmental contamination. This is consistent with the findings of Sari et al. (2022), who stress the significance of incorporating local knowledge into the curriculum. Concept analysis was conducted using a concept map that includes definitions, types, mitigation efforts, and Gresik's local values.

Compared to a number of earlier studies, the study's results show a higher degree of efficacy, which generally reported moderate to high improvements in student learning outcomes when using project-based or multimedia-supported modules. In contrast, the e-module developed in this research demonstrated stronger gains, suggesting that its combination of local wisdom, PjBL structure, and multimedia elements provided a more comprehensive learning stimulus. Nevertheless, for some indicators, the results remain consistent with earlier studies showing that students with lower readiness tend to experience slower improvement.

The differences observed in this study may be influenced by local factors specific to the *Tegal Deso–Okol* context. The integration of local wisdom reflecting students' cultural environment strengthened contextual understanding and made learning more personally meaningful, contributing to higher engagement and creativity. Additionally, the characteristics of the *Tegal Deso–Okol* community such as strong communal values, familiarity with local practices, and a tendency toward collaborative work aligned naturally with the principles of Project-Based Learning, thereby enhancing its effectiveness. Variations in student readiness in this region, however, also contributed to differing levels of improvement, as some learners required more time and guidance to adapt to independent and project-oriented tasks.

In the design stage, the learning e-module was developed in an engaging electronic format using Canva and Photoshop, and equipped with Student Worksheets 1 and Student Worksheets 2. Student Worksheets 1, which includes features like Bio Knowledge, Bio Research, Bio Explore, Bio Schedule, Bio Activity, and Bio Evaluation to support problem analysis, project planning, execution, and evaluation, includes a project on making organic fertilizer from rice straw and organic waste as well as an observation of the *Tegal Deso-Okol* local wisdom. Student Worksheets 2 focuses on project presentation through the Bio Think feature and product assessment through Bio Evaluation, which includes peer evaluation, self-reflection, solution analysis, and conclusion drawing. Figures 2 through 4 show the learning e-module's design.

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Figure 2. Display of the Learning E-Module Cover Page



Figure 3. The Feature Mapping Section Displays



Figure 4. Display of the Local Wisdom-Based Student Worksheet

Student worksheets are separated into two assignments in the learning e-module. With features like Bio Knowledge, Bio Research, Bio Explore, Bio Schedule, Bio Activity, and Bio Evaluation that support analysis, planning, implementation, and reflection, making organic fertilizer from straw and organic waste while adhering to local knowledge (*Tegal Deso-Okol*) in Gresik is the first challenge. The second task focuses on presenting project and observation results through Bio Think and Bio Evaluation, which facilitate presentation, peer assessment, self-reflection, and solution analysis. According to research by Handayani et al. (2019), easy-to-use digital module designs that facilitate hands-on activities can increase student enthusiasm and engagement. This structured worksheet and feature integration support a systematic project workflow and meaningful learning engagement.

The developed e-module was designed to be contextual, flexible, and engaging, supporting students with diverse characteristics to participate actively, develop creative thinking skills, and integrate cultural values into solving environmental problems. This is consistent with the assertion made by Bourke et al. (2018) that intercultural relationships within society are shaped by local wisdom. Le et al. (2024) go on to explain that cultural values can serve as the foundation for shaping students' knowledge, attitudes, and behavior, while Firnanda et al. (2024) stress the importance of incorporating cultural values like *Tegal Deso-Okol* into learning so that students are not only academically capable but also possess strong character in protecting the environment. Using the Project-Based Learning (PjBL) approach, which has been demonstrated to greatly enhance creative thinking abilities, the e-module for 10th grade students focuses on environmental degradation (Divac et al., 2022; Elfayetti et al., 2023). The learning activities took place over the course of two meetings: the first involved making organic fertilizer from straw and organic waste and observing the local wisdom of *Tegal Deso-Okol* in Gresik, East Java; the second involved presenting the results of the organic fertilizer project and the findings from the local wisdom observation. Table 2 summarizes the findings of the validation and reliability tests.

Table 2. Experts Verify the Learning E-Module on Environmental Pollution Material Based on Local Wisdom (*Tegal Deso-Okol*) of Gresik to Foster Students' Creative Thinking Capabilities

Indicator	Average	Criteria	Reliability (%)
Presentation Component	3.87	Very valid	97.14
Content Component	3.89	Very valid	95.24
Language Component	3.56	Very valid	85.71
Total Average Feasibility	**3.77**	**Very valid**	**92.70**

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The learning e-module's overall validity score was 3.87 in the very valid category for presentation feasibility, 3.89 in the extremely valid category for content, and 3.56 in the very valid category for language. Overall, the learning e-module's validation results revealed an average reliability score of 3.77 in the extremely valid group and 92.70 in the very high category. Based on the recommendations made by the validators, it may be concluded that the developed learning e-module is authentic and appropriate for use. Learning through the application of local knowledge (*Tegal Deso-Okol*) Gresik, which surrounds kids' homes, can help them comprehend what they are studying material (Jufrida et.al., 2019).

Prior research concentrated on traditional or broad digital teaching resources without making a direct connection between the development of the Pancasila Student Profile and 21st-century skills and regional environmental concerns (Madani et al., 2025). Because it successfully develops students' creative thinking abilities in the Society 5.0 era, the produced e-module is advised for learning (Shiyamsyah et al., 2024). During the introduction of a project-based learning paradigm, teacher and student activity observations were used to demonstrate practicality.

The PjBL phases consist of preliminary and core activities. Phase 1 entails problem analysis and project determination; Phase 2 entails project planning; Phase 3 entails developing the project execution timeline; and (4) closing activities contained the activities of the first meeting. Phase 4: Outside of the classroom, teachers monitored the development of the organic fertilizer project made from straw and organic waste as well as the local wisdom (*Tegal Deso-Okol*) Gresik.

Preliminary activities, core activities that included the PjBL phases (Phase 5: presentation of project findings and Phase 6: review of the project process and results), and closing activities comprised the second meeting's events. Students in the tenth grade can learn about environmental pollution through biology lessons that make use of local knowledge. One initiative by the government to raise the standard of education in Indonesia is the Merdeka Curriculum (Sukmayadi and Yahya, 2020). Many teachers still need to design learning that is integrated with the local wisdom surrounding children, despite the curriculum's emphasis on learning based on local knowledge (Sary et al., 2023). Additionally, a number of earlier research demonstrate that biology content can be taught utilizing a legitimate local wisdom-based learning module (Haka et al., 2024). Figure 5 below displays information from the learning implementation observation results.

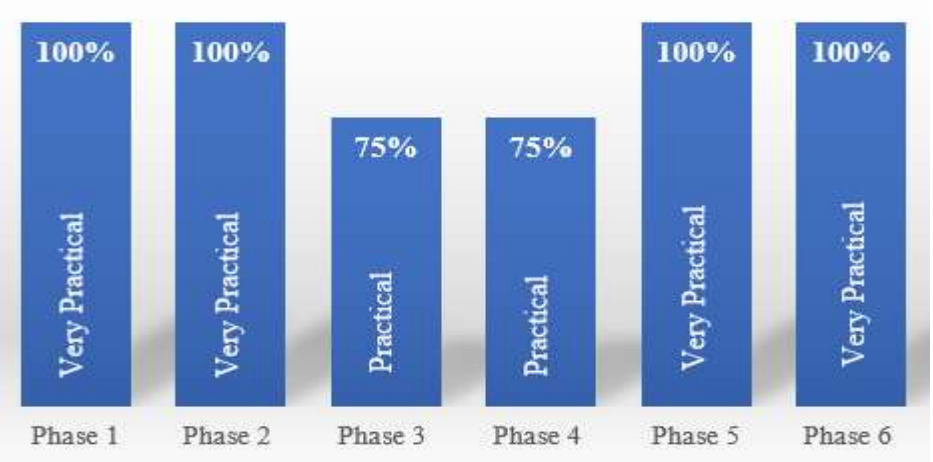


Figure 5. Synopsis of Learning Implementation Results Using (*Tegal Deso-Okol*) Local Wisdom-Based Learning E-Module Gresik on Environmental Pollution Content to Foster Students' Ability to Think Creatively

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Based on Figure 5 regarding the implementation of learning by applying the learning e-module based on local wisdom (*Tegal Deso-Okol*) of Gresik on environmental pollution material to train students' creative thinking skills, The average score was 91.67%, placing it in the category of extremely useful. The findings of the observations revealed variations in the observers' assessments, especially in stages 3 and 4.

Observer 1 scored the indicator as 0 because the scheduling activity was not yet clearly implemented in phase 3, which may have been impacted by time constraints, group dynamics, or students' attention to other project components. This indicates that students' involvement in organizing the project schedule and documentation was still limited. This is consistent with Isnaini and Widjajanti (2023) and Rahmi et al. (2025), who clarify that each project phase, including planning and documentation, must be completed for project-based learning e-modules to be effective, who identify planning and monitoring as common weaknesses in PjBL. In phase 4, Observer 2 also recorded a score of 0 for the indicator of routinely filling in bioactivity forms, indicating that students were not yet consistent in monitoring progress, partly due to the demands of long-term discipline and limited experience in systematic documentation. This condition corresponds with findings by Suhartini and Khaerunnisa (2024) that successful PjBL requires structured scheduling and consistent monitoring, and Ramadhana et al. (2024) and Rukmana et al. (2024), They attest to the fact that modules with monitoring stages enhance students' project completion performance and yield superior learning outcomes. The researcher watched students as they worked on the student worksheets and implemented learning activities. Figure 6 displays the graph of student activity assessment based on signs of creative thinking.

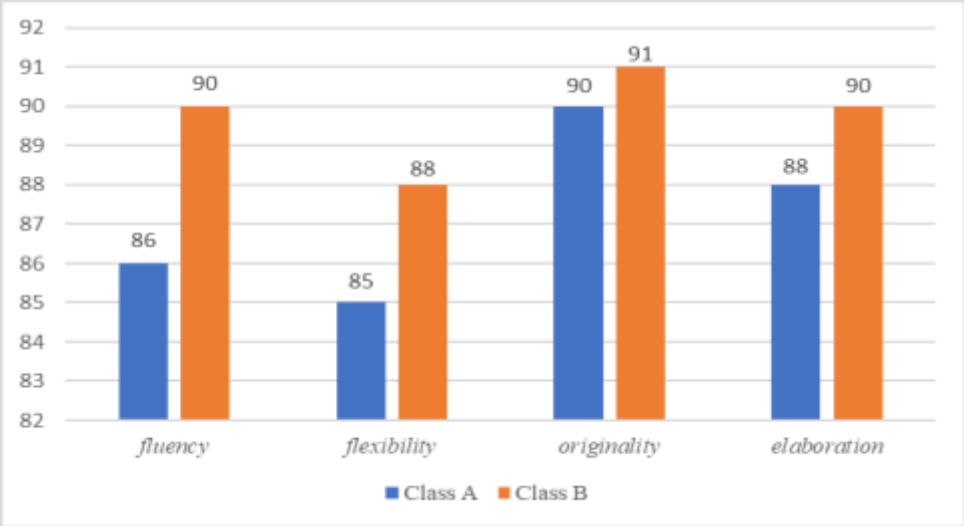


Figure 6. Recapitulation of Creative Thinking Indicator Assessment Graph

Figure 6 displays the findings of the Class B recapitulation of the creative thinking indicator assessment. Flexibility (flexible thinking) scored 86, while fluency (smooth thinking) scored 88. Furthermore, there was a significant increase in elaboration (deep thinking), which scored 90, and originality (original thinking), which obtained the highest score of 91. Although there were differences between the indications in Class A and Class B, the overall profile demonstrated a high degree of creative thinking, which is a crucial basis for resolving challenging issues. These findings highlight how important project-based learning is for developing creative thinking abilities.

The project-based learning paradigm can enhance students' creativity by promoting active engagement in real-world research and problem-solving, according to research by Cahyani et al. (2020). This is consistent with Handayani et al. (2019), who stress that

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originality and usefulness are just as important indicators of creativity as quantity. It has been demonstrated that the learning e-module on environmental contamination based on local knowledge (*Tegal Deso-Okol*) of Gresik is useful for developing creative thinking abilities, project-based learning establishes a flexible learning environment in line with industry-oriented competences (Hayati, 2022), confirming other research showing that while culture-based learning improves students' cultural literacy (Ero et al., 2024). Table 3 displays the outcomes of the students' project outputs.

Table 3. Project Outcomes of Compost Fertilizer Production

Class	Group	Score	Assessed Aspect		
			Colour	Texture	Scent
Class A	1	93	+++	+++	+++
	2	85	++	++	+
	3	89	++	++	+++
	4	89	++	++	+++
	5	80	+	+	+
Class B	1	90	+++	++	+++
	2	85	++	++	+
	3	93	+++	+++	+++
	4	89	++	++	+++
	5	87	++	++	++

Notes: Color: (+) deep black, (++) black, and (+) dark brown. Texture: (+) soft and clumpy, (++) hard but not clumpy, and (+++) very hard but not clumpy. Aroma: (+) mildly potent, (++) potent, and (+++) intensely potent.

Table 3 shows that Group 1 was the best group in Class A, producing perfect compost results (+++) in terms of color, texture, and scent. Group 5 had the lowest results in every category (+), followed by Groups 3 and 4 with outcomes that were almost identical. In Class B, Group 3 performed the best (+++), followed by Group 1. The fact that Group 2 received the lowest mark suggests that the composting procedure was still insufficient. Group 1 had the greatest score and Group 5 had the lowest in Class A, while Group 3 had the highest score and Group 2 the lowest in Class B, according to the disparities in group scores in the Student Worksheets assessment results of Class A and Class B. This illustrates the degree of engagement, originality, and in-depth analysis that students displayed throughout the learning process. Every group performed well on the task. Figure 7 displays the outcomes of the recapitulation.

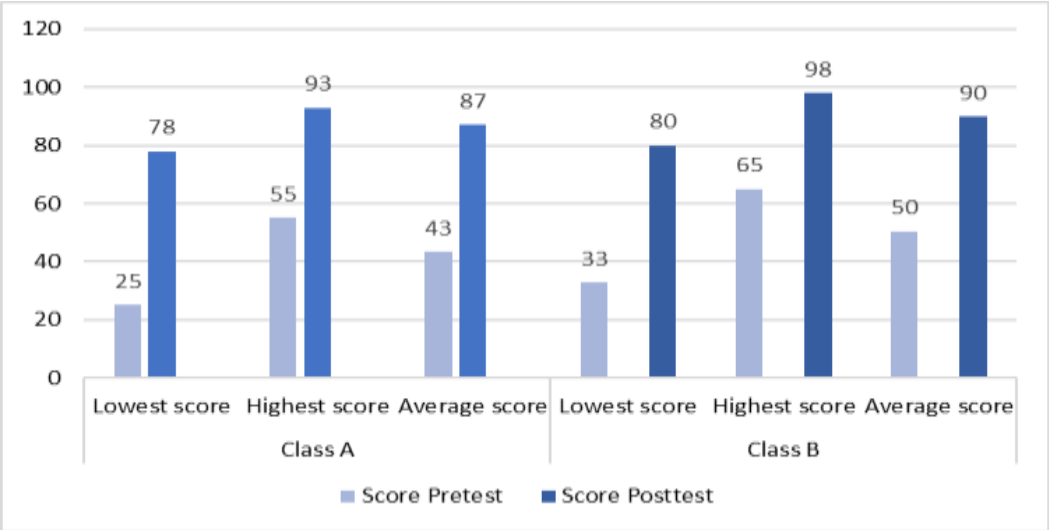


Figure 7. Summary of Student Learning Outcome Data (Pretest and Posttest)

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According to Figure 7, the study's findings indicate that students in Class A and Class B improved their N-Gain scores on average by 0.78 and 0.81, respectively, for an overall average N-Gain of 0.80, which is in the high range. Hake's criteria (1999) state that if the N-Gain score is 0.3 < (g) < 0.7, learning is considered effective. Scores more than (>) 0.7 in the pretest and posttest study data indicate that they fall into the high category. The improvement in creative thinking skills was evaluated based on the pretest and posttest scores. In Class A, the average pretest score of 43 increased to 86 in the posttest. In Class B, the average pretest score of 50 increased to 90 in the posttest. Therefore, the creative thinking skills of students in both classes demonstrated a substantial improvement. Table 4 summarizes the outcomes of the student responses to the learning process utilizing the e-module based on the local knowledge of *Tegal Deso-Okol* in Gresik on environmental pollution material to educate students' critical thinking abilities.

Table 4. Reactions from students Class A and Class B Data

Class	Effectiveness score (%)	Category
Class A	97	Very Effective
Class B	98	Very Effective

Based on Table 4, 97.5% of the student replies in Classes A and B were classified as highly successful. Students were eager and motivated to study the learning e-module, learned more about the local wisdom (*Tegal Deso-Okol*) of Gresik, and formed a desire to preserve the local wisdom, according to the student replies data in Table 4. Students were able to raise their awareness of their environment and enhance their learning results. Ten questions fell into the highly effective category with an average effectiveness score of 97%. As a result, the learning e-module based on Gresik's local knowledge (*Tegal Deso-Okol*) on environmental pollution material to develop students' capacity for creative thought created extremely useful and workable outcomes.

The high effectiveness of the e-module is attributed to its pedagogical design, which integrates local wisdom, Project-Based Learning (PjBL), and multimedia elements. Local wisdom provided relevant cultural context that made abstract concepts easier to understand and encouraged creative idea development, while PjBL facilitated problem-solving, inquiry, and product creation that further strengthened creativity. Additionally, multimedia components such as interactive visuals and videos optimized cognitive processing, improved comprehension, and increased learning motivation.

These mechanisms help explain why the e-module achieved a very high effectiveness score. However, some students still showed lower N-Gain scores compared to others. This variation can be attributed to differences in learning readiness and individual learning styles, which influence the rate at which students can absorb and process material. According to Students who are less prepared and have less prior knowledge typically need more time and instructional support to acquire the same level of understanding as their better prepared peers, according to Hamid et al. (2020). Consequently, even though all categories saw improvement, the magnitude of learning gains varied, highlighting the need for ongoing instructional scaffolding for learners who may require additional adjustment within the PjBL environment.

The systematic organization and accessibility of e-modules can enhance students' conceptual understanding, according to research by Yuliana and Prasetyo (2021). According to research by Rahayu et al. (2020), incorporating local knowledge into educational materials can make the content more relevant to students' everyday experiences, which will promote active participation and a feeling of community. This supports the study's conclusions that

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after using the learning e-module, pupils felt more driven to maintain Gresik's native culture (*Tegal Deso-Okol*). Through the idea of zero waste within a project-based learning framework, this integration encourages environmental conservation (Rukmana et al., 2024).

Academic attainment and student learning outcomes can be enhanced by using electronic modules (E-modules) as self-learning resources that can be accessible for individual learning (Marhayani et al., 2025). A 2019 study by Handayani found that incorporating the project-based learning paradigm into online courses fosters students' ability to think creatively and be environmentally conscientious. Therefore, as a creative and contextual alternative learning medium, particularly in learning that is based on the environment and local culture, students' ability to think creatively is greatly enhanced by the learning e-module on environmental degradation that is based on local knowledge (*Tegal Deso-Okol*) of Gresik..

Conclusion

According to the findings of the development research, this study created an e-module on environmental pollution based on local knowledge (*Tegal Deso-Okol*) of Gresik in order to foster the creative thinking skills of grade X high school students. According to the validity aspect, this is viable with a feasibility score of 3.77 and the criterion of being extremely possible for use in learning, wth a practicality score of 91.67%, the student activities met the high practicality requirement. The e-module's efficacy demonstrated an average N-Gain score improvement of 0.78, placing it in the top category based on the learning outcomes. With an average score of 97%, the student responses fell into the very effective category.

Recommendation

Based on the study findings, teachers are advised to utilize the local wisdom–based e-module in science learning to strengthen contextual understanding and enhance students' creative thinking skills, while adjusting its use to learner characteristics and available technological resources. Future researchers are encouraged to expand implementation to broader educational contexts, improve the e-module with more interactive digital features, and explore additional forms of local wisdom to further strengthen the relevance and effectiveness of culturally integrated learning media.

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