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Development of a SETS-Based E-Module on Climate Change Using Peatland Ecosystems as a Contextual Learning Resource for Grade X Senior High School Students

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A B S T R A C T

Climate change is a major environmental challenge, particularly in peatland ecosystems, which store substantial carbon. However, climate change learning in schools remains largely theoretical and rarely uses local peatland contexts or digital resources. This study aimed to develop a quality SETS-based (Science, Environment, Technology, and Society) e-module on climate change for Grade X senior high school students, using peatland ecosystems as a learning context. This Research and Development study used a modified ADDIE model limited to the Analysis, Design, and Development stages. The e-module was assessed through expert validation and a limited trial with 10 university students and 20 senior high school students. Data from validation sheets and response questionnaires were analyzed descriptively. The e-module obtained an average validation score of 3.59 and a limited-trial score of 3.88, giving an overall score of 3.74, categorized as very high quality. Trial responses indicated that the e-module was easy to use, attractive, and potentially supports students' understanding of climate change concepts. Because the Implementation and Evaluation stages were not conducted, these findings reflect user responses rather than validated learning outcomes. In conclusion, the e-module is suitable as a Biology learning resource with potential to enhance environmental literacy and peatland conservation awareness.

1. Introduction

Climate change has emerged as one of the most critical global environmental challenges of the twenty-first century (Maharani & Hatami, 2024). The increasing concentration of greenhouse gases in the atmosphere has contributed to rising global temperatures, changing precipitation patterns, and the increased frequency of extreme weather events (Irma & Gusmira, 2024). Regional climate modeling also indicates a potential increase in extreme rainfall events in the future (Nurlatifah et al., 2023). These environmental changes affect various sectors, including agriculture, public health, infrastructure, and

transportation (Ainurrohmah & Sudarti, 2022), and pose direct and indirect risks to human health (Melo & Rahmadani, 2022). Given these wide-ranging impacts, education plays a strategic role in fostering awareness and sustainable behavior toward climate action. Therefore, improving climate change literacy among younger generations has become an important objective of contemporary science education (Harpina et al., 2025).

Peatland ecosystems play a significant role in the global climate system due to their ability to store large amounts of carbon (Harris et al., 2022). Indonesia possesses extensive tropical peatlands, particularly in Riau Province, which serve as important carbon sinks and regulators of hydrological processes (Saputra et al., 2026). However, human activities such as land conversion, drainage, and peatland fires have accelerated peat decomposition and released substantial amounts of carbon dioxide into the atmosphere (Shiraishi et al., 2023). As a result, peatland degradation has become one of the major contributors to climate change and environmental deterioration (Doelman et al., 2023). Consequently, peatland ecosystems provide a highly relevant local context for learning climate change concepts.

The implementation of the Merdeka Curriculum emphasizes contextual and student-centered learning that connects scientific concepts with real-world phenomena (Bait et al., 2025). Contextual learning enables students to relate concepts to phenomena in their surroundings, making learning more meaningful (Fitriani et al., 2023). Contextual Teaching and Learning-based modules have likewise been reported as feasible for Physics learning (Agusti, 2023). In the Natural Sciences subject, climate change is included in the Phase E learning outcomes (Peraturan Menteri Pendidikan Dasar Dan Menengah Republik Indonesia Nomor 13 Tahun 2025, 2025), in which students are expected not only to understand its scientific principles but also to analyze its causes, impacts, mitigation strategies, and adaptation efforts (Peraturan Menteri Pendidikan Dasar Dan Menengah Republik Indonesia Nomor 13 Tahun 2025, 2025). Nevertheless, preliminary interviews with three Biology teachers from SMAN 1, SMAN 2, and SMAN 4 Pekanbaru revealed that climate change is a difficult topic because it requires higher-order analysis and the ability to link concepts with current issues. Learning also remains largely theoretical and teacher-centered, which has been reported to be less effective than media-supported learning (Indrawati et al., 2025). Learning resources are generally limited to textbooks and unguided internet sources that do not adequately integrate local environmental issues (Laaloua, 2023), particularly peatland ecosystems. As a result, students often have difficulty relating climate change concepts to environmental phenomena in their surroundings.

The development of digital learning resources offers opportunities to enhance students' engagement and understanding. Electronic modules (e-modules) have gained increasing attention because they provide interactive, multimedia-rich, and flexible learning experiences (Radhitya et al., 2025). Previous studies have demonstrated that SETS (Science, Environment, Technology, and Society)-based learning materials can improve scientific literacy (Atmojo & Wardhana, 2025), critical thinking skills (Kusmianty et al., 2020), and environmental literacy (Rizka et al., 2023). Furthermore, SETS enables learners to understand scientific concepts within broader environmental, technological, and societal contexts, making learning more meaningful and relevant (Supriyadi et al., 2019).

Despite the growing body of research on SETS-based learning materials (Ramadani et al., 2026), studies focusing on climate change education integrated with peatland ecosystems remain limited. Most previous studies have concentrated on topics such as biotechnology (Zahrah et al., 2025), the endocrine system (Ramadani et al., 2026), and environmental pollution (Nurohmawati et al., 2023). Climate change learning materials have been developed in digital form, but without a SETS approach or a local peatland context (Flood et al., 2025), while SETS-based learning on global warming has been implemented through practicum-based models rather than interactive e-modules (Kusmianty et al., 2020). Meanwhile, peatland studies mostly address ecological, restoration, and policy aspects rather than learning resources. Furthermore, the availability of interactive digital learning materials that connect climate change, peatland ecosystems, technology, and societal issues is still insufficient, as confirmed by the teacher interviews in the preliminary study (Appendix 1). This gap highlights the need for innovative learning resources that support contextual and environmentally relevant science education.

To address these challenges, this study aimed to develop a SETS-based e-Module on Climate Change for Grade X Senior High School students using peatland ecosystems as a learning context. The e-module integrates scientific concepts, environmental issues, technological applications, and societal perspectives related to peatland conservation and climate change mitigation. The study also sought to evaluate the quality of the developed e-module through expert validation and limited user trials. It is expected that the developed e-module will support

meaningful learning, enhance environmental literacy, and foster students' awareness of the importance of peatland conservation in addressing climate change challenges.

2. Methodology

Research Design

This study employed a Research and Development (R&D) approach to develop a SETS-based (Science, Environment, Technology, and Society) e-module on climate change for Grade X Senior High School students, using peatland ecosystems as a contextual learning resource. The development process adopted a modified ADDIE model consisting of three stages: Analysis, Design, and Development. The Implementation and Evaluation stages were excluded for two reasons. First, the study was conducted within a limited period, from January to May 2026, which was sufficient for developing, validating, and revising the product but not for classroom implementation and evaluation of learning outcomes. Second, the scope of the study focused on producing a feasible product and assessing its quality rather than its long-term impact on student learning. Consequently, the limited trials served to evaluate the product's practicality and user perception, not its instructional effectiveness.

During the Analysis stage, curriculum, material, and learner analyses were conducted to identify learning objectives, student characteristics, and ways to integrate peatland issues into climate change learning. The Design stage involved designing the e-module structure, learning activities, assessment instruments, and the integration of SETS components. In the Development stage, the e-module was created using Canva for visual design, Liveworksheet for interactive activities, and Heyzine for conversion into a digital flipbook. The product was then validated by experts and tested in limited trials.

Instruments

The instruments were non-test questionnaires consisting of validation sheets and user response questionnaires. The validation sheets assessed content feasibility, presentation, language, layout, graphics, typography, and usability. The blueprints were adapted from Rahmawati (2024) and adjusted to the focus of this study. The validation involved four validators: one media expert lecturer, one subject matter expert lecturer, and two Biology teachers. The user response questionnaire, also adapted from Rahmawati (2024), covered four aspects: appearance/attractiveness, material, language, and technical quality. All instruments used a four-point Likert scale (Sugiyono, 2013) from 1 (poor) to 4 (very good).

Data Collection

First, preliminary observations and interviews with Biology teachers at SMAN 1, SMAN 2, and SMAN 4 Pekanbaru provided information on curriculum requirements, learning difficulties, and existing learning resources, which became the basis for development. After the e-module was developed, validation data were collected from the four validators, and their suggestions were used for revision. The revised e-module was then tested in two limited trials. The first involved ten Biology Education students of the Faculty of Teacher Training and Education, Universitas Riau. After further revision, the second involved twenty Grade X students of SMAN 4 Pekanbaru. Participants completed the questionnaire after exploring the e-module.

Data Analysis

Data were analyzed using descriptive quantitative techniques (Sugiyono, 2013; Rahmawati, 2024). The mean score for each aspect was calculated as $\bar{X} = \Sigma X / N$, where $\bar{X}$ is the mean score, ΣX the total score, and N the number of items. Mean scores were interpreted using the criteria of Sugiyono (2013): 3.25–4.00 (very valid/very good), 2.50–3.24 (valid/good), 1.75–2.49 (less valid/less good), and 1.00–1.74 (not valid/not good). The overall quality of the e-module was obtained by averaging the validation score and the limited-trial score (modified from Zahrah et al., 2025). The e-module was considered suitable when it reached the good or very good category. Because Implementation and Evaluation were not conducted, classroom implementation and learning-outcome evaluation were beyond the scope of this study.

3. Results and Discussion

Result

Analysis Stage

Curriculum analysis of the Phase E learning outcomes (Peraturan Menteri Pendidikan Dasar Dan Menengah Republik Indonesia Nomor 13 Tahun 2025, 2025) showed that students are required to apply science concepts to address real problems related to climate change. This was elaborated into three learning objectives across three meetings (6 lesson hours): (1)

concepts and symptoms of climate change, (2) causes and impacts, and (3) mitigation, adaptation, and global cooperation, all set in peatland ecosystems. Material analysis showed that climate change is abstract, multidisciplinary, and closely linked to peatlands, which store carbon but release greenhouse gases when degraded, making them a relevant local context. Learner analysis showed that Grade X students (15-16 years old) are at the formal operational stage (Darmayanti, 2023). They have prerequisite knowledge of organism-environment interactions and biogeochemical cycles, and they vary in learning style (visual, auditory, kinesthetic). Preliminary interviews with Biology teachers at SMAN 1, SMAN 2, and SMAN 4 Pekanbaru (Table 1) showed that climate change is among the difficult topics and that available teaching materials are limited and not yet contextual.

Table 1. Summary of Preliminary Interview Results with Biology Teacher

No	Aspect	Findings
1	Learning model used	Learning models are adjusted to the material, with Problem-Based Learning (PBL) being the most frequently applied.
2	Materials perceived as difficult	Ranked from most to least difficult: virus, climate change, ecosystems, biodiversity, and biotechnology.
3	Cause of difficulty	Difficulty is caused mainly by the level of analysis required and the material's distance from students' direct experience; virus material is difficult because it cannot be observed directly, while issue-based materials such as climate change require students to connect concepts with global environmental issues, demanding a higher level of analytical skill.
4	Use of teaching materials	Teaching materials are already used, mainly textbooks.
5	Availability of teaching materials	Limited, as not all students have access to the printed textbook; the teacher often directs students to internet-based sources instead.
6	Influence of teaching materials on students	Has not yet shown a significant impact due to the limitations of available teaching materials.
7	Learning obstacles	Insufficient variety of teaching materials, compounded by internet access constraints (network issues, limited data packages) when digital resources are used.
8	Contextual integration in existing materials	Materials for biodiversity and ecosystems are contextualized through direct observation of the school environment; however, climate change material is only contextualized through internet-based news articles or discussion and presentation, indicating that contextual integration is not yet optimal across all topics.

Design Stage

The e-module consists of a cover, preface, table of contents, list of figures, glossary, an introduction section (learning outcomes, process skills, brief description, instructions for use, an introduction to peatlands ("Mengenal Lahan Gambut"), and a concept map ("Peta Materi")), three learning activities, an evaluation section with scoring guidelines, a bibliography, and an author profile. The content of each learning activity is structured in five SETS stages: Initiation, Concept Formation, Concept Application, Concept Reinforcement (summary), and Assessment (exercises). Before the e-module was built, a learning-objective flow (ATP) and a deep learning plan (RPM) were prepared, integrating Problem-Based Learning syntax with the SETS stages. A storyboard then guided the visual design.

Development Stage

The e-module was produced with Canva, Liveworksheet, and Heyzine and is accessed as a flipbook through a link (Figure 1). Each learning activity is organized by the five SETS stages (Figure 2). Each topic links the science concept to the environment, a technology (IoT-based water-table monitoring), and society's role in peatland restoration (Figure 3).



(a)



(b)

Figure 1. Cover and main menu of the e-module (a, b)



Figure 2. A learning activity page with the five SETS stage navigation

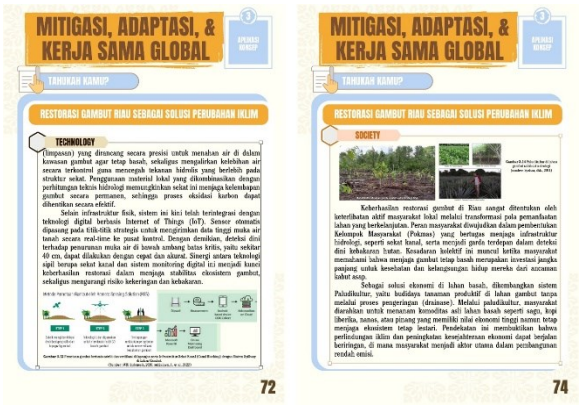


Figure 3. Technology (a) and Society (b) sections on peatland restoration

The four SETS components were not presented as separate sections but as one connected line of reasoning that students follow in each learning activity. The Meeting 3 (mitigation, adaptation, and global cooperation) illustrates this integration (Figure 3). In the Initiation stage, students are asked why restoring Riau's peatlands is considered a climate solution. In the Concept Formation stage, the Science component explains that drained peat is exposed to oxygen, so aerobic decomposition releases carbon dioxide, whereas waterlogged peat keeps decomposition anaerobic and carbon stored (Harris et al., 2022). The Environment component places this process in degraded peat landscapes in Riau, where drainage, land conversion, and fires reduce the carbon sink function (Saputra et al., 2026). The Technology component (Figure 3a) introduces rewetting and IoT-based water-table sensors that send real-time data to a control center, so that a fall in the water table below a critical threshold of about 40 cm can be detected early. The Society component (Figure 3b) shows how community groups participate in managing hydrological infrastructure and in paludiculture, the productive farming of wet-adapted crops, so that restoration also provides livelihoods.

In the Concept Application stage, students are guided by problem-based questions, in line with the Problem-Based Learning syntax integrated into the SETS stages, to trace a chain of relationships: human activities (drainage, land conversion, and burning), peatland degradation, carbon emissions, climate change impacts, and mitigation through rewetting, monitoring, and community-based management. For each link, students identify which SETS component explains it, for example, decomposition (Science), drained peat in Riau (Environment), water-table sensors (Technology), and community management (Society). In this way, students see that mitigation depends on scientific understanding, environmental conditions, technological tools, and social participation together, rather than on any one of them alone. The Concept Reinforcement stage summarizes the chain, and the Assessment stage uses exercises aligned with the learning objectives to check whether students can explain it. The same logic runs through the other meetings: in Meeting 1, rising temperature alters the hydrological cycle (Science), lowers the water table in peatlands (Environment), is recorded by piezometers and soil moisture sensors (Technology), and is felt by communities as erratic rainfall (Society). In Meeting 2, drainage-driven decomposition (Science) degrades peatlands and adds CO_2 to the atmosphere (Environment), is tracked through canal blocking and real-time monitoring (Technology), and causes smoke-related respiratory illness among communities in Riau (Society).

Four validators (one media expert lecturer, one material expert lecturer, and two Biology teachers) assessed the e-module in May 2026 (Table 2). Their suggestions led to revisions: adding the peatland introduction, replacing the fire issue in the Meeting 1 concept application, aligning exercises with the learning objectives and adding more of them, reordering the Meeting 2 material from impact-cause to cause-impact, and clarifying images.

Table 2. Expert Validation Results

Validation Aspect	Mean Score	Category
Content Feasibility	3.51	Very Valid
Presentation	3.58	Very Valid
Language	3.29	Very Valid
Layout	3.78	Very Valid
Graphics	3.63	Very Valid
Typography	3.57	Very Valid
Usability	3.78	Very Valid
Overall	**3.59**	**Very Valid**

All aspects were in the Very Valid category. Layout and usability scored highest (3.78); every usability item (operation on a mobile phone, multimedia, menu buttons, answer columns) scored 3.78, indicating that the features work well technically. Language was the lowest (3.29) and only slightly above the category threshold (3.25), so it remains the main point for improvement. After revision, two limited trials were conducted: Trial I with 10 Biology Education students (22 May 2026) and Trial II with 20 Grade X students of SMAN 4 Pekanbaru (25 May 2026). Both trials rated the e-module Very Good (Table 3).

Table 3. Results of Limited Trials

Trial Stage	Mean Score	Category
Limited Trial I (n = 10)	3.87	Very Good
Limited Trial II (n = 20)	3.88	Very Good
Average	**3.88**	**Very Good**

Across both trials, technical quality scored highest (3.97), followed by appearance (3.87), material (3.84), and language (3.83). These scores reflect user perceptions, not learning outcomes.

Table 4. Overall Quality of the E-Module

Evaluation Component	Mean Score
Expert Validation	3.59
Limited User Trials	3.88
Overall Average	**3.74 (Very High Quality)**

Implementation and Evaluation Stage

These stages were not conducted because the study took place within a limited period (January-May 2026) and focused on product quality rather than its effect on learning. Expert validation and limited trials served as formative review within the Development stage, so no learning outcomes were measured.

Discussion

The developed e-module reached the very high-quality category in both expert validation (3.59) and user response (3.88), with an overall score of 3.74 (Table 4). All seven validation aspects and all four response aspects fell in the highest category, indicating that the e-module meets the requirements of a quality digital learning resource in content, presentation, graphics, and usability. Because the study stopped at the Development stage, these scores represent the feasibility and perceived quality of the product, not its effect on learning.

The structure of the e-module may partly explain the high content and presentation scores (3.51 and 3.58). Learning materials intended for independent study should have complete opening, core, and closing components arranged systematically (Famulaqih & Lukman, 2024), which the e-module provides through its cover, glossary, learning activities, exercises, and evaluation. The SETS approach adds a further framework by connecting scientific concepts with environmental, technological, and societal contexts (Supriyadi et al., 2019). In the e-module, each topic follows five SETS stages, for example linking peat decomposition (science) with drained peatlands (environment), IoT-based water-table monitoring (technology), and community-based restoration (society). Rumaysa & Dalimunthe (2025) likewise reported that a SETS-based module was valid and positively received, which is consistent with the present findings. However, the lowest item in the content aspect was material depth (3.44), and validators recommended replacing the fire issue in the Meeting 1 application stage. This suggests that integrating several SETS components within limited lesson hours requires a careful balance between breadth and depth.

The peatland context also appears to contribute to the quality of the module. Contextual learning connects concepts with students' real-life situations and makes materials more meaningful (Fitriani et al., 2023), and local-context modules have been developed for other Biology topics (Hasmiati et al., 2023). Peatlands are suitable for climate change because they store large amounts of carbon, which is released when they are drained or burned (Harris et al., 2022). The validators' request to add an introduction to peatlands before the main material shows that the context needs to be explained first, especially for students who have not been in direct contact with peatlands. The score for the material aspect in the trials (3.84) suggests that users found the content clear and relevant. This should not be read as improved understanding, which was not measured.

Language was the lowest-scoring validation aspect (3.29), only slightly above the very valid threshold (3.25). Climate change and peatland materials contain many abstract terms, such as greenhouse gas emissions, anaerobic and aerobic decomposition, and carbon sinks, and the validators' comments on pronoun use in the preface indicate that wording still needed refinement. The glossary was included to help, but this result shows that language remains the main aspect to improve. Notably, the language aspect in the student trials was rated higher (3.83), which suggests that students found the wording understandable even though experts saw room for refinement.

The high usability (3.78) and technical quality (3.97) scores show that the combination of Canva, Liveworksheet, and Heyzine worked smoothly on mobile phones, in line with the view that e-modules can provide interactive, multimedia-rich, and flexible learning (Suarmita et al., 2025). This matters in the local context, since the teacher interviews reported limited printed textbooks and unguided use of internet sources. Nevertheless, these scores indicate technical readiness and positive perception, not increased engagement or motivation, which would require observation or an engagement instrument.

The findings are comparable with earlier SETS e-modules. Zuhlia (2026) reported a validity score of 3.88 for a SETS-based e-book on the immune system, and Permatasari et al (2025) reported expert validation scores of 91.1% and 86.9% for an eco-enzyme e-module. Direct comparison is limited by differences in topic, instrument, and scoring method. What distinguishes the present study is its focus on climate change in peatlands, a combination that earlier studies had not addressed. SETS-based learning has been linked to scientific literacy (Atmojo & Wardhana, 2025) and environmental literacy (Rizka et al., 2023), and local environmental education may foster students' awareness (Aziiz et al., 2025). The e-module therefore has potential in these areas, but this potential needs to be tested.

The results suggest practical implications. Teachers in Riau may use the module as a contextual resource that reduces dependence on printed books, and developers may adopt the five-stage SETS structure for other local environmental topics.

Several limitations should be noted. First, the high scores should be interpreted with caution. Validators and participants knew that the e-module was developed by the researcher, which may inflate ratings through social desirability bias. Trial I participants were Biology Education students rather than target users, and Trial II students had already studied climate change. Scores were also close to the scale maximum, which limits differentiation between aspects. Second, only 30 participants took part, with no comparison group, so the results cannot be generalized. Third, because the Implementation and Evaluation stages were not conducted, no learning outcomes, such as conceptual understanding or environmental literacy, were measured. Future research should implement the e-module in full classroom learning with pre-test and post-test measures, and could include a larger and more varied sample.

4. Conclusion

This study developed a SETS-based (Science, Environment, Technology, and Society) e-module on climate change using peatland ecosystems as a contextual learning resource for Grade X Senior High School students. The e-module integrates scientific concepts, environmental issues, technological applications, and societal perspectives, and it was assessed through expert validation and limited user trials. The findings indicate that the e-module falls in the very high-quality category in terms of content, presentation, language, visual design, and usability, and that users responded to it positively. On this basis, the e-module is suitable for use as a Biology learning resource. This suitability reflects the product's quality according to expert validation and user perceptions. It is not direct evidence that the e-module improves students' learning outcomes, because the study was limited to the Analysis, Design, and Development stages, and the Implementation and Evaluation stages were not conducted.

By linking climate change with local peatland issues, the e-module has the potential to help students connect scientific concepts with phenomena in their surroundings, support independent learning, and strengthen environmental literacy and awareness of peatland conservation. It also aligns with the contextual learning emphasis of the Merdeka Curriculum. Future studies should implement the e-module in classroom learning and examine its effects on learning outcomes, critical thinking skills, environmental attitudes, and climate change literacy, using larger samples and more varied educational settings.

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References

Agusti, R. H. (2023). Implementation of Contextual Teaching and Learning Based Physics

Module on Newton's Law Material to Improve Critical Thinking Skills of Class X Students. *Journal of Education and Learning Research*, *1*(1), 8–19. https://doi.org/10.62208/jelr.1.1.p.8-19

Ainurrohmah, S., & Sudarti, S. (2022). Jurnal Phi Analisis Perubahan Iklim dan Global Warming yang Terjadi sebagai Fase Kritis. *Jurnal Phi: Jurnal Pendidikan Fisika Dan Fisika Terapan*, *8*(1), 1–10. https://doi.org/10.22373/p-jpft.v8i1.13359

Atmojo, S. E., & Wardhana, A. K. (2025). The Impact Of Sets-Based Science Learning Assisted By It Media On Science Literacy And Digital Literacy. *Jurnal Cakrawala Pendas*, *11*(1), 129–140. https://doi.org/10.31949/jcp.v11i1.11773

Aziiz, W., Mukti, H., & Erdianti, O. (2025). Pendidikan lingkungan berbasis proyek untuk meningkatkan kesadaran siswa terhadap perubahan iklim. *JUSI Jurnal Studi Ilmiah*, *1*(1), 18–23. https://journal.innoscientia.org/index.php/jusi/article/view/166

Bait, E. H., Mulyasari, E., Hendriawan, D., Arwasih, A., & Ulwan, M. N. (2025). Kurikulum Merdeka dan Dinamika Tujuan Pendidikan: Integrasi Capaian Pembelajaran (CP), Tujuan Pembelajaran (TP), dan Alur Tujuan Pembelajaran (ATP). *Kalam Cendekia: Jurnal Ilmiah Kependidikan*, *13*(1), 615–624. https://doi.org/10.20961/jkc.v13i1.97505

Darmayanti, K. K. H. (2023). Proses Pembelajaran dan Perkembangan Kognisi Menurut Perspektif Jean Piaget. *Journal of Lifespan Development*, *1*(1), 39–54.

Doelman, J. C., Verhagen, W., Stehfest, E., & Van Vuuren, D. P. (2023). The role of peatland degradation, protection and restoration for climate change mitigation in the SSP scenarios. *Environmental Research: Climate*, *2*(3), 1–13. https://doi.org/10.1088/2752-5295/acd5f4

Famulaqih, S., & Lukman, A. (2024). Pengembangan Bahan Ajar Modul Pembelajaran. *Karakter : Jurnal Riset Ilmu Pendidikan Islam*, *1*(2), 1–12. https://doi.org/10.61132/karakter.v1i4.156

Fitriani, F., Krismanto, W., & Usman, U. (2023). Improving Science Learning Process and Outcomes in Elementary Schools Through Contextual Teaching & Learning. *Education and Human Development Journal*, *8*(1), 38–46. https://doi.org/10.33086/ehdj.v8i1.3980

Flood, K., Wilson, D., & Renou-Wilson, F. (2025). Evidence Synthesis and Knowledge Integration for Sustainable Peatland Management. *Land*, *14*(7), 1–26. https://doi.org/10.3390/land14071397

Harpina, H., Darfin, S. A., & Kholifatun, U. N. (2025). Science Literacy and Climate Change Issues in Elementary School Science Learning as a Green Education Effort. *Journal of Humanities, Social Sciences, And Education (JHUSE)*, *1*(2), 55–68. https://doi.org/10.64690/jhuse.v1i2.34

Harris, L. I., Richardson, K., Bona, K. A., Davidson, S. J., Finkelstein, S. A., Garneau, M., Mclaughlin, J., Nwaishi, F., Olefeldt, D., Packalen, M., Roulet, N. T., Southee, F. M., Strack, M., Webster, K. L., Wilkinson, S. L., & Ray, J. C. (2022). The essential carbon service provided by northern peatlands. *Frontiers in Ecology and the Environment*, *20*(4), 222–230. https://doi.org/10.1002/fee.2437

Hasmiati, H., Rukmana, M., Agustina, T. P., & Watung, F. A. (2023). Pengembangan Modul Biologi Berbasis Potensi Lokal Kabupaten Enrekang pada Materi Plantae untuk Siswa Kelas X SMA. *Jurnal Biotek*, *11*(1), 1–13. https://doi.org/10.24252/jb.v11i1.37011

Indrawati, I., Suardi, S., & Kaharuddin, K. (2025). The Effect of Problem-Based Learning Model Assisted by Audio- Visual Media on Interest and Learning Outcomes in Social Studies. *Journal of Educational Sciences*, *6*(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Irma, M. F., & Gusmira, E. (2024). Tingginya Kenaikan Suhu Akibat Peningkatan Emisi Gas Rumah Kaca Di Indonesia. *JSSIT: Jurnal Sains Dan Sains Terapan*, *2*(1), 26–32. https://doi.org/10.30631/jssit.v2i1.49

Kusmianty, D., Widiyanto, B., & Kusuma, M. (2020). Efektivitas Model Pembelajaran Sets Metode Praktikum Pada Materi Pemanasan Global Dalam Meningkatkan Kemampuan Berpikir Kritis. *Cakrawala: Jurnal Pendidikan*, *14*(1), 41–51. https://doi.org/10.24905/cakrawala.v14i1.1508

Laaloua, H. (2023). The Role of Education in Addressing Environmental Challenges: A Study of Environmental Education Integration in Moroccan Geography Textbooks. *International Journal of Social Science and Human Research*, *06*(04), 2317–2325. https://doi.org/10.47191/ijsshr/v6-i4-41

Maharani, G., & Hatami, M. A. (2024). The Role of Scientific Literacy in Climate Change-Based

Science Learning: A Literature Review. *Indonesian Journal of STEM Education*, *6*(2), 86–101. https://doi.org/10.67434/ijse.v7i2.1921

Melo, R. H., & Rahmadani, N. A. (2022). Dampak Perubahan Iklim Terhadap Kesehatan Manusia. *Geosfera: Jurnal Penelitian Geografi (GeoJPG)*, *1*(1), 40–45. https://doi.org/10.34312/geojpg.v1i1.26522

Nurlatifah, A., Hatmaja, R. B., & Rakhman, A. A. (2023). Analisis Potensi Kejadian Curah Hujan Ekstrem di Masa Mendatang Sebagai Dampak dari Perubahan Iklim di Pulau Jawa Berbasis Model Iklim Regional Conformal Cubic Atmospheric Model. *JURNAL ILMU LINGKUNGAN*, *21*(4), 980–986. https://doi.org/10.14710/jil.21.4.980-986

Nurohmawati, C., Pramadi, A., & Maryanti, S. (2023). Pengaruh Pendekatan Science Environment Techonology And Society (Sets) Terhadap Keterampilan Berpikir Kreatif Peserta Didik Pada Materi Pencemaran Lingkungan. *JURNAL EDUKASI*, *1*, 63–69. https://doi.org/10.60132/edu.v1i1.86

Peraturan Menteri Pendidikan Dasar Dan Menengah Republik Indonesia Nomor 13 Tahun 2025, 167 (2025). https://peraturan.bpk.go.id/Details/322506/permendikdasmen-no-13-tahun-2025

Permatasari, N., Sajidan, S., & Fatmawati, U. (2025). Development of an e-module for eco-enzyme production in biotechnology learning using the SETS approach oriented toward problem-solving skills. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, *7*(3), 424–434. https://ppjp.ulm.ac.id/journal/index.php/bino DOI: 10.20527/bino.v7i3.23689

Radhitya, T., Rahmawati, A., & Cahyono, B. T. (2025). Development of a Problem-Based Learning Interactive E-Module to Improve Learning Outcomes in Lathe Machining Techniques at Vocational High School. *International Journal of Pedagogy and Teacher Education*, *9*(2), 310–321. https://doi.org/10.20961/ijpte.v9i2.105341

Rahmawati, A. (2024). *Pengembangan E-Modul Berbasis Science Environment Technology Society (Sets) Dengan Model Project Based Learning Pada Materi Energi Terbarukan Sma/Ma*. Unpublished: Universitas Islam Negri Raden Intan Lampung.

Ramadani, E., Kundera, I. N., Alibasyah, L., & Bialangi, M. S. (2026). Developing a Science , Environment , Technology , and Society (SETS) Based Biology Module to Improve Students ' Motivation and Critical Thinking. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *10*(2), 397–406. https://doi.org/10.23887/jppp.v10i2.105896

Rizka, C., Mariningsih, P., & Tirtayasa, S. A. (2023). Meningkatkan Literasi Lingkungan Pada Konsep Perubahan Lingkungan untuk Kelas X SMA. *Jurnal Pendidikan Dan Pembelajaran Biologi*, *01*(02), 50–63. https://ejournal.unma.ac.id/index.php/bp/

Rumaysa, N. A., & Dalimunthe, M. (2025). Pengembangan Modul Berbasis Sets (Science , Environment , Technology , And Society) Berbantuan Quick Response Code (Qr-Code) Pada Materi Hidrokarbon Kelas Xi Sma / Ma. *Panthera : Jurnal Ilmiah Pendidikan Sains Dan Terapan*, *5*(3), 405–419. https://doi.org/10.36312/panthera.v5i3.457

Saputra, A. D., Irfan, M., Yusup, M., & Khakim, N. (2026). Impact of Tropical Climate Anomalies on Land Cover Changes in Sumatra ' s Peatlands , Indonesia. *Sustainability*, *18*(919), 1–27. https://doi.org/10.3390/su18020919

Shiraishi, T., Hirata, R., Hayashi, M., & Hirano, T. (2023). Carbon dioxide emissions through land use change , fire , and oxidative peat decomposition in Borneo. *Scientific Reports*, 1–12. https://doi.org/10.1038/s41598-023-40333-z

Suarmita, S., Suarman, S., & Gusnardi, G. (2025). Development of Multimedia-Based Interactive Module Teaching Materials to Increase Learning Independence Learners. *Journal of Education and Learning Research*, *2*(2), 141–151. https://doi.org/10.62208/jelr.2.2.p.141-151

Sugiyono, S. (2013). Metode Penelitian Kuantitatif Kualitatif dan R&D. In Alfabeta (Ed.), *Alfabeta* (13th ed., Vol. 8, Number 2). Alfabeta. https://digilib.unigres.ac.id/?p=show_detail&id=43

Supriyadi, S., Rusilowati, A., Linuwih, S., Binadja, A., & Salawane, C. (2019). Science environment technology and society approach learning to improve natural disaster mitigation literacy. *Journal of Physics: Conference Series*, *1387*, 1–6. https://doi.org/10.1088/1742-6596/1387/1/012119

Zahrah, T., Idramsa, I., & Lubis, K. (2025). Pengembangan E-Modul Berbasis SETS (Science , Environment , Technology , and Society) Pada Materi Inovasi Teknologi Biologi untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas X SMA / MA.

Bioscientist: Jurnal Ilmiah Biologi, *13*(4), 3254–3263.

Zuhlia, S. (2026). Pengembangan E-Book Berbasis Sets Materi Sistem Imun Untuk Melatihkan Keterampilan Literasi Sains Pada Peserta Didik. *Bioedu: Berkala Ilmiah Pendidikan Biologi*, *15*(1), 21–30. https://doi.org/10.26740/bioedu.v15n1.p21-30

.

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