



DEVELOPMENT OF A SCIENCE E-MODULE INTEGRATING THE LOCAL POTENTIAL OF BANTIMURUNG NATIONAL PARK

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Abstract

Science education in elementary schools requires teaching materials that not only present conceptual knowledge but also connect learning to students' immediate environment. This study aimed to develop a science e-module that integrates the local potential of Bantimurung National Park as contextual teaching material to support science learning in accordance with the Merdeka Curriculum. The research employed a Research and Development (R&D) approach using the 4-D model (define, design, develop, disseminate), implemented through the limited trial stage. Participants included subject matter experts, media experts, classroom teachers, and 15 fifth-grade students. Data were collected through interviews and questionnaires and analyzed descriptively by converting quantitative scores into qualitative categories. The results indicate that the developed e-module was rated "very feasible" by experts and perceived as practical and comprehensible by teachers and students. The integration of locally based conservation themes enhances the contextual relevance and meaningfulness of science learning. Thus, the e-module based on the local potential of Bantimurung National Park is suitable for use as a teaching resource in elementary school science education.

Keywords:

Science e-module, local potential, Merdeka Curriculum, science learning, elementary school

INTRODUCTION

Advances in information and communication technology in the 21st century have significantly transformed educational practices. There has been a clear shift from reliance on printed teaching materials toward the adoption of digital resources that are more dynamic, interactive, and accessible. This transition demands that educators not only master subject matter but also develop the competence to design technology based teaching materials that foster effective and meaningful learning processes (Munir, 2017). In fact, digital competence is increasingly recognized as a multidimensional skill encompassing pedagogical knowledge, technological proficiency, and instructional design ability essential for creating meaningful digital learning environments (OECD, 2023; Rakisheva & Witt, 2023). Well integrated digital resources can enhance access, interaction, and equity in education, ultimately improving learning quality when supported by appropriate pedagogical strategies (OECD, 2023). The post pandemic era has further accelerated the need for digital adaptation in education, highlighting persistent gaps in teachers' digital readiness, especially in remote and rural areas (UNESCO, 2023; Kemdikbudristek, 2023). Therefore, strengthening teachers' digital competencies through systematic professional development and institutional support is crucial for the successful integration of technology into classroom practice (Saragih et al., 2025; Spante et al., 2023).

Interactive digital media has also been shown to improve elementary students' ecoliteracy through more engaging environmental learning experiences (Ivanka & Nurani, 2025). In this context, the development of contextual digital teaching materials such as e-modules that integrate local potential emerges as a relevant strategy to promote meaningful and context-based science learning in elementary schools. These conditions have prompted the Indonesian government to implement the Merdeka Curriculum as an effort to reform the learning system in schools. This curriculum emphasizes learner-centered learning, provides flexibility for educators in designing learning, and encourages the use of contextual learning resources. In the context of Natural Sciences (IPA) learning, the Merdeka Curriculum emphasizes the importance of learning experiences that are real, exploratory, and relevant to the students' living environment (Kemendikbudristek, 2022). Consistent with this trend, research focusing on elementary science education indicates that the use of technology can increase student engagement and support independent learning (Pratama et al., 2021). These findings are aligned with international studies

demonstrating that interactive digital teaching materials in science learning not only boost engagement but also deepen conceptual understanding through contextual learning experiences (Huang et al., 2022).

At the elementary school level, science learning is not only directed at mastering scientific concepts, but also at forming scientific attitudes and concern for the environment. Science is directly related to natural phenomena and the interaction between humans and their environment. Therefore, science learning should ideally be developed by linking the subject matter to the real conditions encountered by students in their daily lives. Learning that is linked to the real environmental context helps students understand science concepts in a more meaningful way (Anderson & Krathwohl, 2010). However, the practice of science learning in elementary schools does not yet fully reflect these ideal conditions. Preliminary study results at SD Negeri 17 Langnga-Langnga show that science learning still relies on textbooks as the main source of learning. Teachers face limitations in developing innovative digital teaching materials and have not optimally utilized the surrounding environment as a learning resource. These findings are in line with the findings of (Putri & Nugroho, 2019), which reveal that the limitations of context-based digital teaching materials are still an obstacle in the implementation of science learning in elementary schools.

In addition to teaching material issues, the interview results also indicate that students' concern for the environment is still relatively low. Behaviors that do not maintain school environmental cleanliness are still often found, reflecting that science learning has not fully integrated environmental education in a meaningful way. In fact, concern for the environment is an important part of character education that needs to be integrated into science learning from elementary school onwards (Khanafiyah, & Yulianti, 2013). Recent research also shows that science learning that is not linked to local environmental issues tends to be less effective in fostering environmental awareness among students (Rahmawati, et al., 2021). Conceptually, the Merdeka Curriculum directs science learning to be contextual, flexible, and utilize local potential as an authentic learning resource (Kemendikbudristek, 2022). Through this approach, students are expected to be able to relate science concepts to environmental phenomena around them. Contextual environmental-based learning modules have also been reported to support meaningful science learning experiences in elementary education (Budiono et al., 2024). However, in practice, the local potential available in the school environment has not been optimally utilized in learning.

The teaching materials used are still general in nature and do not describe the characteristics of the local environment, so the gap between the curriculum requirements and learning practices in the field is still clearly visible (Susanti & Lestari, 2020). One alternative to bridge this gap is the development of digital teaching materials in the form of science e-modules. Previous studies indicate that ESD-based e-modules can significantly enhance students' scientific literacy and sustainability understanding (Hanifah et al., 2025). E modules are designed as systematic and interactive electronic teaching materials that combine text, images, videos, animations, and exercises. These characteristics allow students to learn more independently and flexibly according to their learning needs. A number of studies report that the use of science e-modules can help teachers present material in a more contextual manner and improve the quality of learning (Yuliani & Fitriani., 2022). In order for the science e-module to be truly meaningful, its development needs to be tailored to the local potential of the area where the students are located.

Local potential can serve as an authentic learning context because it is closely related to the students' life experiences. Science learning based on local potential not only increases student engagement but also contributes to fostering environmental awareness from an early age (Barker, 2011; Suhartini, 2019). Recent studies emphasize the effectiveness of place-based education in strengthening students' connection to their environment and enhancing the relevance of science learning (Sobandi & Nurdin, 2022; Ardoin & Bowers, 2020). The local potential utilized in this study is the natural tourism of Bantimurung National Park. This area has a wealth of natural resources and various environmental phenomena that are relevant to elementary school science material, especially on the topic of the relationship between humans and the environment. In addition to functioning as a conservation area and natural tourism area, this area also faces a number of environmental problems, such as waste management, water pollution, and pressure on the ecosystem due to human activities. These phenomena can be used as a context for real and relevant environment-based science learning (Utami et al., 2023).

The integration of the local potential of Bantimurung National Park's nature tourism into the science e-module is expected to help students understand science material more concretely. Learning that links science concepts to the surrounding environmental conditions can foster students' awareness of the importance of preserving natural resources. This view is in line with (Tsuma, 1998), which emphasizes that environmental education plays an important role in increasing public awareness of the value of natural resources and the need for sustainable environmental management. Based on this description, this study aims to develop a science e-module based on the local potential of Bantimurung National Park's natural tourism that is in line with the Merdeka Curriculum as teaching material to support science learning in elementary schools.

The novelty of this research lies in the utilization of conservation areas as the main context for the development of elementary school science e-modules. Unlike previous studies, which generally integrate local potential in general, this study specifically uses Bantimurung National Park as a contextual learning resource for material on the relationship between humans and the environment. The use of conservation areas as learning contexts has been shown to improve ecological literacy and pro-environmental attitudes among young learners (Jamilah & Hidayat, 2021). In addition to functioning as a conservation area and natural tourism area, this area also faces a number of environmental problems, such as waste management, water pollution, and pressure on the ecosystem due to human activities. These phenomena can be used as a context for real and relevant environment-based science learning (Utami et al., 2023).

METHOD

This study is a Research and Development (R&D) study that aims to develop a science e-module based on the local potential of Bantimurung National Park's natural attractions. The development model used is the 4-D model (define, design, develop, and disseminate), which has been widely applied in the design of digital learning materials due to its systematic and iterative nature (Branch, 2020). However, this study is limited to a limited trial phase, without conducting extensive field trials. The define stage was carried out to identify science learning needs in elementary schools through an analysis of learning problems, student characteristics, learning tasks and materials, concepts, and learning objectives in the subject of Man and the Environment. Data was obtained through interviews with fifth-grade teachers at SD Negeri 17 Langnga-Langnga.

The design stage focused on the design of the science e-module, including the preparation of research instruments, the determination of the format and software, and the preparation of the initial draft of the e-module. The use of Flip PDF Professional was selected for its ability to produce interactive and accessible digital modules, which aligns with current trends in e-module development for elementary science (Akbar & Anggraeni, 2023). The draft developed included the main components of user instructions, learning activities, supporting media (images, animations, and videos), summaries, evaluations, glossaries, and reference lists. The development stage aimed to produce a usable e-module. The draft e-module was validated by subject matter experts, media experts, and classroom teachers. Input from the validators was used to revise the product. The revised e-module was then tested through limited trials to obtain data on its feasibility, practicality, and readability.

The dissemination stage is carried out on a limited basis through the distribution of e-modules to target schools and the publication of research results in the form of scientific articles and intellectual property rights (IPR) submissions. The limited pilot test subjects consisted of 15 fifth-grade students from SD Negeri 39 Tamalalang who were selected based on high, medium, and low achievement categories. Data collection was conducted using interviews and questionnaires. Interviews were used to obtain initial data on learning needs, while questionnaires were used to assess the feasibility of the e-module through expert validation, practicality according to teachers, and readability according to students. All research instruments were validated by experts before use.

Qualitative data were analyzed descriptively, while quantitative data were analyzed by converting questionnaire scores into qualitative categories to determine the level of feasibility, practicality, and readability of the science e-module. The quantitative data from the assessment was

analyzed by converting the questionnaire scores into qualitative categories to determine the level of suitability of the e-module. The score conversion was based on the criteria proposed Widyoko (2017), as presented in Table 1.

Table 1. Validation Results

Formula	Mean Score	Classification
$X > \bar{X}_i + 1,8 \times s_{bi}$	$> 4,2$	Very feasible
$\bar{X}_i + 0,6 \times s_{bi} < X \leq \bar{X}_i + 1,8 \times s_{bi}$	$> 3,4 - 4,2$	Feasible
$\bar{X}_i - 0,6 \times s_{bi} < X \leq \bar{X}_i + 0,6 \times s_{bi}$	$> 2,6 - 3,4$	Moderately feasible
$\bar{X}_i - 1,8 \times s_{bi} < X \leq \bar{X}_i - 0,6 \times s_{bi}$	$> 1,8 - 2,6$	Not feasible
$X \leq \bar{X}_i - 1,8 \times s_{bi}$	$\leq 1,8$	Very not feasible

Explanation:

$\frac{1}{2}$ (ideal maximum score + ideal minimum score) = (\bar{X}_i) (ideal average) $\frac{1}{6}$ (ideal maximum score – ideal minimum score) = S_{bi} (ideal standard deviation) Score obtained = X

FINDINGS AND DISCUSSION

Findings

This study produced a science e-module based on the local potential of Bantimurung National Park's natural attractions, developed using the 4-D model up to the define, design, and develop stages, with the disseminate stage carried out on a limited basis in target schools. The results of the needs analysis showed that science learning was supported by adequate learning tools, but was still dominated by the use of textbooks and did not optimally utilize facilities and the potential of the surrounding environment as learning resources. This condition indicates the need for additional contextual teaching materials. An analysis of student characteristics shows that students are relatively capable of answering questions based on memorization, but still experience difficulties with questions that require reasoning. The results of a needs survey involving 45 students show that all students need the science e-module as a learning resource. Most students expect e-modules to be equipped with visual media, easily accessible independently, and usable via smartphone devices, both online and offline.

Task and concept analysis was carried out by examining core competencies, basic competencies, and competency achievement indicators in the Human and Environment material. The results of this analysis formed the basis for the development of learning objectives and the structure of the e-module material. At the design stage, the e-module was developed using Flip PDF Professional with the main components including instructions for use, an introduction to the local potential of Bantimurung National Park, learning activities, student worksheets, interactive quizzes, summaries, evaluations, a glossary, and a list of references. Each learning activity is designed to link science concepts with real environmental phenomena. The following is a preview of the science e-module based on the local potential of Bantimurung National Park's natural tourism.



Figure 1. Cover Display



Figure 2. Home Page Display

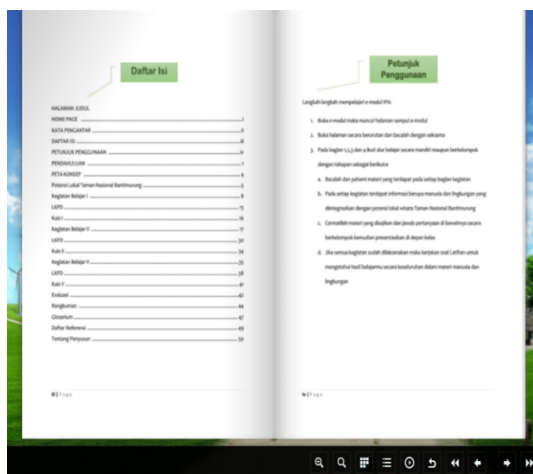


Figure 3. Instructions Page Display

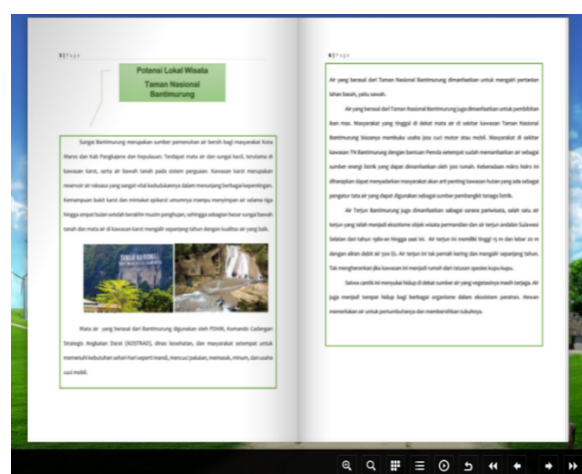


Figure 4. Local Potential Display

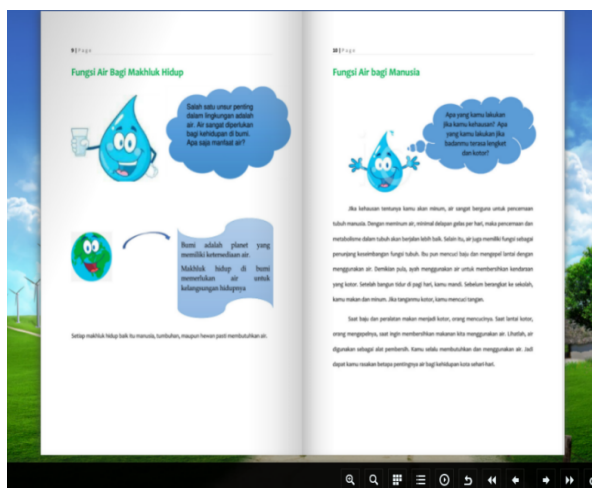


Figure 5. Learning Activities Display

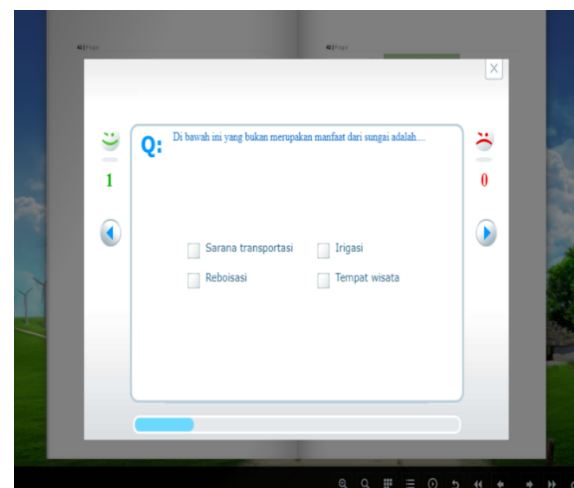


Figure 6. Quiz Display

The development stage produced the final version of the science e-module integrating the local tourism potential of Bantimurung National Park. Product feasibility was evaluated through expert validation and practicality assessment by teachers, followed by limited and field trials.

Material Expert Validation

Material validation was conducted by one subject-matter expert using a 60-item instrument covering four main aspects: content feasibility, language, presentation, and module characteristics. Each item was rated on a 5-point Likert scale. The detailed results are presented in Table 2.

Table 2. Material Expert Validation Results with Specific Indicators

No	Main Aspect	Specific Indicators (with Sample Items)	Total Score	Mean Score	Category
1.	Content Feasibility	<ul style="list-style-type: none"> • Alignment with Core Competencies Learning Outcomes and Learning Objectives • Material accuracy and scientific validity • Material relevance and contextualization • Material completeness for Grade 5 	68	4.25	Very Feasible
2.	Language	<ul style="list-style-type: none"> • Language readability and clarity • Compliance with Indonesian language rules • Consistency of terminology usage 	52	4.33	Very Feasible
3.	Presentation	<ul style="list-style-type: none"> • Systematic presentation flow • Completeness of learning components • Learning interactivity 	99	4.30	Very Feasible
4.	Module Characteristics	<ul style="list-style-type: none"> • Integration with local potential • Development of critical thinking skills 	32	4.00	Feasible
	Overall Mean		251	4.2	Very Feasible

The e-module achieved an overall mean score of 4.2 (84%) categorized as "Very Feasible." The expert concluded that the module meets theoretical and instructional requirements for elementary science learning. Suggestions included refining competency indicators and simplifying user instructions.

Media Expert Validation

Media validation was conducted by one media expert using a 60-item instrument evaluating three main aspects: graphical design, technical quality and usability, and module characteristics. Detailed results are shown in Table 3.

Table 3. Media Expert Validation Results with Specific Indicators

No	Main Aspect	Specific Indicators (with Sample Items)	Total Score	Mean Score	Category
1.	Graphical Design	<ul style="list-style-type: none"> • Layout and placement consistency • Color harmony and display • Typography and font selection • Cover page attractiveness 	118	4.2	Very Feasible
2.	Technical Quality & Usability	<ul style="list-style-type: none"> • Navigation consistency and ease • Software stability and error-free operation • Program control and user-friendliness • Usage clarity and effectiveness 	96	4.8	Very Feasible
3.	Module Characteristics	<ul style="list-style-type: none"> • Complete e-module framework • Electronic media elements • Flip PDF Professional features 	60	5.0	Very Feasible
	Overall Mean		274	4.6	Very Feasible

The e-module obtained an overall mean score of 4.6 (92%), categorized as "Very Feasible." The media expert noted strong technical performance and visual quality, recommending improvements to the concept map layout and quiz items.

Teacher Practicality Assessment

Three elementary school teachers evaluated the module's practicality using a structured instrument. Results are presented in Table 4.

Table 4. Teacher Practicality Assessment Results

No	Aspect	Specific Indicators Evaluated	Teacher 1	Teacher 2	Teacher 3	Mean	Category
1.	Presentation	<ul style="list-style-type: none"> • Integration with lesson plans • Time allocation suitability • Component completeness 	98	103	105	4.1	Very Feasible
2.	Technical Quality & Usage	<ul style="list-style-type: none"> • Ease of access and installation • Operational stability • Device compatibility 	77	83	85	4.1	Very Feasible
3.	Language	<ul style="list-style-type: none"> • Instruction clarity • Language appropriateness for students 	48	48	48	4.0	Feasible
4.	Overall Mean per Teacher		4.0	4.1	4.2	4.1	Feasible-Very Feasible

The module received an average practicality score of 4.1 (82%). Teachers reported it was easy to implement for the "Humans and Environment" topic, suggesting increased font size and offline accessibility.

Student Readability Test

A limited readability test with 15 fifth-grade students evaluated 10 specific indicators using a 5-point Likert scale. Results are shown in Table 5.

Table 5. Student Readability Test Results by Specific Indicator

No.	Readability Indicator	Total Score	Mean Score	Category
1	Language clarity and understandability	63	4.1	Very Feasible
2	Image and illustration comprehensibility	65	4.3	Very Feasible
3	Learning activity instruction clarity	64	4.2	Very Feasible
4	Visual design attractiveness	65	4.3	Very Feasible
5	Page navigation ease	65	4.3	Very Feasible
6	Material relevance to daily life	64	4.2	Very Feasible
7	Local content (Bantimurung) usefulness	65	4.3	Very Feasible
8	Ease of independent use	64	4.2	Very Feasible
9	Difficulty level appropriateness	64	4.2	Very Feasible
10	Learning motivation enhancement	65	4.3	Very Feasible
Overall Mean			4.24	Very Feasible

The readability test yielded an overall mean score of 4.24, categorized as "Very Feasible," indicating students found the module clear, understandable, and engaging. The dissemination stage

was carried out in a limited manner through the distribution of e-modules in the form of offline and online files to target schools, as well as through the publication of scientific articles and the submission of Intellectual Property Rights (IPR).

Discussion

The findings of this study indicate that the science e-module developed by integrating the local potential of Bantimurung National Park demonstrates a high level of feasibility, practicality, and comprehensibility for use in elementary school science learning. These results also address the research problem concerning the limited availability of contextual digital teaching materials and the underutilization of local environmental potential as a source of science learning. The developed e-module helps bridge the gap between the curriculum's emphasis on contextual learning and classroom practices that continue to rely predominantly on general textbooks. The high feasibility and practicality levels can be attributed to the presentation of relevant environmental content, systematically structured learning activities, and interactive digital features that enhance student engagement and understanding. Recent studies support that e-modules with local and environmental content not only improve conceptual understanding but also foster critical thinking and environmental attitudes (Fauzi & Suryani, 2022; Chen et al., 2023).

This study is consistent with and extends previous research on context-based learning and local potential integration. The high feasibility rating supports earlier findings that e-modules can improve the quality of science learning by providing interactive and structured materials (Yuliani & Fitriani, 2022). The emphasis on local conservation themes is also consistent with studies showing that environmental education integrated into science learning can enhance students' environmental awareness (Khanafiyah & Yulianti, 2013; Barker, 2011). Similar findings were reported by Wulandari et al. (2025), who demonstrated that ESD-based electronic modules improve students' critical thinking skills and environmental awareness. However, this study offers a distinct contribution by specifically utilizing formal conservation areas namely national parks as the primary authentic learning context, rather than relying solely on general local wisdom. This approach differs from the study by Susanti and Lestari (2020), which examined local potential in a broader sense, by offering a more structured ecological and conservation-based framework aligned with national educational and environmental objectives. The novelty of this research lies in the systematic integration of national park-based conservation areas as the central contextual framework in the development of digital science teaching materials for elementary schools.

Theoretically, this study contributes to the field of educational technology and curriculum development by demonstrating a concrete model for integrating the principles of the Merdeka Curriculum into digital learning resources. The study operationalizes the concept of contextual learning by placing ecologically significant locations at the core of material design, learning activities, and assessment, thereby reinforcing the pedagogical principle that learning becomes more meaningful when linked to authentic contexts familiar to students (Anderson & Krathwohl, 2010). Furthermore, this study enriches the discourse on Education for Sustainable Development (ESD) at the elementary level by providing a concrete example of how conservation education can be systematically integrated into science subjects through digital media. These findings also support the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the integration of technological, pedagogical, and content knowledge in designing effective digital teaching materials (Mishra & Koehler, 2006). Teacher digital competence within the TPACK framework plays a critical role in supporting effective integration of technology into elementary instruction (Siregar et al., 2024).

Practically, this e-module provides an alternative learning resource that can be readily used by elementary school teachers with minimal adaptation. Teachers can employ it as the primary teaching material for the topic "Humans and the Environment" or as a supplementary enrichment resource. The smartphone-accessible design, available both online and offline, helps address accessibility constraints across diverse school contexts. To optimize its use, teachers are encouraged to facilitate discussions that connect the module content with students' surrounding environments, fostering stronger personal engagement. Schools and local education authorities may also consider

disseminating similar e-modules based on other local conservation areas to establish a repository of contextual digital learning resources.

Although the results are promising, this study has several limitations. The development and testing processes were conducted on a limited scale, involving only one school and 15 students in the readability testing phase. The effectiveness of the e-module in improving learning outcomes, critical thinking skills, and long-term environmental attitudes has not yet been comprehensively examined. Therefore, future research is recommended to conduct large-scale field trials with control groups to empirically examine the effects of the e-module on cognitive and affective learning outcomes. In addition, longitudinal studies are needed to assess its sustained impact on students' environmental awareness. Future studies may also develop similar e-modules for different grade levels and science topics, as well as across diverse geographical contexts with varying local potential.

Overall, this study demonstrates that the development of digital teaching materials grounded in local conservation contexts represents a strategic approach to enhancing the relevance of elementary science learning. The resulting e-module functions not only as a digital learning medium but also as a pedagogical tool that integrates curriculum content, local potential, and environmental education. By utilizing Bantimurung National Park as the central learning context, this study offers a replicable model for developing contextual digital teaching materials that can make science learning more relevant, meaningful, and impactful in fostering environmental awareness from an early age.

CONCLUSION

This study shows that the development of a science e-module based on the local potential of Bantimurung National Park's natural attractions is able to address the problems of science learning in elementary schools, which have been dominated by the use of general teaching materials and have not taken advantage of the surrounding environment as a source of learning. In line with the demands of the Merdeka Curriculum, which emphasizes contextual and student-centered learning, the developed e-module has been proven to be feasible, practical, and easy to understand based on expert validation, teacher assessment, and student readability tests.

The integration of conservation areas as the main context of learning provides a more authentic learning experience, thereby helping students understand science concepts, especially on the subject of human and environmental relations, in a more concrete and relevant manner. These findings confirm that local potential can not only serve as a complement to learning, but also as the main context that strengthens the meaning of learning and supports the formation of environmental awareness from an early age.

However, this study still has limitations, particularly in the scope of the trial, which was conducted on a limited basis. Therefore, further research is recommended to test the effectiveness of this science e-module on a broader scale and to assess its impact on improving student learning outcomes, critical thinking skills, and environmental awareness. In addition, the development of e-modules based on local potential in other science subjects or at different levels of education also has the potential to be carried out as an effort to enrich digital teaching materials that are contextual and relevant to regional characteristics. Future studies should consider adapting similar contextual e-modules to diverse geographical and cultural settings to promote inclusive and locally relevant science education (Nugroho & Putri, 2024).

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REFERENCES

- Akbar, M. F., & Anggraeni, F. D. (2023). Development of interactive e-module using Flip PDF Professional for elementary school science. *International Journal of Interactive Mobile Technologies*, 17 (6), 120–134.
- Anderson, L. W., & Krathwohl, D. R. (2010). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Pearson Education.
- Ardoin, N. M., & Bowers, A. W. (2020). Early childhood environmental education: A systematic review of the literature. *Environmental Education Research*, 26b(9), 1201–1224.
- Barker, D. (2011). Environmental education for sustainability: Curriculum and practice. *Journal of Environmental Education*, 41 (1), 55–67.
- Budiono, H., Khoirunnisa, & Chan, F. (2024). Development of environmental education teaching module using discovery learning model for elementary students. *Jurnal PAJAR (Pendidikan dan Pengajaran)*, 8(4).
- Branch, R. M. (2020). *Instructional design: The ADDIE approach* (2nd ed.). Springer.
- Chen, J., Wang, L., & Zhang, Q. (2023). Effects of digital game-based learning on environmental awareness in primary schools. *Computers & Education*, 198, 104758.
- Fauzi, A., & Suryani, N. (2022). E-module development with local content to improve critical thinking skills in elementary school. *Journal of Education and Learning*, 16 (3), 345–356.
- Huang, C., Chen, C., & Chou, Y. (2022). Effects of digital learning materials on students' engagement and understanding in science learning. *Computers & Education*, 182, 104463.
- Hanifah, W., Rochintaniawati, D., & Agustin, R. R. (2025). Enhancing students' scientific literacy through ESD-based e-modules on low carbon energy topic. *Pedagogia: Jurnal Ilmiah Pendidikan*, 17(1), 113–125.
- Jamilah, S., & Hidayat, T. (2021). Pemanfaatan kawasan konservasi sebagai sumber belajar IPA di sekolah dasar. *Jurnal Basicedu*, 5 (4), 2240–2251.
- Ivanka, W., & Nurani, D. C. (2025). The effect of digital media on elementary school students' ecoliteracy development. *EduStream: Jurnal Pendidikan Dasar*, 9 (1), 105–112.
- Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. (2022). *Panduan pembelajaran dan asesmen Kurikulum Merdeka*. Kemendikbudristek.
- Khanafiyah, S., & Yulianti, D. (2013). Model pembelajaran IPA berbasis pendidikan lingkungan untuk menumbuhkan sikap peduli lingkungan. *Jurnal Pendidikan IPA Indonesia*, 2 (1), 35–42.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108 (6), 1017–1054.
- Munir. (2017). *Pembelajaran Digital*. Alfabeta.
- Nugroho, A., & Putri, R. (2024). Adaptation of contextual e-modules for diverse geographical settings in Indonesian elementary schools. *Journal of Science Education Research*, 18 (1), 45–60.
- OECD. (2023a). *OECD Digital Education Outlook 2023*. OECD Publishing.
- OECD. (2023b). *Shaping Digital Education*. OECD Publishing.
- Pratama, R. A., Saputra, H., & Lestari, S. (2021). Pengembangan e-module berbasis multimedia interaktif pada pembelajaran IPA sekolah dasar. *Jurnal Ilmiah Pendidikan IPA*, 8 (3), 201–210.
- Putri, A. R., & Nugroho, A. A. (2019). Analisis kebutuhan bahan ajar digital berbasis konteks lokal pada pembelajaran IPA SD. *Jurnal Basicedu*, 3 (2), 524–532.
- Rahmawati, Y., Ridwan, A., & Suryani, I. (2021). Pendidikan lingkungan dan pembangunan berkelanjutan. *Jurnal Pendidikan Lingkungan Dan Pembangunan Berkelanjutan*, 22 (1), 1–10.
- Saragih, L. S., Darma, J., & Siregar, S. D. N. (2025). *Journal of Education: Journal of research and library studies in education, teaching, and learning*. *Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran, Dan Pembelajaran*, 11 (1), 226–236.
- Siregar, V. V., Rajab, Hermansyah, Ardinal, E., Hidayatullah, R., & Alimudin, N. (2024). Analyzing the influence of digital literacy and pedagogical knowledge on TPACK in elementary school

- teachers. *Jurnal Ilmiah Sekolah Dasar*, 8(3), 476–486.
- Sobandi, A., & Nurdin, E. A. (2022). Integration of local wisdom in science learning: A systematic review. *Jurnal Pendidikan IPA Indonesia*, 11 (1), 145–156.
- Spante, M., Hashemi, S. S., & Lundin, M. (2023). Digital competence and teacher professional development in post-pandemic education. *Journal of Digital Learning in Teacher Education*, 39 (2), 78–92.
- Susanti, E., & Lestari, P. (2020). Pembelajaran IPA berbasis potensi lokal sebagai upaya penguatan karakter peduli lingkungan. *Jurnal Pendidikan Dasar Nusantara*, 6 (1), 65–74.
- Tsuma, C. K. (1998). Environmental education and sustainability. *International Journal of Environmental Education*, 14 (2), 140–149.
- UNESCO. (2023). Technology in education: A tool on whose terms? UNESCO Global Education Monitoring Report.
- Utami, N. P., Hasanah, U., & Kurniawan, D. (2023). Pemanfaatan kawasan wisata alam sebagai sumber belajar IPA sekolah dasar. *Jurnal Pendidikan IPA Indonesia*, 12 (2), 210–221.
- Witt, A., & Rakisheva, A. (2023). Digital competence frameworks in teacher education: A literature review. *Issues and Trends in Learning Technologies*, 11 (1).
- Wulandari, S., Suwondo, S., & Husna, R. A. (2025). Implementation of an education for sustainable development (ESD)-based electronic module to improve critical thinking skills and environmental awareness among students. *Journal of Educational Sciences*, 9(6), 5192–5205.
- Yuliani, S., & Fitriani, E. (2022). Pengembangan e-module IPA berbasis lingkungan untuk siswa sekolah dasar. *Jurnal Inovasi Pendidikan IPA*, 8 (1), 78–88.