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Development of *Ekoterin* E-Modules to Improve Learning Outcomes of Fifth Grade Elementary School Students

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Abstract. The low achievement of Indonesian students in science and numeracy, as reflected in the 2022 PISA results, highlights limited innovation and weak integration of numeracy in elementary science learning. Classroom observations at SDN 2 and SDN 1 Kalipucangwetan further revealed conventional, teacher-centered learning with minimal use of digital media. This study aimed to develop and evaluate the effectiveness of the *ekoterin* e-module an ecosystem-based digital learning module integrated with numeracy to improve fifth grade students' learning outcomes in the IPAS subject. Using the research and development (R&D) method with the ADDIE model (analysis, design, development, implementation, and evaluation), data were collected through interviews, observations, questionnaires, and pretest–posttest assessments. The e-module was designed using canva for website, converted into an android application, and equipped with interactive multimedia such as videos, games, and quizzes. Expert validation yielded an average feasibility score of 94.6% ("very feasible"), while teacher and student practicality tests scored 95.58% ("very practical"). Effectiveness testing, analyzed using a quasi-experimental design, showed a significant difference ($p < 0.001$) between the experimental group (mean = 81.71; N-Gain = 0.56) and the control group (mean = 72.56; N-Gain = 0.36). These findings indicate that the *ekoterin* e-module is valid, practical, and effective in improving students' IPAS learning outcomes, particularly in understanding ecosystem concepts and integrating numeracy in science learning.
Keywords: *Ekoterin* e-module, science, numeracy, ecosystem, learning outcomes

Introduction

Education plays a strategic role in shaping and developing society (Hussen et al., 2024) and strengthening the nation's cultural identity (Santoso et al., 2023). More than just a means of individual development, education plays a crucial role in shaping noble character and producing a generation that is knowledgeable, skilled, and collaborative in diversity (Mayudin & Rahmi, 2024;Gusteti & Neviyarni, 2022). This is crucial in facing increasingly complex global competition (Anjani et al., 2023; Cahya & Bektiningsih, 2024). In accordance with the objectives of the national education system, education is expected to shape individuals who are faithful, pious, have noble character, are capable, creative, and responsible (Depdiknas, 2003).

In response to global demands and challenges in national education, the independent curriculum was launched as a policy that provides room for differentiation and flexibility in curriculum development according to student characteristics (Anggraena et al., 2022; Alimuddin, 2023; Warsidah et al., 2022). This curriculum aims to realize the *pancasila* student profile, reflecting the ideal Indonesian student with global competence and strong character (Subekti & Nuraeni, 2024; Satria et al., 2022). The independent curriculum's focus on in-depth, contextual, and student-centered learning opens up opportunities for strengthening literacy, numeracy, and character (Nurfadillah et al., 2024; Zamjani et al., 2024; Martatiyana et al., 2023).

Despite this, the quality of Indonesian education still faces serious challenges, particularly in mathematics and science literacy. The 2018 PISA survey showed that Indonesia's mathematics and science literacy scores were still below the OECD average, at 379 and 389, respectively, compared to an average of 487 and 489, placing Indonesia 72nd out of 78 countries (OECD, 2019). PISA 2022 recorded a slight improvement in ranking, but numeracy and science scores remained low (366 and 383), and have not yet reached the international average (OECD, 2023; Pidianti et al., 2024; Febriana et al., 2024). This stagnation is caused by several factors, including a lack of learning innovation, low understanding of numeracy, and minimal use of technology in the learning process (Widiasri et al., 2024).

The 2013 curriculum (K13) previously emphasized a balance between attitudes, knowledge, and skills through a thematic and scientific approach (Amiruddin et al., 2023; Lutfan et al., 2023). However, strengthening basic numeracy competencies, such as number sense, was not optimal (Fahlevi, 2022; Yayuk et al., 2023). Numeracy is the ability to access, use, interpret, and communicate information and mathematical ideas related to numbers in a particular context (Yustitia et al., 2021).The independent curriculum instead places numeracy as one of the key competencies in the graduate competency standards (SKL), which include reasoning and contextual problem-solving (Kemendikbudristek, 2022; Saleh et al., 2022). In its implementation, the minimum competency assessment (AKM) serves as an instrument for mapping students' numeracy abilities (Meliyanti et al., 2021; Dewayani et al., 2021), which is strengthened through efforts to establish a numeracy culture in schools (Muliastrini, 2024; Iswara et al., 2022). The role of teachers is very important in designing, implementing, and evaluating numeracy learning (Bintoro et al., 2024), but various obstacles are still found such as limited teacher understanding, inadequate teaching tools, low innovation, and minimal training (Rusmiati et al., 2023; Alimuddin, 2023).

To support the implementation of the independent curriculum, a deep learning approach was introduced in 2024, emphasizing learning that is mindful, meaningful, and joyful (Deng et al., 2024; Neyshabur et al., 2017; Aryanto et al., 2025). This approach aligns well with numeracy learning, as it fosters connections between learning experiences and student understanding (Chen et al., 2023; Fullan et al., 2018). In the natural and social sciences (IPAS) subject, which integrates science and social studies (Surul & Septiliana, 2023), learning is designed to promote a holistic and contextual understanding of phenomena (Kemendikbudristek, 2024; Mahmudah et al., 2025), while also developing students’ process skills, scientific attitudes, and social awareness (Sulikah et al., 2020; Aulia et al., 2023 & Fakhriyah et al., 2025).

Ideally, science learning should be active, contextual, ICT-based, and able to integrate numeracy (Jati et al., 2020; Anggraena et al., 2022). Numeracy as a cross-disciplinary competency (Goos et al., 2015) can be developed in science subjects through activities such as data analysis, graph interpretation, measurement, and quantitative modeling that are appropriate to the context of the material (Wijaya & Dewayani, 2021; Putri et al., 2024). Ecosystem is defined as the basic functional unit of ecology that includes organisms and their environment (Odum, 1996; Anggraini & Asante, 2024). In the topic of ecosystems, numeracy integration can be applied in analyzing population data, comparing organism sizes, and predicting the impact of environmental change mathematically (Bennison, 2019; Goos & O'Sullivan, 2022). The numeracy developed covers cognitive levels ranging from understanding, application, to reasoning (Wijaya & Dewayani, 2021; Mullis & Martin, 2017), which can be facilitated through an interdisciplinary approach (Aini et al., 2025).

However, the author's observations at SDN 2 and SDN 1 Kalipucangwetan showed that science learning remained conventional, lecture-dominated, with minimal use of ICT, and a lack of numeracy integration. Consequently, student motivation was low, learning outcomes did not meet the minimum competency criteria (KKTP), and active participation was lacking. Teachers experienced difficulties designing digital teaching materials, while students demonstrated limitations in understanding concepts and summarizing the material. This situation highlights the urgency of developing innovative and contextual digital teaching materials to support 21st-century learning (Antari et al., 2023).

One potential solution is the use of interactive e-modules as an innovative form of teaching module in the independent curriculum. Teaching modules are systematic and engaging learning guides designed to achieve learning outcomes (Anggraini, 2023). Interactive e-modules are equipped with multimedia features such as text, images, videos, animations, and interactive quizzes that support independent learning and differentiation (Sari & Ridwan, 2020; Zamjani et al., 2024 & Delita et al., 2022). In the context of science and science, the development of e-modules based on *ekoterin* (ecosystem integrated numeracy) is an alternative approach that links understanding ecosystems with strengthening numeracy skills in a contextual and scientific manner. This approach has been shown to encourage students' critical and analytical thinking through numerical activities such as measurement, comparison, and data visualization (Handayani, 2023).

Learning outcomes are the primary indicator of learning success, encompassing changes in the cognitive, affective, and psychomotor domains (Krathwohl, 2002; Farokah & Winarso, 2021). In fifth-grade science instruction, the primary emphasis is on conceptual understanding and practical application of knowledge. Therefore, learning media that can effectively facilitate these three dimensions are necessary.

The ADDIE development model offers a structured framework for creating learning media, encompassing five key stages: analysis, design, development, implementation, and evaluation (Branch, 2009; Putri Weldami & Yogica, 2023). Applying this model helps ensure that the media developed such as numeracy-based science (IPAS) e-modules—are well-directed, valid, and effective.

Several studies support the effectiveness of numeracy and environmental-based e-modules. (Susanti & Sholihah, 2021) demonstrated that STEM-based e-modules on ecosystems improved students' scientific thinking skills. Nurhayati and Wibowo (2024) also demonstrated that integrating numeracy into science improved conceptual understanding and data processing. Rachman (2023) concluded that the use of the ADDIE model in e-module development positively impacted elementary school students' learning outcomes.

Based on prior theoretical and empirical studies, a conceptual framework was established indicating that the use of the *ekoterin*-based interactive e-module in science learning can enhance students' understanding of ecosystem concepts through visualizations, simulations, and contextual numeracy activities. Developed using the ADDIE model, the e-module is designed to be an effective and engaging learning tool aimed at improving student learning outcomes.

Methods

This study adopts the research and development (R&D) method as outlined by in (Taufik & Prasetyaningtyas, 2024), with the primary goal of producing and testing the effectiveness of an integrated numeracy ecosystem e-module (*ekoterin*). The development process follows the ADDIE model, chosen for its structured and flexible approach, which allows for ongoing evaluation and refinement at each stage (Zamsiswaya et al., 2024; Hanida et al., 2023 & Rusdi et al., 2022). The ADDIE model consists of five stages: analyze, design, develop, implement, and evaluate (Gustiani, 2019).

The data in this study were obtained from various sources, including students, teachers, media experts, subject matter experts, linguists, and the researchers themselves (Arikunto, 2017; Sidiq & Choiri, 2019). The data collected consisted of both qualitative data—such as interviews, observations, and documentation—and quantitative data in the form of questionnaires and pretest-posttest results (Creswell, 2014; Ibrahim, 2018).

Data collection techniques were conducted through tests and non-tests. Tests were used to measure student learning outcomes through pretests and posttests (Ibrahim, 2012; Rusdiana & Wulandari, 2022). Non-test techniques included interviews, observations, questionnaires, and documentation (Creswell, 2014). The research instruments used consisted of interview sheets for needs analysis, observation sheets for learning activities (Bogdan & Biklen, 2017), validation questionnaires, and user responses with a Likert scale (Hanida et al., 2023; Mawarni & Hendriyani, 2021), as well as pretests and posttests structured based on learning outcomes (CP) and learning objectives (TP).

The research procedure begins with the first stage, analysis. The analysis phase was conducted through interviews, observations, and documentation studies to identify the need for science teaching materials for ecosystems. This activity was conducted at SDN 2 Kalipucangwetan and SDN 1 Kalipucangwetan in Welahan District, Jepara Regency. Data from the analysis were used as a basis for designing teaching materials that were more contextual and tailored to student characteristics.

The next stage is designing an e-module that addresses the curriculum, learning outcomes, and the integration of numeracy elements (Rahmawati, 2024; Adeng et al., 2023). The e-module design was developed using the canva for website platform, and is structured around materials, educational videos, games, and assessments (Ninawati et al., 2021). The implementation of learning in this e-module adopts the problem-based learning (PBL) approach, which encourages students to actively identify and solve real-world problems related to the learning content (Seibert, 2021; Zhao et al., 2020 ; Uliyandari et al., 2021 & Saputra et al., 2019). Each element in the module is designed to encourage student engagement and support the achievement of the *pancasila* student's profile.

The next stage was development, which utilized the canva for website platform and various digital media. The product was validated by subject matter, media, language, and practitioner experts (Siburian et al., 2022; Taufik & Prasetyaningtyas, 2024) using a validation sheet. Based on the validation results, the module was then revised to improve its content, appearance, and interactivity.

The implementation phase involved both limited and field trials. In the limited trial, the practicality of the e-module was evaluated by its users—10 students from SDN 1 Kalipucangkulon and 2 teachers from SDN 1 Kalipucangkulon and SDN 2 Kalipucangwetan, Welahan District, Jepara Regency. The study employed a quasi-experimental design with a nonequivalent control group, where the experimental group was from SDN 2 Kalipucangwetan and the control group from SDN 1 Kalipucangwetan. The research design is presented as follows.

Table 1. Quasi-experimental design patterns

Group	Pretest	Treatment	Posttest
Experimental	O1	X (*ekoterin* e-module)	O2
Control	O3	Conventional Learning	O4

The final stage is evaluate, which evaluates the product's quality in terms of content feasibility, practicality of use, and effectiveness on student learning outcomes. The evaluation is based on the results of validation tests by experts, teacher and student responses to practicality, and the results of pretest and posttest data analysis using statistical tests and N-Gain calculations. This evaluation aims to ensure that the *ekoterin* e-module is not only feasible and practical to use, but also effective in simultaneously improving students' understanding of ecosystem material and their numeracy skills.

Validation tests were carried out to evaluate the feasibility of the *Ekoterin* e-module in terms of content, media, language, and usability. Assessments were conducted by education experts and practitioners using a 4-point Likert scale. The results served as the basis for product revisions prior to implementation (Sidiq & Choiri, 2019).

Table 2. E-Module validation criteria

Quantitative Score	Qualitative Score	Criteria
86.00– 100	A	Very Feasible
71.00 – 85.99	B	Feasible
56.00 – 70.99	C	Fairly Feasible
< 56.00	D	Less Feasible

(Source: Nurhadi in Sutrisni et al., 2022)

The practicality test aimed to determine the ease of use and convenience of the e-module according to teachers and students through a Likert-scale questionnaire. The data was used to assess the product's implementability in a real-world context (Mawarni & Hendriyani, 2021).

Table 3. Practicality criteria of e-modules

Practicality Criteria (%)	Category
81 - 100	Very Practical
61 - 80	Practical
41 - 60	Fairly Practical
21 - 40	Less Practical
0 - 20	Not Practical

(Source: Susanti & Sholihah, 2021)

An independent sample t-test was carried out to examine whether there were significant differences in learning outcomes between the experimental and control groups. The test was preceded by prerequisite analyses to ensure data normality and homogeneity.

Table 4. T-test value and interpretation

Sig. Value (p)	Interpretation
≤ 0.05	Significant difference exists
> 0.05	No significant difference

(Source: Sugiyono in Sarumaha, 2023).

The N-Gain test is applied to evaluate the effectiveness of e-modules in enhancing learning outcomes by measuring the improvement between students' pretest and posttest scores (Hake, 1999).

Table 5. Interpretation of the N-Gain index

N-Gain Score	Effectiveness Category
≥ 0.70	High
0.30 – 0.69	Medium
< 0.30	Low

(Source:Hake, 1999)

Results and Discussion

Analyze Stage

The needs analysis stage is a crucial initial step in the development of the STEM) e-module. Its primary objective is to identify the current state of science and science learning in fifth grade and to understand the needs of teachers and students for innovative, relevant, and numeracy-integrated teaching materials. The analysis was conducted through field studies (interviews and observations) and literature review.

Interviews were conducted in person and semi-structured with fifth-grade teachers at SDN 1 and SDN 2 Kalipucangwetan, Welahan District, Jepara Regency. The interviews showed that science learning is still dominated by monotonous lecture methods, with limited use of printed materials and minimal use of digital technology. Teachers expressed difficulties in designing digital teaching materials that integrate numeracy, while students experience obstacles in understanding abstract concepts such as ecosystems. Teachers suggested the need for digital-based e-modules that are engaging, interactive, and include contextual numeracy exercises to support independent learning and improve learning outcomes.

Table 6. Summary of fifth grade teacher interview

No	Fifth Grade Teacher	Interview Summary
1	SDN 1 Kalipucangwetan	IPAS learning still focuses on textbooks and worksheets, with limited practicum activities and no integration of numeracy. About 48% of students have not met the minimum mastery criteria, and learning motivation is low. Teachers face difficulties creating simple digital teaching materials, despite efforts through consultation and reference searches. Teachers expect digital materials to be engaging and easy to understand.
2	SDN 2 Kalipucangwetan	Learning uses Kemendikbud and LPHS books, with limited use of digital media. Practicums are rarely conducted, and numeracy integration is not yet understood. Most students have not achieved the minimum criteria, tend to be

	passive, and are hindered by lack of facilities. Teachers struggle to understand IPAS concepts and to develop digital and numeracy-based materials. Teachers hope for simple and interactive modules.

In addition to interviews, researchers also conducted direct observations of the science and science learning process at both schools. Aspects observed included the learning environment, the use of digital teaching materials, and numeracy integration. Observation scores were analyzed using a 4-point Likert scale, with the following criteria:

Table 7. Learning quality category

No	Score Range	Category
1	3.01 – 4.00	Highly Implemented (HI)
2	2.01 – 3.00	Moderately Implemented (MI)
3	1.01 – 2.00	Not Implemented (NI)
4	0.00 – 1.00	Poorly Implemented (PI)

Table 8. Learning quality observation results

No	Aspect	Score		Average Score	Category
		SDN 1	SDN 2		
1	Learning Situation	2.45	2.36	2.40	Moderately Implemented
2	Use of Digital Teaching Media	1.00	1.80	1.40	Not Implemented
3	Numeracy Integration	1.90	2.00	1.95	Not Implemented

Based on observations, science learning remains teacher-centered, with minimal visualization and low student participation. Abstract concepts like the food chain are not fully understood, while the potential for integrating numeracy through data processing, measurement, and modeling has not been fully utilized. Furthermore, a literature review was conducted on curricula, textbooks, national and international journals, and e-module development guidelines. Studies show that e-modules offer high flexibility, support independent learning and differentiation, and enable students to learn anytime and anywhere (Sidiq & Najuah, 2020; Kemendikbud, 2017). Interactive e-modules equipped with multimedia have been shown to increase learning interest and motivation (Cheva & Zainul, 2019). Specifically, e-modules developed on ecosystem topics can facilitate understanding of abstract concepts such as food chains and energy cycles through visualization and simulation (Adeng et al., 2023). Furthermore, e-modules can also improve students' numeracy skills through graphs, tables, and data-based case studies (Apriyanti et al., 2024).

Overall, the needs analysis results indicate an urgency to develop the *ekoterin* e-module. Science and science learning, which is still conventional and lacks innovation, needs to be improved through contextual and engaging digital teaching materials. Teachers face challenges in developing numeracy learning media, while students struggle to understand ecosystem concepts. On the other hand, there is significant potential in the availability of ICT devices, enthusiasm for technology, and the readiness of both teachers and students to innovate. Ecosystem material is also highly suitable for numeracy reinforcement, such as reading population graphs, calculating interactions between living things, and analyzing data-based environmental changes. Therefore, the *ekoterin* e-module is designed as an innovative, contextual, and numeracy-integrated science and science learning solution to address the challenges and needs of the 21st century.

Design Stage

The design stage plays a vital role in developing the *ekoterin* (numeracy integrated ecosystem) e-module by transforming the needs analysis into a structured and systematic product plan. This process begins with analyzing the fifth-grade science learning outcomes (CP), formulating learning objectives (TP), and drafting the learning objective flow (ATP). Core ecosystem materials were sourced from textbooks, scientific articles, and other relevant references. The researcher then created supporting components for the e-module, including student worksheets (LKPD), assessment items, and learning videos, all adapted to the context and characteristics of elementary school students.

The e-module was designed based on the identification of learning challenges and existing potentials in the field, guided by key principles for developing effective digital teaching materials interactivity, flexibility, multimedia integration, and user-friendliness (Rahmawati, 2024; Adeng et al., 2023). This e-module also integrates contextual numeracy activities into science learning, so that students can develop logical and quantitative thinking skills through activities relevant to everyday life. To facilitate the development process, researchers compiled a storyboard and navigation flowchart that describes the structure and flow of using the e-module.

The e-module structure is designed to be integrated with an attractive, communicative interface that is appropriate for the characteristics of elementary school students, to support motivation and learning engagement (Ninawati et al., 2021). The primary platform used in development is canva for website, which allows for visual and interactive content packaging. The final product is then converted into an Android application in .apk format, allowing teachers and students to flexibly access the e-module both at school and at home.

The final version of the *ekoterin* e-module features interactive visuals, instructional videos to clarify abstract concepts, ecosystem-themed educational games, and integrated assessments to thoroughly evaluate student understanding. This comprehensive approach is designed to enhance both science and numeracy learning simultaneously.

Develop Stage

The development phase of the *ekoterin* (integrated numeracy ecosystem) e-module was carried out based on a previously prepared design. This process began with the preparation of a storyboard as an initial framework that illustrates the navigation flow, page layout, and content, to ensure the integration and consistency of each section within the module. Content development was carried out using canva for website, a platform that enables the creation of visual, interactive, and responsive digital teaching materials, so they can be accessed through various devices.

Once the e-module is developed in web format, it is then converted into an android application (.apk) using website to apk builder, so it can be installed directly on students' devices. In addition to the app format, the e-module can also be accessed via a web link, making it flexible for use in online, offline, and blended learning.

The module structure consists of three main parts: introduction, core, and conclusion. The introduction contains the cover display, main navigation, a brief description, user instructions, and learning objectives that refer to the phase c science learning outcomes. The core section presents ecosystem material in the form of e-books, infographics, learning videos, and interactive activities such as the ecosystem hunter and foodchain game. Meanwhile, the conclusion section contains an assessment quiz, discussion of questions, student reflections, and developer profiles.

Table 9. *Ekoterin* e-module structure

Section	Main Components
Introduction	Cover, navigation, module description, user guide, learning objectives
Core Content	E-book material, instructional videos, infographics, student worksheets: Ecosystem Hunter & Foodchain Game
Closing	Quiz, answer discussion, student reflection, and developer profile

The interface display of the e-module *ekoterin* (numeracy integrated ecosystem) is depicted as follows.

Figure 1. View of the introductory section of the *ekoterin* e-module

Figure 2. Core section view of *ekoterin* e-module

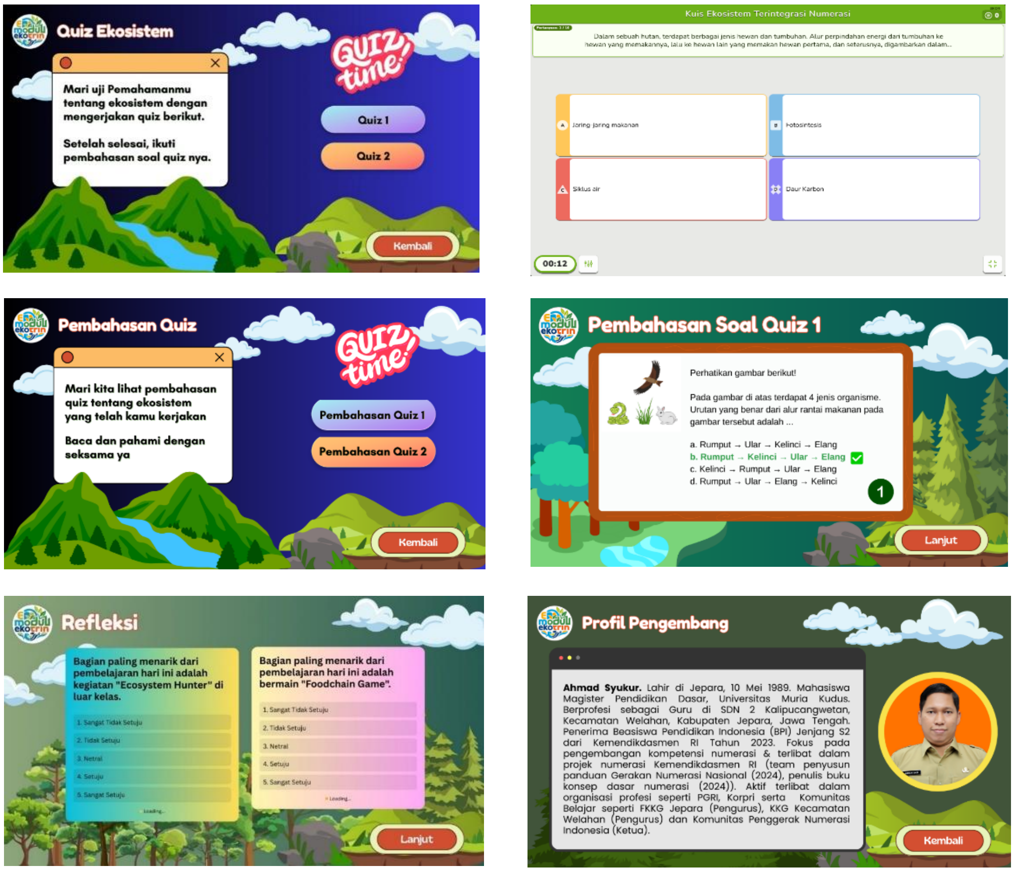


Figure 3. View of the cover section of the *ekoterin* e-module

Feasibility

After the *ekoterin* e-module was developed, the next stage was design validation to ensure the product's suitability in terms of content, visual appearance, and learning before widespread use. Validation was conducted by four parties: three experts from Muria Kudus University (UMK) media, materials, and language experts and one education practitioner, an elementary school teacher from Welahan District, Jepara Regency. The assessment used a four-point Likert scale (not suitable, less suitable, suitable, very suitable) to ensure an objective evaluation.

The media expert evaluated two key aspects: content design and visual communication. Based on 21 assessment items, the validation yielded an average score of 94.5%, placing it in the "very feasible" category.

Table 10. Media expert validation results

No	Assessment Aspect	Average Score	Criteria
1	E-Module Content Design	96	Very Feasible
2	Visual Communication	93	Very Feasible
	Average	94.5	Very Feasible

Content expert evaluated five aspects: self-instruction, self-contained, stand-alone, adaptive, and user-friendly. The total validation score was 95.2%, categorized as "very feasible."

Table 11. Results of content expert validation

No	Assessment Aspect	Average Score	Criteria
1	Self-instruction	100	Very Feasible
2	Self-contained	98	Very Feasible
3	Stand-alone	90	Very Feasible
4	Adaptive	100	Very Feasible
	Average	95.2	Very Feasible

Linguist validation covered communicative and interactive aspects, readability, and conformity to language rules. The average score was 91.7%, categorized as "very appropriate."

Table 12. Results of validation by linguist

No	Assessment Aspect	Average Score	Criteria
1	Communicative and Interactive	92	Very Feasible
2	Readability	88	Very Feasible
3	Language Rules	95	Very Feasible
	Average	91.7	Very Feasible

The practitioner evaluated the media, material, and language aspects, resulting in an average score of 97%. The validation confirmed that the *Ekoterin* e-module is highly appropriate for use in learning and does not require revision.

Table 13. Practitioner validation results

No	Assessment Aspect	Average Score	Criteria
1	Media	97	Very Feasible
2	Content	94	Very Feasible
3	Language	100	Very Feasible
	Average	97	Very Feasible

Table 14. Recapitulation of *ekoterin* e-module validation

No	Validator	Validation Score (%)	Criteria
1	Media Expert	94.5	Very Feasible
2	Content Expert	95.2	Very Feasible
3	Language Expert	91.7	Very Feasible
4	Practitioner	97.0	Very Feasible
	Average	94.6	Very Feasible

Following the validation process, researchers received various feedback, which was then followed up on by revising the e-module's content and presentation. The following is a summary of the feedback and follow-up actions.

Table 15. Summary of feedback and revisions

Expert	Suggestions	Revisions
Media	Add a "previous" navigation button for sections with more than one page, such as the quiz discussion and reflection sections.	The "previous" navigation button has been added for sections with more than one page
Content	1. Ensure that the instructional video uses language that is easy for students to understand. 2. Adjust the number of meetings and reflections.	The instructional videos have been revised using student-friendly language. The number of meetings and reflections has been adjusted accordingly.
Language	1. Add communicative call-to-action phrases. 2. Pay attention to punctuation and capitalization.	Communicative call-to-action phrases have been added, and punctuation and capitalization have been adjusted.
Practicioner	1. Ensure background colors contrast well with the content. 2. Add a download button to the infographic section.	Background colors have been adjusted and a download button has been added to the infographic section.

Table 16. *Ekoterin* e-module view before and after revision

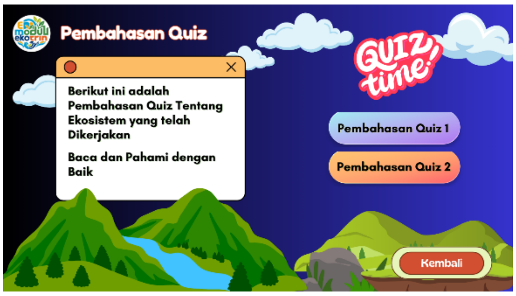
Before Revision	After Revision
The media expert suggested adding a "previous" navigation button for sections with multiple pages (quiz discussion and reflection).	A "previous" navigation button was added for sections with multiple pages (quiz discussion and reflection).

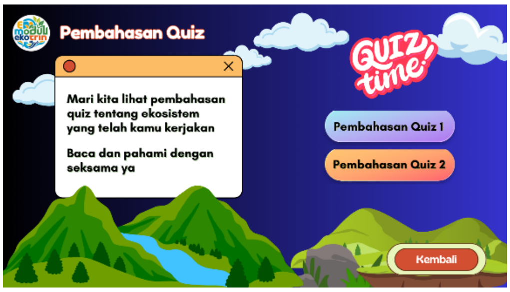
The content expert suggested that the instructional videos should use language that is easy for students to understand and that the number of meetings and reflections should be adjusted.

The instructional videos have been revised using student-friendly language, and the number of meetings and reflections has been adjusted accordingly.

The language expert suggested adding communicative call-to-action sentences and paying attention to punctuation and capitalization.

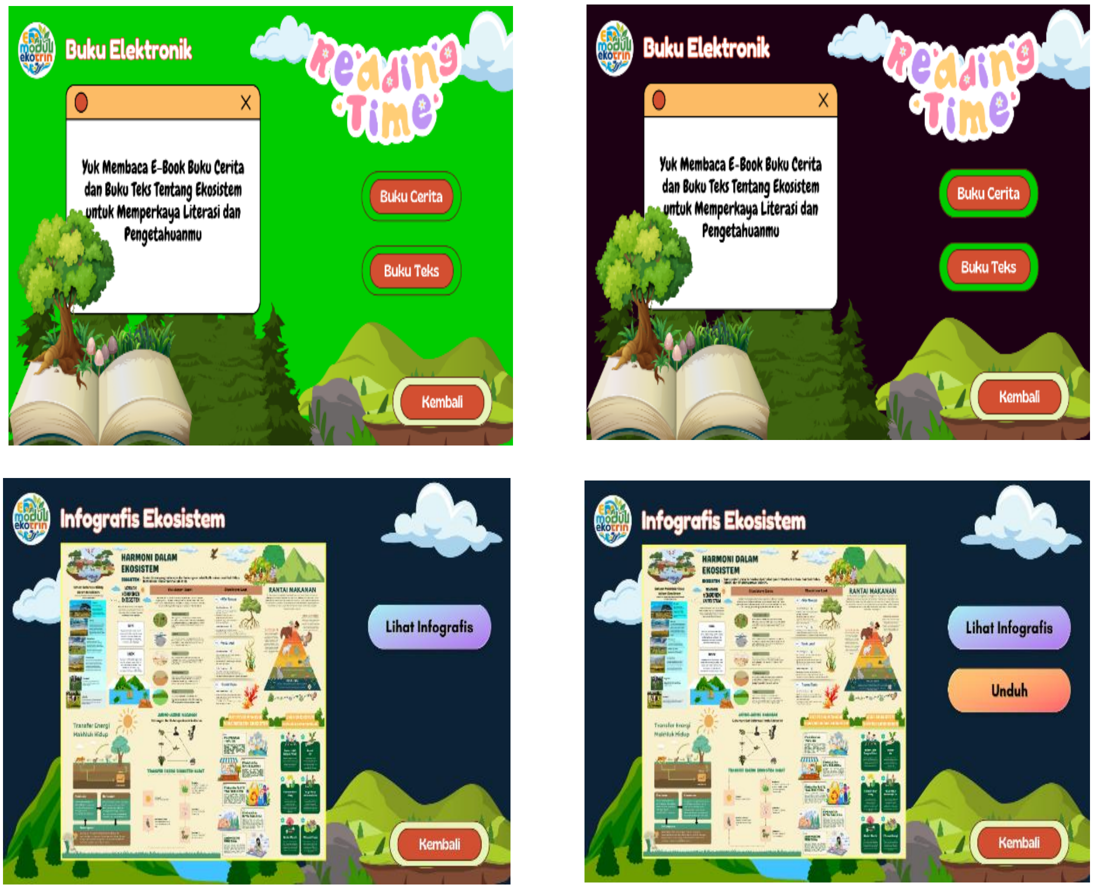
Communicative call-to-action sentences have been added, and punctuation and capitalization have been adjusted accordingly.





The practitioner suggested ensuring the use of background colors that contrast well with the content and adding a "download" button in the infographic section.

Background colors have been adjusted for better contrast, and a "download" button has been added to the infographic section.



Implement Stage

The implementation phase in the development of the *ekoterin* e-module is intended to evaluate its practicality and acceptability in a limited field setting. This phase consists of two stages: a limited trial and a field trial. Data from the limited trial serve as the basis for improving the e-module prior to its broader application in the field trial involving fifth-grade students at the same school (Rahmawati, 2024).

The limited trial involved two main groups: fifth-grade students and teachers. Ten fifth-grade students from SDN 1 Kalipucangkulon (five boys and five girls) were involved as trial subjects. In addition, two teachers from SDN 1 Kalipucangkulon and SDN 2 Kalipucangwetan participated to assess the practicality of the e-module. The e-module was used directly in learning, and respondents were asked to complete a practicality assessment questionnaire.

Practicality

The practicality test results showed that the *ekoterin* e-module received highly positive feedback. Student questionnaire responses yielded an average practicality score of 95.4%, categorized as very practical, indicating that the module supports effective learning and can be used independently by students. Similarly, evaluations from two teachers produced scores of 96 and 97, with an average of 96.5%. Overall, the combined average practicality score from both students and teachers was 95.58%, confirming that the e-module is highly practical for classroom use.

Table 17. Results of the practicality test of e-modules on teachers and students

No	Respondent	Score Obtained	Max. Score	%	Category
1	Student 1	96	100	96	Very Practical
2	Student 2	98	100	98	Very Practical
3	Student 3	94	100	94	Very Practical
4	Student 4	97	100	97	Very Practical
5	Student 5	94	100	94	Very Practical
6	Student 6	95	100	95	Very Practical
7	Student 7	94	100	94	Very Practical
8	Student 8	96	100	96	Very Practical
9	Student 9	95	100	95	Very Practical
10	Student 10	95	100	95	Very Practical
11	Teacher 1	96	100	96	Very Practical
12	Teacher 2	97	100	97	Very Practical
	Average Score	95.58		95.58	Very Practical

Although practical results indicated that the e-module was highly suitable for use, researchers continued to make limited improvements based on feedback from respondents collected through a questionnaire. Teacher input, in particular, was a crucial consideration in improving the quality of the module's content and presentation to optimally support the integration of science and numeracy.

Table 18. Results of suggestion and revision of the *ekoterin* e-module by teachers

Suggestion	Revision
Instructional videos should be divided into sub-sections or specific topics being discussed.	Instructional videos have been divided into sub-sections or specific topics being discussed.

Table 19. *Ekoterin* e-module appearance before and after revision

Before Revision	After Revision
The teacher suggested dividing the instructional videos into sub-sections or specific topics being discussed.	The instructional videos have been divided into sub-sections or specific topics being discussed.

After completing the limited trial, the study proceeded to a field trial to assess the effectiveness of the *ekoterin* e-module. A quasi-experimental design with a nonequivalent control group was employed. The experimental group comprised fifth-grade students from SDN 2 Kalipucangwetan who engaged in learning with the *ekoterin* e-module, while the control group consisted of fifth-grade students from SDN 1 Kalipucangwetan who underwent conventional learning without the module.

The design involved administering a pretest before the intervention and a posttest after the learning process. The comparison of scores between the two was used to evaluate the impact of the e-module on learning outcomes. The results showed that the *ekoterin* e-module effectively improved learning outcomes and was considered suitable for broader implementation without the need for further revisions.

Table 20. Pretest and posttest results of experimental and control classes

Aspect	Experimental Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Highest Score	74	95	72	85
Lowest Score	42	70	44	59
Average Score	59.03	81.71	56.78	72.56

The implementation phase aimed to assess the practicality and acceptability of the *Ekoterin* e-module in fifth-grade science learning. A limited trial was carried out involving two target groups: ten fifth-grade students from SDN 1 Kalipucangkulon (five boys and five girls) and two teachers from SDN 1 Kalipucangkulon and SDN 2 Kalipucangwetan. During this phase, the e-module was used directly in classroom activities, after which both students and teachers completed a practicality questionnaire.

Evaluate Stage

The evaluation phase is the final step in the ADDIE development model, aiming to assess the effectiveness and quality of the *ekoterin* e-module comprehensively after going through the design, validation, and implementation processes. The evaluation is conducted to measure the module's feasibility, practicality, and success in achieving the science and science learning objectives. The assessment is conducted through a combination of qualitative data (feedback from experts and users) and quantitative data (results of statistical tests on effectiveness).

The evaluation results show that the *ekoterin* e-module meets the criteria of being highly feasible and highly practical. Validation conducted by media experts, content experts, language experts, and education practitioners resulted in an average score of 94.6%, categorizing it as highly feasible. Meanwhile, the practicality test results from users were also very high, with students giving an average score of 95.7% and teachers giving a score of 96.5%, both of which fall into the highly practical category.

The next stage of evaluation focused on assessing the effectiveness of the e-module in enhancing student learning outcomes. Data were collected through pretests and posttests administered to two groups: the experimental class, which used the e-module, and the control class, which used conventional methods. Before conducting hypothesis testing, prerequisite tests—normality and homogeneity—were performed, confirming that the data met the criteria for further analysis.

The t-test results showed a significant difference between the two groups. The experimental class experienced a higher increase in learning outcomes than the control group, with an average N-Gain score of 0.56 (moderate category), while the control class only achieved 0.36 (low-moderate category). These findings confirm that the use of the *ekoterin* e-module has a positive contribution to improving student learning outcomes.

Effectiveness of *Ekoterin* E-Module

Normality Test

A normality test was performed to verify that the pretest and posttest data from both the experimental and control classes followed a normal distribution, allowing for the use of parametric statistical tests. The analysis employed the Kolmogorov–Smirnov and Shapiro–Wilk methods at a 5% significance level ($\alpha = 0.05$), with data considered normally distributed if the Sig. (2-tailed) value exceeded 0.05. The test was conducted using SPSS version 30.

Table 21. Experimental class normality test results

Test Type	Pretest Sig.	Posttest Sig
Kolmogorov-Smirnov	0.073	0.200
Shapiro-Wilk	0.130	0.170

Based on the table, all significance values from the Kolmogorov–Smirnov and Shapiro–Wilk tests for the experimental class's pretest and posttest were above 0.05. This confirms that the data were normally distributed and met the necessary assumptions for further statistical analysis.

Table 22. Results of the normality test for the control class

Test Type	Pretest Sig.	Posttest Sig
Kolmogorov-Smirnov	0.200	0.200
Shapiro-Wilk	0.345	0.621

The control class data also met the normality criteria, as the significance values from both test methods for the pretest and posttest were well above 0.05, indicating a normal distribution. Since both groups met the normality assumption, the pretest and posttest data from the experimental and control classes could be validly analyzed using parametric tests, including homogeneity and t-tests. This strengthens the validity of the effectiveness evaluation of the *ekoterin* e-module.

Homogeneity Test

A homogeneity test was carried out to confirm that the posttest data from the experimental and control classes had consistent variance. This step is crucial before performing parametric tests like the t-test. In this study, homogeneity was assessed using Levene's test for equality of variances at a 5% significance level ($\alpha = 0.05$), with the analysis conducted using SPSS version 30.

Table 23. Results of the posttest homogeneity test

Test Type	F	df1	df2	Sig.
Levene’s Test	0.938	1	56	0.337

Based on the results, the obtained significance value (Sig.) was 0.337, which exceeds 0.05. This indicates no significant difference in variance between the posttest scores of the experimental and control classes. Therefore, it can be concluded that the data from both groups are homogeneous and evenly distributed.

Fulfilling this homogeneity assumption confirms that the data are suitable for further analysis using a t-test. The uniform variance between the experimental and control groups also indicates that an objective comparison of learning effectiveness with and without the *ekoterin* e-module can be conducted.

Hypothesis Testing (Independent Sample T-Test)

To evaluate the effectiveness of the *ekoterin* e-module in improving learning outcomes, an independent sample t-test was performed on the posttest scores of the experimental and control classes. This test aimed to determine whether a statistically significant difference existed between the two groups. The analysis used a 5% significance level ($\alpha = 0.05$), with results considered significant if the Sig. (2-tailed) value was less than 0.05.

Table 24. Independent sample t-test posttest results

Variable	Levene's Test (Sig.)	t-Test (Sig. 2-tailed)
Posttest Score	0.337 (homogen)	< 0.001

Based on the t-test results, the analysis referred to the equal variances assumed row, as the data were previously confirmed to be homogeneous (Levene's Sig. > 0.05). The significance value of < 0.001 indicates a statistically significant difference in the average scores between the experimental and control classes.

Table 25. Descriptive statistics of posttest scores

Class	N	Mean	Standard Deviation
Experimental	31	81.71	7.039
Control	27	72.56	6.589

The Table 25, reveals that the experimental class attained a higher average posttest score of 81.71, compared to 72.56 in the control class. This difference demonstrates that the use of the *ekoterin* e-module had a positive impact on student learning outcomes.

N-Gain Test

To assess the improvement in student learning outcomes, a comparative analysis of pretest and posttest scores was carried out using the average normalized Gain (N-Gain). This analysis involved two groups: the experimental class that used the *ekoterin* e-module and the control class that did not.

The N-Gain analysis indicates that the experimental class achieved an average score increase of 0.56 (56%), classified as moderate. In comparison, the control class recorded a lower average N-Gain of 0.36 (36%), also in the moderate category but significantly below the experimental class. Detailed N-Gain statistics for the experimental class are presented in Table 26.

Table 26. N-Gain statistics of pretest and posttest of experimental and control classes

Description	Experimental Class	Control Class
Average N-Gain	0.56 (Medium)	0.36 (Medium)
N-Gain (%)	56%	36%
Highest N-Gain	0.81	0.54
Lowest N-Gain	0.23	0.04
Number of Students	31	27

The control class achieved an average N-Gain of 0.36 (36%), while the experimental class reached 0.56 (56%), both falling into the moderate improvement category. This indicates that the experimental class experienced a greater increase in learning outcomes. Therefore, the use of the *ekoterin* e-module is effective in enhancing the learning outcomes of fifth-grade students. These findings are consistent with those of (Antari et al., 2023; Taufik & Prasetyaningtyas, 2024), who also reported that systematically developed e-modules positively impact student achievement. Based on the overall results of statistical tests and data analysis, it can be concluded that the *ekoterin* e-module is effective in enhancing fifth-grade students' understanding and learning outcomes on ecosystem material.

Table 27. Learning completion statistics for experimental and control classes (posttest)

Description	Experimental Class	Control Class
Number of Students	31	27
Average Score	81.71	72.56
Highest Score	95	85
Lowest Score	70	59
Achieved Mastery (> KKTP)	31	24
Not Achieved Mastery (< KKTP)	0	3

Based on the data in the table above, all students in the experimental class achieved the KKTP on the posttest. Meanwhile, in the control class, there were still three students who had not achieved the KKTP on the posttest. This indicates that the use of the *ekoterin* e-module not only helps students understand the material but also accelerates the achievement of learning completion.

Conclusion

This study concludes that the ekoterin e-module, developed using the ADDIE model, is highly feasible, practical, and effective in enhancing fifth-grade students' learning outcomes in science and numeracy. Expert validation yielded high scores, and both teachers and students responded positively. Effectiveness testing revealed significant learning gains and a higher N-Gain in the experimental group. Theoretically, the findings reinforce the ADDIE model's effectiveness and support numeracy integration in non-mathematics subjects. Practically, the module promotes student independence, supports teachers in implementing technology-based instruction, and serves as a valuable digital resource for schools.

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