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Development of Multi Model Based Electronic Ecology Textbook to Empower Student Environmental Literacy

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ABSTRACT

In the Era of Society 5.0, education must prioritize the development of creativity by leveraging technology to empower the quality of learning. Digital technology presents strategic opportunities to support the success of education and learning within higher education institutions. The objective of this research is to develop a valid and practical multi model based electronic textbook on Ecology to empowering students environmental literacy. The utilization of electronic textbooks offers several benefits, including easy accessibility. The developed electronic textbook is based on a multi model approach, namely problem based learning and guided inquiry. This research and development (R&D) study, following the Lee & Owens model. The results of material expert validation obtained an average validity score of 100, while the validation for media and teaching materials of 92, and the validation by Biology education practitioners of 96. These three validation scores are categorized as very valid. The product trial demonstrated a high level of practicality, with a score of 96. The research results show that the developed electronic ecology textbook has been proven valid and practical to empower students' environmental literacy.

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1. INTRODUCTION

In the era of Society 5.0, education must prioritize the development of creativity that leverages technology to enhance the quality of learning. Digital technology holds strategic potential and opportunities to contribute to and support the success of education and learning in higher education institutions (Hills & Thomas, 2019). One of the strategic potentials of digital technology in the learning process is the use of electronic textbooks (Afifulloh & Cahyanto, 2021). Electronic textbooks are digital books that can be accessed through mobile devices such as laptops, smartphones, tablets, or computers (Hayati & Azizah, 2021). Compared to printed textbooks, electronic textbooks offer several advantages, including easier text search, better accessibility, interactivity, dynamic content, the ability to download and copy materials, immediate feedback, as well as integration of images, audio, video, and animations (D'Ambra et al., 2022). They can also be easily accessed through electronic devices (Humairah, 2022). The use of electronic textbooks in learning offers several benefits, including ease of access.

Learning success is influenced by several factors, namely active student involvement, the learning environment, and interactive textbooks (Puteri et al., 2023). Interactive electronic textbooks provide students with the flexibility to study independently, adjust their learning pace, and deepen their understanding of the material (Anasro et al., 2023). Interactive textbooks are very necessary in the learning process. This is supported by a needs analysis conducted by Cindy Noviana in 2024, with interviews with a lecturer teaching Ecology at Universitas Negeri Malang. Based on the needs analysis, it was found that there is a need to develop electronic textbooks for ecology courses.The development of an electronic textbook will be effective if it can empower students' environmental literacy (Rafidah et al., 2024).

Environmental literacy refers to an individual's capacity to preserve environmental sustainability, which includes an understanding of environmental issues, a sense of responsibility in protecting nature, and the skills to formulate solutions to environmental problems (Ariyatun et al., 2024). Environmental literacy is essential for university students, as environmental changes can occur at both local and global levels. By improving students' environmental literacy, they can better understand, care for, and address environmental issues (Wulandari et al., 2022). Students with environmental literacy will comprehend various aspects of the environment and the factors

that influence it, recognize the impact of human activities on nature, be able to analyze environmental problems and draw conclusions from their analyses, and take concrete actions to solve existing environmental issues (Nurjannah et al., 2023).

Based on the results of a preliminary environmental literacy study on November 18, 2024, the test instrument used was multiple-choice questions and a Likert scale based on the National Environmental Literacy Assessment (NELA) and adapted to student abilities. This instrument was administered to a class of 31 students. The preliminary study did not involve all students taking the Ecology course. The results of the preliminary environmental literacy study obtained an average score of 63.4, categorized as moderate, with the details for each indicator as follows. The first indicator, which is Ecological Knowledge, received a score of 64.1, categorized as moderate, meaning that students have a fair understanding of the environment and its interactions. The second indicator, which is Environmental Issue Identification, received a score of 38.7, categorized as low, meaning that students are unable to identify environmental issues that occur. The third indicator, which is Environmental Issue Analysis, received a score of 39.7, categorized as low, meaning that students are unable to analyze environmental issues that occur. The fourth indicator, which is the environmental action plan, received a score of 27.4, categorized as low, meaning that students are unable to plan actions for the environment. The fifth indicator, which is the intention to act, received a score of 75.5, categorized as moderate, meaning that students have a fair intention to take action towards the environment. The sixth indicator, which is sensitivity to the environment, received a score of 73.8, categorized as moderate, meaning that students have a fair level of sensitivity to events occurring in the environment. The seventh indicator, which is feelings towards the environment, received a score of 76.9, categorized as moderate, meaning that students have a fair level of feeling towards preserving and maintaining the environment. The eighth indicator, which is real commitment, received a score of 39.3, categorized as low, meaning that students do not have a real commitment as a form of individual treatment towards the environment. The results of the tests and questionnaires indicate the need for efforts in empowering environmental literacy, especially on indicators that are categorized as low and moderate, so that students can achieve high environmental literacy.

High environmental literacy scores enable individuals to propose better environmental problem solving concepts, keenly analyze solutions to environmental issues, and present various plans to overcome environmental problems (Yeh et al., 2022). According to Suryawati et al. (2020) environmental literacy can help students develop environmental awareness while enhancing their analytical and creative abilities to solve environmental problems with innovative solutions. Learners who possess strong environmental literacy will exhibit greater responsibility for their surroundings (Hariyadi et al., 2021).

Students' environmental literacy can be empowered in various ways, one of which is by integrating it into the learning process (Nasution, 2021). The empowerment of environmental literacy can also be achieved by selecting appropriate and innovative learning strategies (Sukri, 2023). One such method is the use of an electronic textbook integrated with a learning model. The learning model used is a multi-model approach, namely problem based learning and guided inquiry. The reason for using a multi model approach is that varied learning models can make learning more engaging and relevant for students. Using a single learning model continuously can make the learning process monotonous and boring for students, thereby decreasing their motivation and engagement (Zhang, 2022). According to Albina et al. (2022) the variety of available learning models makes it easier for educators to select and implement models that are appropriate for the learning material.

The developed multi model based electronic textbook contains ecological material, including the organizational structure in ecological studies, distribution and dispersal, behaviour and habitat selection, as well as abiotic and biotic factors. The learning activities for the topic of organizational structure in ecological studies (individual, population, community, ecosystem, biome, biosphere/ecosphere) and behaviour and habitat selection utilize the problem based learning model. Meanwhile, learning activities for the topics of distribution and dispersal, and abiotic and biotic factors use the guided inquiry model. According to Manurung (2021) implementing a variety of learning models can help students and lecturers in the teaching and learning process.

The improvement of students' environmental literacy can be achieved through the development of a multi model based Ecology electronic textbook, namely problem based learning and guided inquiry. This is supported by the research of Mursyd et al. (2023), which states that a problem based learning model textbook is effective for use in Ecology lectures. According to Yeyendra et al. (2024), the application of the problem based learning model is proven to influence the improvement of students' environmental literacy. When integrated with environmental problems, the problem based learning model educates students to behave with environmental awareness (Febriani et al., 2020). When students are familiar with learning through concepts linked to their immediate surroundings, they will develop strong environmental awareness and knowledge, resulting in enhanced environmental literacy (Wajdi et al., 2022). The application of the guided inquiry model makes students more actively involved in the learning process, enabling them to connect their new ideas with existing knowledge (Royani & Atun, 2023). According to Apriliani et al. (2022), the guided inquiry learning model can encourage students to actively seek knowledge, thus becoming independent individuals. Based on the problems described,

the purpose of this research is to produce a valid and practical multi model-based Ecology electronic textbook for empowering students' environmental literacy.

2. RESEARCH METHOD

This study employs a research and development (R&D). The research and development model used is the Lee & Owens (2004) model. This research and development model consists of five stages: assessment/analysis, design, development, implementation, and evaluation. This research was conducted from March 2024 to May 2025. The analysis phase took place in March 2024, the design phase in April–May 2024, and the development phase from June 2024 to January 2025. The analysis phase aims to identify the causes of the gaps and facilitate the determination of necessary solutions. The analysis stage is carried out in two stages, namely needs assessment and front-end analysis.

The design stage aims to design the product to be developed. The design stage involves creating schedules, team member work lists, media specifications, learning structures, configuration control, and a review cycle. The project team consists of students and supervising lecturers who are responsible for conducting the research and carrying out specific tasks. The specifications of the developed media include the type of media, text fonts, grammar, subject topics, and the software used to create the electronic textbook, which is Google Sites. The learning structure is implemented using the Problem Based Learning model and Guided Inquiry. The learning process is carried out in a balanced manner, providing clear tasks and instructions. The instruction is delivered clearly, firmly, and logically, and assessments are conducted to measure the course learning outcomes aligned with the semester learning plan, namely analyzing the organizational structure of life in ecological studies and analyzing environmental factors, utilizing, preserving, and conserving them as natural resources.

The development phase aims to realize the design ideas created and approved in the previous phase. The product is then validated by subject matter, media, and teaching materials experts, as well as Biology Education practitioners. After the validation phase, the product is tested. Validation is carried out by experts or lecturers who are competent in their fields. This validation consists of three main aspects: content suitability, presentation suitability, and language suitability. The content suitability aspect focuses on the essence or substance of the material. In textbooks, the material must be aligned with advancements in science, and the explanations, examples, and exercises must be presented in a relevant manner and reflect current events or conditions. After testing the validity of the product, a product trial is conducted to determine the practicality of the product before

it is implemented in learning activities. The trial is carried out in stages through three stages, namely one-to-one trial, small group trial, and field trial. One to one trial was conducted on three students from Offering D, Batch 2022: one student with an academic score above average, one student with an average academic score, and one student with an academic score below average.

The implementation stage is carried out to prepare the learning environment, aiming to test the product's effectiveness. The evaluation stage covers understanding reactions, knowledge, and performance. This research and development (R&D) study was conducted to the development stage to determine the validity and practicality of an Ecology electronic textbook. The subjects of this study consisted of two groups: 1) material expert validators, media, and teaching materials, and Biology Education practitioners, all of whom held at least a master's degree with a minimum of five years of teaching experience; and 2) student participants, comprising 31 students from the 2023 cohort of the Undergraduate Biology Education Program (Offering A) and 13 students from the 2022 cohort of the Undergraduate Biology Education Program (Offering D).

The instruments used in this development research are: 1) validation sheets for subject matter experts, media and teaching material experts, and Biology education practitioners; 2) student response questionnaires regarding the electronic Ecology textbook; and 3) an environmental literacy test adapted from the National Environmental Literacy Assessment (NELA). Two types of data were obtained: qualitative data and quantitative data. Quantitative data consist of scores, while qualitative data consist of suggestions/comments obtained from the assessments by subject matter experts, media and teaching material experts, Biology education practitioners, and student responses. The validity of the electronic Ecology textbook was tested using a specific formula. The results from this calculation were used to analyze the validity criteria of the electronic Ecology textbook (Table 1). The formula used to calculate validity is as follows.

$$\textbf{Expert validation} = \frac{\textbf{Total score of validation results}}{\textbf{Maximum total score}} \textbf{x100}\%$$

Table 1. Percentage and Validity Criteria of the Electronic Ecology Textbook

Percentage (%)	Validity Criteria
100	Highly valid, or the product can be used without revision
$85{,}00 \leq X \leq 99{,}99$	Highly valid, or the product can be used with minor revisions
$70{,}00 \leq X < 85{,}00$	Valid, or the product can be used with moderate revision
$55{,}00 \leq X < 70{,}00$	

Percentage (%)	Validity Criteria
40,00 ≤ X < 55,00	Less valid, or the product is not recommended for use because it needs major revisions
X < 40,00	Invalid, or the product should not be used
	Highly invalid, or the product should not be used

Source: Adapted from Sulisetijono (2018:76)

Practicality test data were obtained from student responses through questionnaires developed by the researcher regarding the use of the Ecology electronic textbook. The criteria for the practicality of the electronic textbook can be seen in (Table 2). The technique used to analyze the student response scores was analyzed using the following formula.

$$\textbf{User validation} = \frac{\textbf{Total response score}}{\textbf{Maximum total score}} \textbf{x100}\%$$

Table 2. Percentage and Practicality Criteria of Ecology Electronic Textbooks

Percentage (%)	Practicality Criteria
100	Highly practical, or the product can be used without revision
85,00 ≤ X ≤ 99,99	Highly practical, or the product can be used with minor revisions
70,00 ≤ X < 85,00	Practical, or the or the product can be used with moderate revision
55,00 ≤ X < 70,00	Less practical, or the product is not recommended for use because it needs major revisions
40,00 ≤ X < 55,00	Impractical, or the product should not be used
X < 40,00	Highly impractical, or the product should not be used

Source: Adapted from Sulisetijono (2018:76)

3. RESULT AND DISCUSSION

The results of the research and development conducted include the development of a multi model based electronic textbook on Ecology for empowering students' environmental literacy. The electronic textbook used has undergone several stages, including assessment /analysis, design, and development.

Assessment/Analyze

The results of the need assessment phase provided information about existing gaps, their causes, and the solutions implemented on campus. Students experience difficulties in understanding topics such as the concept of the organizational structure of life in ecological studies, distribution and dispersion, behaviour and habitat selection, as well as abiotic factors (temperature, water salinity, sunlight). Based on the results of a preliminary study of 31 students selected by random sampling, namely the 2022 intake of the Biology Education Bachelor's program, State University of Malang, it was found that their level of environmental literacy was moderate. Therefore, the solution implemented in the learning process of the Ecology course was the development of an electronic Ecology textbook integrated with a multi model approach, namely problem based learning and guided inquiry, which can assist lecturers in empowering students' environmental literacy during the learning process. This is supported by the study of Mursyd, et al. (2023), which found that textbooks based on the problem based learning model are effective for use in Ecology courses.

The results of front-end analysis provided holistic information about the product being developed. This stage was conducted to analyze and determine solutions to the gaps identified in the needs analysis. This stage consists of student analysis, technology, situation, tasks, critical incidents, problems, objectives, media, existing data, and costs. The result of the student analysis showed that the average score of environmental literacy was 63.4, categorized as moderate. The result of the technology analysis, obtained through observation, revealed that Universitas Negeri Malang has highly adequate facilities for learning activities, such as the availability of Wi-Fi networks, projectors, all students owning either smartphones or laptops, and a library equipped with computers.

The result of the task analysis was a description of the work expected as an outcome of the training or performance support during the research and development process, namely based on the learning outcomes of the Ecology course: analyzing the organizational structure of life in ecological studies and environmental factors, utilizing, maintaining, and preserving them as natural resources. The result of the critical incident analysis in this research and development indicated that students need an electronic Ecology textbook based on a multi model approach for the Ecology course to empower environmental literacy. The result of the situation analysis showed that Universitas Negeri Malang, as the implementation site, has excellent infrastructure and facilities to support the learning process of the Ecology course. The result of the objective analysis was to develop an electronic Ecology textbook based on a multi model approach that is expected to empower environmental literacy. The result of the media analysis was an electronic Ecology textbook that can be accessed by students anytime and anywhere because it is in website format. According to Nugraha, et al. (2025), learning materials designed in website format can be stored online, making access and use easier for students. The result of the existing data analysis included available data, materials, and content that need to be developed. The results of the analysis of costs incurred in

research and development include the costs of printing validation sheets, research and development reports, electronic textbooks on ecology, and validator services.

Design Stage Results (Design)

The configuration results are the steps taken to control the creation of electronic textbooks, including the type of format, formatting application, and reasons for choosing the format. The type of format chosen in the development of electronic textbooks is a website. The system used on the internet is Hypertext Markup Language (HTML) to organize the components of the electronic textbook being created. HTML format was chosen because it can process documents that can be accessed in the form of a website, so that with just a link to the book, it can be accessed anywhere and anytime. The formatting application used in the creation of the electronic textbook is a website. Google Sites software is used to create electronic textbooks in the form of a website. The development of electronic teaching materials based on websites is one form of educational innovation in the era of the 5.0 revolution, where the learning process is conducted by leveraging technology (Ningrum, et al., 2021).

Development

The result of the pre-production stage is a storyboard that serves as a guideline for developers in creating content for electronic textbooks. The storyboard consists of the design and flow of the electronic textbook, created from the initial display to the final display. The production stage is carried out by compiling and inserting text into the framework of the electronic textbook storyboard. Each learning material is accompanied by videos, graphics, and audio according to the storyboard specifications. This aims to ensure that the elements within the storyboard framework align with the content that is the focal point of the electronic textbook storyboard and the course development standards. According to Priyambodo, et al. (2022), a storyboard is an initial sketch of a product created to plan the sequence of presenting information visually and logically, whether in the form of images, sketches, or text descriptions. This makes it easier for the author to see the overall content of the book or product before it is produced.

The results of the content presentation production stage are the focal point for attracting students to engage in the process of forming knowledge. The content created must be models, meaning that aspects of knowledge, skills, and procedures must be included in the electronic textbook being developed. The post-production and quality review stages are carried out through a comprehensive evaluation of the electronic textbook being developed. The review results, involving subject matter experts, media and instructional materials experts, and biology education practitioners, are outlined as follows.

a. Results of Expert Validation

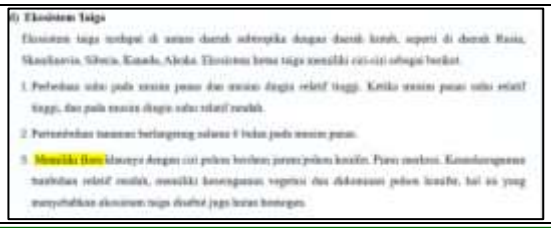
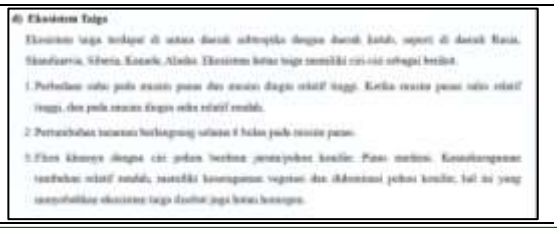
The results of the material expert validation of the Ecology electronic textbook are presented in Table 3.

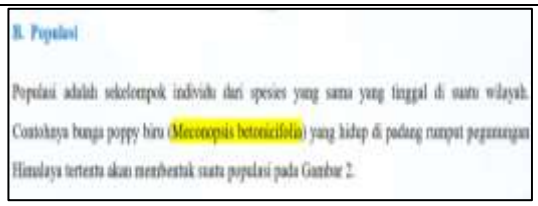
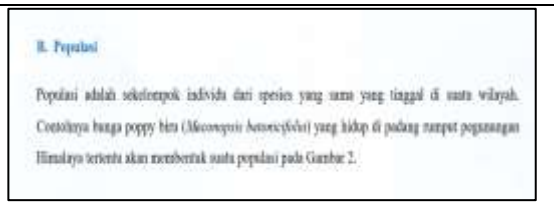
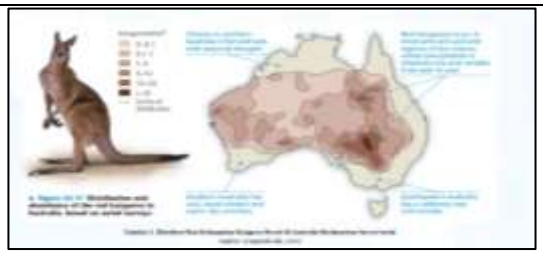
Table 3. Aspect, Percentage Before and After Revision, and Subject Matter Expert Validation Category

No.	Aspect	Before Revision (%)	Category	After Revision (%)	Category
1.	Content Suitability	86	Highly Valid	100	Highly Valid
2.	Presentation Suitability	92	Highly Valid	100	Highly Valid
3.	Language Suitability	86	Highly Valid	100	Highly Valid
	Average	**88**	Highly Valid	**100**	Highly Valid

Based on the data in Table 3, it shows the validation results before and after revision by subject matter experts covering aspects of content feasibility, presentation feasibility, and language feasibility. The validation results before revision were classified as highly valid with a percentage of 88, while after revision they were classified as highly valid with a percentage of 100. The material in the developed book was assessed as highly valid because it was reviewed in terms of material coverage, meaning that it presented material in accordance with the requirements of the course learning outcomes. The material must cover everything from concept introduction to application in accordance with the course learning outcomes and have depth and breadth of material for students (Wati, et al., 2021). The created textbook needs to go through a validation process initially to confirm that the content, format, and learning framework established meet quality standards (Chaerani, et al., 2022). The results before and after revision based on comments and suggestions from subject matter experts can be seen in Table 4.

Table 4. Results Before and After Revision Based on Comments and Suggestions from Subject Matter Experts

No	Before Revision	After Revision
1.		

No	Before Revision	After Revision
	The sentence structure is incorrect; it should follow the pattern Subject, Predicate, Object, Adverbial.	The sentence has been revised to follow the correct sentence structure pattern.
2.	 Incorrect scientific name, because it is not written in italics.	 Scientific name is written in italics.
3.	 Add case examples using areas in Indonesia, because the material only contains case examples from outside Indonesia.	 In accordance with the validator's suggestion, it has been revised by adding cases from Indonesia.

Based on comments and suggestions from expert validators, the structure of sentences must follow the correct sentence structure pattern. According to Prasetyo, et al. (2023), the pattern Subject, Predicate, Object, Adverbial is a standard grammatical rule in Indonesian, so following the pattern ensures that each sentence has a logical structure and is easy for readers to understand. A valid textbook must have consistency between the practice questions and the requirements of the material being taught, in accordance with the learning objectives (Zaputra, et al., 2021).

Subject matter experts ensure that the knowledge presented is accurate, relevant, and in accordance with scientific principles (Syahroni & Suwidagdho, 2024). The presentation suitability aspect assesses whether the material is presented logically, coherently, and easily followed, and checks whether the presentation methods (use of narrative, illustrations, tables, graphs, infographics) are appropriate for conveying specific concepts and suitable for the characteristics of the students. The language suitability aspect focuses on assessing whether the sentences used are clear, unambiguous, easy to understand, and free of spelling, punctuation, and grammatical errors. Spelling or grammatical errors can reduce the credibility of the material (Taufiq & Agustito, 2021). Textbooks should use simple and communicative language. The language presented in textbooks should be appropriate for the target audience and easy to understand.

b. Results of Media and Teaching Materials Expert Validation

The results of the media and instructional material expert validation of the electronic Ecology textbook are presented in Table 5.

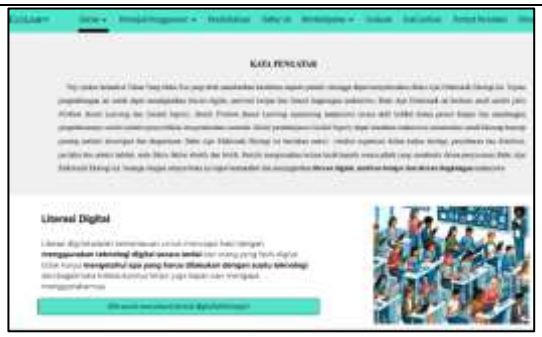
Table 5. Aspect, Percentage Before and After Revision, and Category by Media and Instructional Material Experts.

No.	Aspect	Before Revision (%)	Category	After Revision (%)	Category
1.	Feasibility and Graphicality	92	Highly Valid	95	Highly Valid
2.	Integration of Electronic Textbooks	75	Valid	88	Highly Valid
3.	Characteristics of Electronic Textbooks	92	Highly Valid	95	Highly Valid
	Average	**86**	Highly Valid	**92**	Highly Valid

Based on the data in Table 5, the results of validation before and after revision by media and teaching material experts covering aspects of feasibility and graphics, integration of electronic textbooks, and characteristics of electronic textbooks are shown. The results of validation before revision were classified as

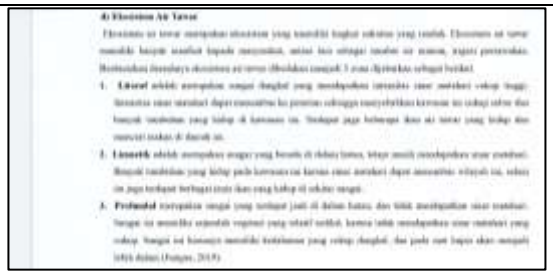
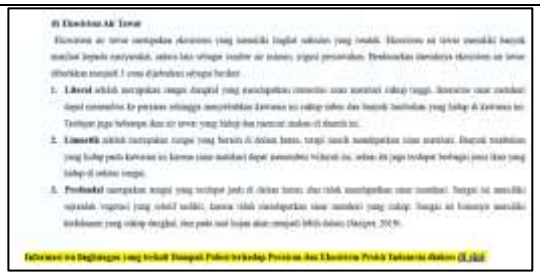
highly valid with a percentage of 86, while after revision they were classified as highly valid with a percentage of 92. The developed textbook is considered highly valid due to its attractive graphic elements and visual design, ease of understanding, and the selection of colors, fonts, layout, and relevant images or illustrations that support material comprehension. An interactively designed textbook can encourage innovative and creative thinking in learning (Radović, et al., 2020). According to Laili, et al. (2024) navigation in electronic textbooks allows users to easily move between sections or subsections of the material, as well as interactive elements that support student understanding, such as quizzes or media-based assignments. The results before and after revision based on comments and suggestions by expert validators of media and teaching materials can be seen in Table 6.

Table 6. Results Before and After Revision Based on Comments and Suggestions from Media and Teaching Material Experts

No	Before Revision	After Revision
1.	 The title cover is too wide; it can be changed to make it more appealing.	 The cover has been revised according to the validator's suggestions.
2.	 The material section does not yet have article links.	 Article links have been added to the material section to provide additional learning resources.
3.	 It would be good to add an introductory video below the introduction section, a video about the contents of the electronic textbook.	 There is already an introductory video about the contents of the electronic textbook, so that students will be more interested in studying it.

4.		
	The glossary does not yet have clickable links for each word, which would take you to the relevant section of the material.	The glossary now has clickable links for each word, which take users to the relevant section of the material, making it easier for students.

Continued from Table 6 ...

5.		
	The content on one page is too long; buttons for "next page" and "previous page" need to be added.	The content has been divided so that it is not too long on one page, and buttons for "next page" and "previous page" have been added.
6.		
	There are no links related to environmental issues in the material section.	Links to articles containing environmental issues have been added.

Based on comments and suggestions from media and teaching material experts, the first issue is that the cover title of the electronic textbook is too wide and could be changed to make it more appealing. The visual design of the textbook cover, including layout arrangement, color selection, text type, illustrative images, and multimedia elements, plays a crucial role in supporting students' comfort and interest in the learning process (Anggyani, 2023). Other suggestions include adding videos, article links, an interactive glossary, and navigation button features. Electronic textbooks that combine animations, text, audio, images, and other engaging features can help students understand the material better and make learning more enjoyable (Anggono & Setiawan, 2025).

The integration aspect of electronic textbooks is to ensure that the material presented is relevant and in line with learning objectives and to integrate environmental literacy into the learning process in the textbooks developed. In addition, interactive elements (such as videos, links, and assignments) that can be combined with other learning resources must also be integrated. Learning materials designed systematically and featuring interactive text, images, videos, and animations can assist students in achieving learning objectives. Electronic textbooks have a significant impact on student performance and relevant factors in educational practice because their features motivate students to learn (Kgosiyame & Eze, 2023).

c. Validation Results of Biology Education Practitioners

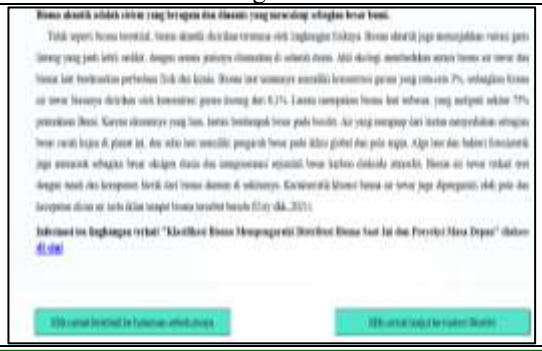
The results of Biology education practitioners' validation of the Ecology electronic textbook are presented in Table 7.

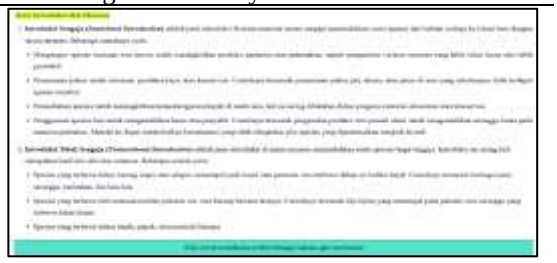
Table 7. Aspect, Percentage, and Category of Biology Education Practitioner Validation

No.	Aspect	Percentage (%)	Category
1.	Presentation Techniques	100	Highly Valid
2.	Presentation Support Materials	95	Highly Valid
3.	Learning Presentation	90	Highly Valid
4.	Presentation Completeness	93	Highly Valid
5.	Language	100	Highly Valid
	Average	**96**	Highly Valid

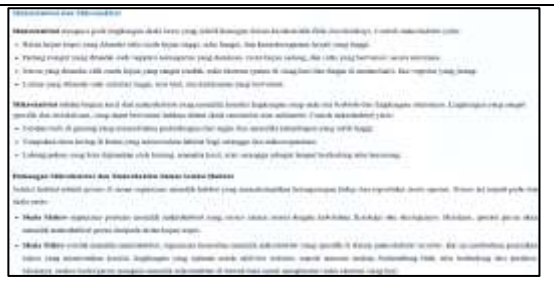
Based on the data in Table 7, the validation results are highly valid with a percentage of 96. The aspects assessed are presentation techniques, presentation support materials, learning presentation, completeness of presentation, and language. The textbook developed was deemed highly valid by the validators due to its systematic, logical, sequential, and coherent presentation techniques. According to Yasa, et al. (2018), textbooks can help students learn more systematically and master the competencies required by learning activities. The use of electronic textbooks in learning allows students to study each topic individually according to their abilities and competencies, thereby enhancing their learning experience (Lim, et al., 2020). The results before and after revision based on comments and suggestions from biology education practitioners can be seen in Table 8.

Table 8. Results Before and After Revision Based on Comments and Suggestions from Biology Education Practitioners

No	Before Revision	After Revision
1.	 Practice questions need to be supplemented with HOTS (Higher Order Thinking Skills) questions.	 HOTS (Higher Order Thinking Skills) questions have been added to practice questions 1-4.
2.	 There is a double numbering, namely in “Figure 3” which should be “Figure 4.”	 The numbering in the figure has been corrected to “Figure 4.”
3.		

	There are no links to articles containing examples of each level of the ecological organization.	In the material section, links to articles have been added, each containing examples at every level of the ecological hierarchy.
4.	 In the material on spread and distribution, an explanation of the types of human introduction needs to be added.	 Material related to the types of human introduction has been added.

Continued Table 8…

5.	 In the habitat selection material, there is no explanation regarding macrohabitat and microhabitat.	 Macrohabitat and microhabitat material has been added as suggested by the validator.

Based on comments and suggestions from biology education practitioners, the questions should include Higher Order Thinking Skills (HOTS) exercises, provide links at the end of each material, and include detailed explanations related to the material. HOTS questions do not merely test memory or basic understanding but require students to analyze, evaluate, and synthesize complex information. This trains students not only to accept raw information but also to question, break down, and understand the relationships between concepts (Baharsyah, et al., 2023). Additionally, links to articles from scientific journals or reliable sources can support the accuracy of the material, allow for deeper exploration of the material by accessing relevant additional references directly from the links, and ensure that students always have access to the latest information through relevant articles (Azizah, et al., 2021).

b. Product Trial Results

The electronic textbook was tested by students who had taken the Ecology course. The results of the Ecology electronic textbook trial are presented in Table 9.

Table 9 Product Trial Aspect, Percentage, and Category

No.	Aspect	Percentage	Category
1.	One to One Trial	97	Highly Valid
2.	Small Group Trial	95	Highly Valid
3.	Field Trial	96	Highly Valid
	Average	**96**	Highly Valid

These individual trials were carried out with students from Offering D of the S1 Biology Education study program, Batch 2022, who had completed the Ecology course. The results of the individual trials showed a very practical outcome with a percentage of 97%. The developed book was considered very practical because it was easy for students to use, and its appearance (design, layout, illustrations) and content effectively helped achieve learning objectives. According to Al-Hawari, et al. (2021) the convenience of textbooks plays a significant role in enhancing motivation for both educators and learners engaged in the educational process. The practical trial findings suggest that students effectively comprehend and use the media and learning resources offered (Hanifah, et al., 2020). Positive feedback obtained from students during the individual trials included that the electronic textbook was excellent because the developed media was very good for dissemination as it contained a lot of information and instructions for use, and was easy to use. Adding learning videos to the electronic ecology

textbook being developed, so that students can more easily understand the material. According to Moonik, et al. (2020), learning videos are useful for clarifying material so that it can be clearly visualized, allowing students to replay videos as needed, and enabling flexible and independent learning processes.

This small group trial was conducted on 10 students from Offering D of the S1 Biology Education study program, Batch 2022, who had completed the Ecology course. The results of the small group trial were very practical with a percentage of 95%. Positive feedback obtained from students during the small group trial included that the content in the electronic textbook was rich and in-depth, not just text, but also videos, images, and articles, which made them more interested in understanding the material in the book. The addition of features like YouTube videos, hyperlinks, animated text, images, and audio in the textbook will increase students' appeal and interest in learning (Khairinal et al., 2021).

Field trials were conducted to determine the practicality of the revised electronic textbook and to gather feedback through student response questionnaires. The field trial was carried out in one class, Offering A of S1 Biology Education students, Batch 2023, who had completed the Ecology course. The results of the field trial were very practical with a percentage of 96%. Positive feedback obtained from students during the field trial included that the electronic textbook provided links to scientific articles, making it easy for them to explore topics further with just one click.

4. CONCLUSION

This research shows that the results of the material expert validation were categorized as very valid with a percentage of 100%, media and teaching materials validation at 92%, and Biology education practitioner validation at 96%. The product trial was very practical with a percentage of 96%. The developed Ecology electronic textbook is proven to be valid and practical for use in learning.

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6. REFERENCES

Afifulloh,M.,& Cahyanto, B.(2021). Analisis Kebutuhan Pengembangan Bahan Ajar Elektronik di Era Pandemi Covid-19. *Jurnal Pendidikan Dasar Indonesia*, *6* (2) :31-36.

Al-Hawari, F., Barham, H., Al-Sawaeer, O., Alshawabkeh, M., Alouneh, S., Daoud, M. I., & Alazrai, R. (2021). Methods to Achieve Effective Web Based Learning Management Modules: MyGJU versus Moodle. *PeerJ Computer Science*, 7, 498.

Anggyani, T. (2023). *Pengembangan E-Modul Berbasis Literasi Lingkungan Pada Materi Ekosistem Untuk Siswa SMP/MTs* Disertasi dipublikasikan. Riau: Universitas Islam Negeri Sultan Syarif Kasim

Anggono, W.A., & Setiawan,D. (2025). engembangan Media Flipbook Heyzine Terintegrasi Berbasis Masalah Belajar untuk MemberdayakanHasil Belajar Alami dan Sosial Siswa Sekolah Dasar. *Jurnal Pendidikan MIPA*, 26 (1), 280-304. http://dx.doi.org/10.23960/jpmipa/v26i1.pp280-304

Anasro, Insyirah, I., & El-yunusi, M. Y. M. (2023). Kreativitas Guru PAI dalam Mengembangkan Bahan Ajar di Madrasah Darut Taqwa 1 Watukosek Gempol Pasuruan. Impressive: Journal of Education, 1(3), 124–140. https://doi.org/10.61502/ijoe.v1i3.27.

Apriliani, L., Ramdani, A., Bahri, S., & Mahrus, M. (2022). Pengembangan LKPD Berbasis Inkuiri Terbimbing untuk MemberdayakanKeterampilan Proses Sains dan Hasil Belajar Biologi Peserta Didik Kelas X. *Jurnal Ilmiah Profesi Pendidikan*, 7(4), 2401–2411. https://doi.org/10.29303/jipp.v7i4.107.

Ariyatun, S, Wardani, S., Saptono, S., & Winarto. (2024). Bibliometric Analysis of Environmental Literacy in Sustainable Development: A Comprehensive Review Based on Scopus Data From 2013 to 2023. *International Journal of Educational Methodology*, *10*(1), 979-995.

Azizah, Y., Lathifah, Suci., & Hidayat, N. (2021). Pengembangan E-ensiklopedia Keanekaragaman Talas di Kabupaten Bogor Berbasis ESD untuk MemberdayakanLiterasi Digital Siswa. Pedagogia: *Jurnal Ilmiah Pendidikan*, 13(2), 52-56.

Baharsyah,A.F., Fauzi,M..Sabarudin., & Suprapni,Y. (2023). Kemampuan Mahasiswa dalam Menyelesaikan Soal-Soal Hots pada Materi Pai Sekolah/Madrasah. *Jurnal Tawadhu*, *7*(1), 1-11. https://doi.org/10.52802/twd.v7i1.519

Chaerani, C., Candramila, W., & Yeni, L. F. (2022). Pengembangan E-module Mengupas Tuntas Peranan Bakteri sebagai Bahan Ajar Materi Kingdom Monera Kelas X SMA. *Bioedusiana: Jurnal Pendidikan Biologi*, 7(1), 144-158. https://doi.org/10.37058/bioed.v7i1.4597.

D'Ambra, J., Akter., S., & Mariani,M. (2022).Digital Transformation of Higher Education in Australia: Understanding Affordance Dynamics in ETextbook Engagement and Use. Journal of Business Research, Elsevier,149, 283-295. https://doi.org/10.1016/j.jbusres.2022.05.048.

Febriani, R., Farihah, U., & Nasution, N.E.A. (2020). Adiwiyata School: An environmental care program as an effort to develop Indonesian students' ecological literacy. *Journal of Physics: Conference Series*. 1563. 012062. 10.1088/1742-6596/1563/1/012062.

Hanifah, H., Afrikani, T., & Yani, I. (2020). Pengembangan Media Ajar EBooklet Materi Plantae untuk Meningkatkan Hasil Belajar Biologi Siswa. *Journal Of Biology Education Research (JBER)*, *1*(1), 10-16. https://doi.org/10.55215/jber.v1i1.2631

Hariyadi, E., Maryani, E., & Kastolani, W. (2021). Analisis literasi lingkungan pada mahasiswa pendidikan geografi. Gulawentah: *Jurnal Studi Sosial*, *6*(1),1-16. https://doi.org/10.25273/gulawentah.v6i1.6685.

Hayati, N., & Azizah, Z. (2021). Bahan Ajar Elektronik Book Berbasis Kvisoft Flipbook Maker pada Mata Kuliah Penilaian Program PLS. *Journal of Nonformal Education and Community Empowerment*, *5*(2), 139-144. https://doi.org/10.15294/jnece.v5i2.50182.

Hills, D., & Thomas, G. (2019). Digital technology and outdoor experiential learning. *Journal of Adventure Education and Outdoor Learning*, *20*(2), 155–169. https://doi.org/10.1080/14729679.2019.1604244.

Humairah, E. (2022). Penggunaan Buku Ajar Elektronik (E-Book) Berbasis Flipbook Guna Mendukung Pembelajaran Daring di Era Digital. *Prosiding Seminar Nasional 1 Amal Insani Foundation*, 66-71. https://prosiding.amalinsani.org/index.php/semnas

Kgosiyame, K., & Eze,I.R.(2023). Examine the Immensity of Using E-Textbooks as Opposed to Hardcopy Textbooks by Learners in Botho University: in the 21st Century. *IJSAR Journal of Advancement in Education and Computing*, *7*(2), 234-246.

Khairinal, K., Suratno, S., & Aftiani, R. Y. (2021). Pengembangan Media Pembelajaran E-Book Berbasis Flip Pdf Professional untuk MemberdayakanKemandirian Belajar dan Minat Belajar Siswa Pada Mata Pelajaran Ekonomi Siswa Kelas X Iis 1 SMA NEGERI 2 Kota Sungai Penuh. *Jurnal Manajemen Pendidikan dan Ilmu Sosial*, *2*(1),458–470.

Laili, N. H., Pertiwi, N. A. S., & Ashoumi, H. (2024). Pengembangan Pengembangan Bahan Ajar Akhlak Berbasis Make a Match Kelas XI di MA Al Bairuny Jombang. *JoEMS (Journal of Education and Management Studies)*, 7(3), 90–100. https://doi.org/10.32764/joems.v7i3.1161.

Lee, W., & Owens, L.D. 2004. *Multimedia Based Instructional Design, Second Edition*. San Francisco, CA: John Wiley & Sons, Inc.

Lim, B., Liu, L., & Chian Hou, C. (2020). Investigating the Effects of Interactive E-Book towards Academic Achievement. Asian Journal of University Education, 16(3), 78-88. https://doi.org/10.24191/ajue.v16i3.10272

Moonik, J., Tampang., Takaradase., & Agustinus. (2022). Pengembangan Konten Video Pembelajaran Instalasi Penerangan Listrik di SMKN 1 Tumpaan. *JURNAL EDUNITRO Jurnal Pendidikan Teknik Elektro*. 2. 97-104. 10.53682/edunitro.v2i2.4246.

Mursyd, D., Suhadi, S., & Fatchur Rohman, F. R. (2023). Efektivitas Buku Ajar Komunitas Serangga Berbasis *Problem based learning* Terhadap Keterampilan Literasi Sains dan Sikap Peduli Lingkungan Mahasiswa. *BIODIK*, *9*(2), 50-56. https://doi.org/10.22437/biodik.v9i2.26611.

Nasution, R. (2021). Analisis tingkat literasi lingkungan mahasiswa FKIP Universitas Mulawarman dengan transformasi skor NELA (National Environmental Literacy Assessment). *Jurnal Ilmiah BioSmart (JIBS)*, *7*(1), 38-51. https://doi.org/10.30872/jibs.v1i1.423.

NELA. (2011). *National Environmental Literacy Assessment, Phase Two: Measuring the Effectiveness of North American Environmental Education Programs with Respect to the Parameters of Environmental Literacy*. Sub. Environment Education Division Grant#NA08SEC4690026.

Ningrum, D. E. A. F., Khasani, F., Rosi, R. I., Priatmoko, S., & Sugiri, W. A. (2021). *Pendidikan Abad 21: Interpretasi, Edukasi, dan Aksi* (1st ed.). Edulitera.

Nugraha, A.G., Siahaan,S.M.,& Hartono. (2025). Mengintegrasikan Teknologi Website dalam Sistem Penyimpanan Bahan Ajar untuk Pendidikan Modern. *Jurnal Inovasi Penelitian Pendidikan dan Pembelajaran, 5*(1): 337- 345.

Nurjannah., Al Muhdhar,M.H.I., Dharmawan,A., Achmad,R.,& Asfany,L. (2023). The Correlation Between Digital Literacy and Collaboration Skill with Environmental Literacy of Class X Students of SMAN2 Malang. *BIOEDUKASI: Jurnal Biologi dan Pembelajarannnya*, 21(3), 228-240.

Puteri, D. A. R., Ibrahim, N., & Priyono. (2023). Increase Student Activity Through The Use of Interactive Learning Videos in Civics Learning during the Study From Home. Journal of Educational Research and Evaluation, 7(2), 313–320. https://doi.org/10.23887/jere.v7i2.38784.

Prasetyo,M.D., Hamdani,M.T., Vintoko,Y., Aufa, A.M., Utomo,A.P.Y.,& Mijianti.Y. (2023). Analisis Kalimat pada Teks Cerita Sejarah dalam Buku Sosiologi Kelas XI Kurikulum Merdeka. *Student Scientific Creativity Journal, 1*(5), 30–57. https://doi.org/10.55606/sscj-amik.v1i5.1803.

Priyambodo,A.S., Budiman,F.R.,& Husnadi,M. (2022). Pembuatan Media Pembelajaran Digital Fisika Berbasis Web Applicationpada Platform Androiddengan Pendekatan Saintifik pada Siswa SMAKelas X pada Materi Gerak Parabola. *PROSIDING Seminar Nasional Pendidikan Fisika FITK UNSIQ,3*(1): 20-35.

Radović, S., Radojičić, M., Veljković, K., & Marić, M. (2020). Examining the effects of Geogebra applets on mathematics learning using interactive mathematics textbook. *Interactive Learning Environments*, *28*(1), 32-49. https://doi.org/10.1080/10494820.2018.1512001.

Rafidah, H. N., Rachmadiarti, F., & Prastiwi, M. S. (2024). Stepping together with nature of Malang Raya: The Development Environmental Changes EBook Based on Problem-Based Learning (PBL). Jurnal Penelitian Pendidikan IPA, 10(7), 3556–3568. https://doi.org/10.29303/jppipa.v10i7.7377.

Rahmawati, D.E., & Trimulyono, G. (2021). Validitas Pengembangan Instrumen Penilaian HOTS Berbasis Kurikulum 2013 Terhadap Sikap Disiplin. *Berkala Ilmiah Pendidikan Biologi (BioEdu), 11 (1), 141*.

Rokhmah, Z., & Fauziah, A. N. M. (2021). Analisis literasi lingkungan siswa SMP pada sekolah berkurikulum wawasan lingkungan. Pensa E-Jurnal : Pendidikan Sains, 9(2), 176–181. https://ejournal.unesa.ac.id/index.php/pensa/article/view/37765/33947.

Royani, E., & Atun, S. (2023). Development of Guided Inquiry-Based E-Modules on Acid and Alkaline Solutions to Improve Critical Thinking Skills and Scientific Attitudes of High School Students. *Jurnal Penelitian Pendidikan IPA*, 9(10), 8764–8771. https://doi.org/10.29303/jppipa.v9i10.4798.

Sulisetijono. (2018). *Bahan Ajar Matakuliah: Statistika untuk Ilmu Biologi dan Ilmu-ilmu yang Bertautan*. Malang: FMIPA Universitas Negeri Malang.

Syahroni, M., & Suwidagdho,D. (2024). Kelayakan Pengembangan Modul Mata Kuliah Profesi Kependidikan Menggunakan Pendekatan Pembelajaran Berbasis Kasus. Jurnal Pendidikan, *12*(1), 29-38.

Sukri, A. (2023). Enculturation of Lombok Coastal Local Wisdom in PBL as A Conservation Learning Strategy to Improve Students' Environmental Literacy. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6733–6741. https://doi.org/10.29303/jppipa.v9i8.5744.

Suryawati, E., Suzanti, F., Zulfarina, Putriana, A. R., & Febrianti, L. (2020). The implementation of local environmental problem-based learning student worksheets to strengthen environmental literacy. *Jurnal Pendidikan IPA Indonesia*, *9*(2) ,169–178. https://doi.org/10.15294/jpii.v9i2.22892.

Taufiq, I., & Agustito, D. (2021). Uji Kelayakan Modul Trigonometri Berbasis Ajaran Tamansiswa. Mosharafa: *Jurnal Pendidikan Matematika*, *10*(2), 281–290. https://doi.org/10.31980/mosharafa.v10i2.895.

Wajdi, M., Jamaluddin, A.B., Nurdiyanti., & Maghfirah, N. (2022). The effectiveness of problem-based learning with environmental-based comic in enhancing students environmental literacy. *International Journal of Evaluation and Research in Education (IJERE)*, 11. 1049. Doi.10.11591/ijere.v11i3.22140.

Wati, D.D.E. (2021). Validitas Buku Panduan Penyusunan Rencana Pelaksanaan Pembelajaran (RPP) yang Terintegrasi Kecakapan Abad 21. *Physics and Science Education Journal (PSEJ*), 1(3), 108-115.

Wulandari, W.T., Mayub, A., & Johan, H. (2022). Pengembangan E-Modul Berbasis Analisis Parameter Fisis Air Sungai untuk MemberdayakanLiterasi Lingkungan Peserta Didik. JIPVA (Jurnal Pendidikan IPA Veteran), 6(2), 103-115. https://ejournal.ivet.ac.id/index.php/jipva/article/view/2290

Yasa, A. D. (2018). Pengembangan Modul Tematik Berbasis STM (Sains, Teknologi dan Masyarakat). *Jurnal Pemikiran dan Pengembangan* SD, *6*(1), 21–26.

Yeh, F.Y., Tran, N.H., Hung, S. H., & Huang, C.F. (2022). A Study of Environmental Literacy, Scientific Performance, and Environmental Problem-Solving. *International Journal of Science and Mathematics Education*, *20*(8), 1883–1905. https://doi.org/10.1007/s10763-021- 10223.

Yeyendra, Y., Mellisa,M., Hajar, I., Puspitasari, S., & Santika, R.(2024). Model online *problem based learning* (E-PBL) terintegrasi etnoEkologi untuk memberdayakanliterasi lingkungan mahasiswa pendidikan biologi. Asatiza: *Jurnal Pendidikan*, *5*(1), 61-68. https://doi.org/10.46963/asatiza.v5i1.1690.

Zaputra, R., Festiyed, F., Adha, Y., & Yerimadesi, Y. (2021). Meta-Analisis: Validitas Dan Praktikalitas Modul Ipa Berbasis Saintifik. *Bio-Lectura*, *8*(1), 45–56. https://doi.org/10.31849/bl.v8i1.6039.