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Development of a Rare Flora and Fauna Booklet on the Toba Caldera to Enhance the Knowledge Dimension of Ecoliteracy among Senior High School Students

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Abstract: This study aimed to examine the feasibility and effectiveness of a booklet on the rare flora and fauna of the Toba Caldera as instructional material for biodiversity topics. The study employed a Research and Development (R&D) approach using the 4D model, which consists of the Define, Design, Develop, and Disseminate stages. The feasibility of the booklet was assessed based on expert validation, teacher responses, and student responses, while its effectiveness was evaluated using the Mann–Whitney test and N-Gain analysis. The feasibility results indicated that the booklet was categorized as very good based on expert validation. Teacher responses were also rated very good, with a score of 96.25%, and student responses in each trial likewise fell within the very good category. The effectiveness test conducted on students at SMAN 1 Lumban Julu showed an N-Gain value of 0.68, which was categorized as moderate. The Mann–Whitney test indicated a significant difference in ecological literacy knowledge between the experimental and control classes on the posttest, with a probability value of 0.00 < 0.05. In addition, students' biodiversity ecoliteracy knowledge reached 86.64%, which was classified as high. Therefore, the developed booklet is effective in improving students' ecological literacy knowledge and is feasible for use as a supplementary teaching material in biodiversity learning by utilizing local potential as a learning resource.
Keywords: Booklet; flora and fauna; rare species; biodiversity; ecoliteracy

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INTRODUCTION

Humans are closely interconnected with the natural environment, as each influences the other both directly and indirectly. Therefore, natural resources must be managed wisely, appropriately, and sustainably to ensure the survival of living organisms and the maintenance of ecosystem balance (Wardhani et al., 2018). However, various human activities have caused substantial negative impacts on the environment. One of the major problems is the continuous degradation of forests each year, driven by global climate change, biological invasions, environmental pollution, and deforestation. In addition, habitat loss, environmental contamination, and excessive exploitation of natural resources directly contribute to species decline, disruption of ecosystem balance, and low public awareness of the importance of environmental preservation (Xu & Zang, 2023).

These conditions call for sustained mitigation and conservation efforts, one of which can be pursued through education. Environmental education aims to enhance students' environmental awareness and their capacity to identify solutions to environmental problems (Wardani et al., 2018). In the context of biology education, the global issue of biodiversity decline is an essential topic that should be integrated into the learning process. This integration is necessary so that students develop not only scientific understanding but also ecological awareness. Such efforts are particularly important for Indonesia, a megabiodiversity country with exceptionally rich biological

resources that simultaneously faces serious threats to the conservation of its biodiversity (Manullang et al., 2025; Setiadi et al., 2023).

Biodiversity ecoliteracy refers to efforts to improve the awareness and understanding of students and the wider community regarding biodiversity, while also encouraging attitudes and behaviors that support conservation and the sustainable management of natural resources (Katili et al., 2022). Lewinsohn et al. (2015) stated that ecoliteracy is the awareness required to make informed decisions and take action in addressing environmental problems. In essence, ecoliteracy refers to an individual's ability to recognize and understand the interconnectedness of life systems on Earth; in other words, it involves understanding the fundamental relationship between humans and nature in order to build the public intelligence and awareness needed to support and realize sustainable development (Muliana et al., 2017).

Under the *Merdeka* Curriculum, biodiversity learning is expected to be contextual, relevant to real life, and based on local potential as a source of learning (Gusti et al., 2024). Learning grounded in local potential enables students to relate biological concepts to the environmental conditions surrounding them. One alternative solution to address this need is the development of learning media based on local potential (Dewi et al., 2020; Hoiroh & Isnawati, 2020). A booklet is one type of supplementary instructional material that can complement the main textbook. Through the development of booklet-based learning media, students are expected to strengthen their critical thinking skills, environmental analytical abilities, and sense of responsibility toward the conservation of natural resources as part of the *Pancasila Student* profile (Ramadhani et al., 2024).

The Toba Caldera is an area of high geological and biodiversity value and serves as a habitat for various endemic flora and fauna. The presence of these biological resources in the area holds not only ecological value but also important educational value in enhancing students' knowledge and awareness of biodiversity. However, increasing resource utilization activities in the Toba Caldera, without adequate consideration of its natural functions and ecological roles, have become a threat to environmental sustainability. If this condition continues, it may disrupt ecosystem balance, threaten the existence of endemic flora and fauna, and reduce the biological richness that characterizes the Toba Caldera. Therefore, the Toba Caldera is highly relevant as a contextual example in biodiversity and conservation learning.

Previous studies on the development of learning media have generally focused on students' literacy learning outcomes, but research remains limited regarding biodiversity knowledge ecoliteracy related to the Toba Caldera. Therefore, this study is important because it aims to enhance knowledge-based ecoliteracy through the use of booklet learning media containing information on rare flora and fauna in the Toba Caldera area as supplementary teaching material.

METHOD

This study employed a Research and Development (R&D) approach using Thiagarajan's 4D model, which consists of Define, Design, Develop, and Disseminate. This model is intended to produce a specific educational product that requires prior testing before implementation (Semiawan, 2007).

The subjects involved in this study included expert validators in subject matter, instructional design, and layout design. Product trials and response assessments were conducted with one teacher, 36 students in the control class, and 36 students in the experimental class from SMAN 1 Lumban Julu, using a quasi-experimental design with

a pretest-posttest control group design. The object of this study was a booklet on rare flora and fauna in the Toba Caldera Geopark area.

The research instrument used to measure ecological literacy knowledge related to biodiversity was a learning achievement test consisting of 30 items. The instrument met both validity and reliability requirements. For the test variables, the significance values were Sig < 0.05, and the calculated correlation coefficients were greater than the table value (r-count > r-table = 0.3291). The reliability test yielded a Cronbach's Alpha > 0.6. Therefore, all test items satisfied the validity and reliability criteria and were considered appropriate for use in this study.

The data analysis techniques used in this study included both descriptive and inferential analysis (Sofwatillah et al., 2024). The data comprised qualitative information obtained from the developed booklet on rare flora and fauna of the Toba Caldera, as well as validation results from subject matter experts, graphic design experts, instructional design experts, and responses from the biology teacher and Grade X students of SMAN 1 Lumban Julu. These data were then summarized using descriptive quantitative analysis rather than hypothesis testing. Product feasibility testing was conducted to obtain information regarding the suitability of the developed product as a learning resource. The collected data were measured using a four-level Likert scale, as presented in Table 1.

Table 1. Criteria for determining validation scores and teacher and student responses

Percentage	Score	Criteria
78–100	4	Very Feasible
52–77	3	Feasible
26–51	2	Less Feasible
0–25	1	Not Feasible

(Source: Nasution et al., 2023)

The data were then accumulated using descriptive quantitative analysis based on the following feasibility percentage formula:

Percentage Score = (Total Score Obtained / Total Possible Score) × 100

Product effectiveness testing was conducted to determine the effectiveness of the developed product when applied in actual classroom learning. The study involved two class groups, namely the experimental class and the control class. Effectiveness was evaluated using a pretest-posttest control group design.

Table 2. N-Gain score criteria

N-Gain Value	Category	Criteria
$g > 0.7$	High	Effective
$0.3 \leq g \leq 0.7$	Moderate	Moderately Effective
$g < 0.3$	Low	Ineffective

(Source: Dede et al., 2025)

RESULTS AND DISCUSSION

Based on the findings of this study, the results and discussion on the development of the *Rare Flora and Fauna of the Toba Caldera* booklet are presented according to the stages of Thiagarajan's 4-D model, namely: define, design, develop,

and disseminate (Novianti & Syamsurizal, 2021). The research findings are described as follows.

Define Stage

The analysis at this stage aimed to establish the underlying problem. Learning about biodiversity had only been conducted in the classroom using printed media; consequently, students' ecoliteracy regarding rare biodiversity remained general in nature and required a more specific guidebook. The analysis of the learning objectives for biodiversity materials was intended to examine the rare flora and fauna of the Toba Caldera and their conservation efforts, as students experienced difficulties in achieving these learning objectives. Therefore, students needed additional learning resources based on local potential, specifically concerning the biodiversity of rare flora and fauna in the Toba Caldera area, to provide supplementary information beyond that available in standard textbooks.

Design Stage

The design stage aimed to develop the *Rare Flora and Fauna of the Toba Caldera* booklet as a learning resource. The booklet content was based on research findings concerning the biodiversity of rare flora and fauna in the Toba Caldera, obtained through direct observation and literature review. The initial design of the *Rare Flora and Fauna of the Toba Caldera Geopark* booklet consisted of: (1) front cover, (2) preface, (3) table of contents, (4) list of figures, (5) introduction to the Toba Caldera, (6) main material content, (7) glossary, (8) references, and (9) author biography.

Figure 1. Booklet design

Develop Stage

The development stage was intended to determine the feasibility of the designed product for further development. The booklet was validated by a team of validators consisting of a material expert, a learning design expert, and a layout design expert in order to obtain suggestions, input, comments, and revisions from each validator so that the final product could be improved. Subsequently, responses were also collected from a biology teacher and from students through individual trials involving 3 students, small-group trials involving 9 students, and limited-group trials involving 21 students. The data obtained from the questionnaire assessment sheets were then analyzed and interpreted qualitatively.

Validation Results by Experts

The validation results of the *Rare Flora and Fauna of the Toba Caldera* booklet are presented below.

Validation by Material Expert

The average percentage scores from the material expert team for each component are presented in Table 3.

Table 3. Material expert validation results

No	Assessment Aspect	Percentage	Criteria
1	Material relevance	91.66	Very Good
2	Originality and accuracy of the material	83.33	Very Good
3	Currency of the material	100	Very Good
4	Sources of the material	100	Very Good
5	Presentation technique	91.66	Very Good
6	Presentation feasibility	95.83	Very Good
	Average	**93.74**	**Very Good**

Based on Table 3, the overall feasibility percentage for the presentation aspect validated by the lecturer was 93.74%. Across all six categories, the booklet was classified as very good and declared valid. Therefore, the developed booklet was considered feasible and suitable for use as a supplementary book in learning activities.

Validation by Learning Design Expert

The average percentage scores from the learning design expert team for each component are presented in Table 4.

Table 4. Learning design expert validation results

No	Assessment Aspect	Percentage	Criteria
1	Concept depth	90.62	Very Good
2	Material accuracy	91.6	Very Good
3	Presentation technique	100	Very Good
4	Sentence clarity	100	Very Good
5	Completeness of presentation	100	Very Good
6	Language use	95.8	Very Good
7	Book efficiency in learning	90.62	Very Good
	Average	**95.52**	**Very Good**

The validation results from the learning design expert team showed that the booklet met the very good criterion, with an overall average score of 95.52% across all aspects. Thus, the rare flora and fauna booklet was considered appropriate for use as an interactive learning medium.

Validation by Layout Design Expert

The validation results from the layout design expert for each component are presented in Table 5.

Table 5. Layout design expert validation results

No	Assessment Aspect	Percentage	Criteria
1	Cover design	83.33	Very Good
2	Book design	75	Good

No	Assessment Aspect	Percentage	Criteria
3	Typography	87.5	Very Good
4	Physical appearance	75	Good
	Average	**80.20**	**Good**

The assessment by the layout design expert yielded a score of 80.20%, which fell into the good category. The conclusion and suggestion provided by the layout design expert indicated that the booklet was feasible and suitable for use in learning. A booklet with an attractive appearance can enhance students' interest in learning and support their understanding of the material (Sarip et al., 2022).

Biology Teacher's Response

The average percentage scores from the teacher response calculation are presented in Table 6.

Table 6. Response of the biology subject teacher

No	Assessment Aspect	Percentage	Criteria
1	Material content	93.75	Very Good
2	Language	100	Very Good
3	Presentation	95	Very Good
	Average	**96.25**	**Very Good**

Based on the teacher's response, the booklet received a very good rating on all assessed aspects. Overall, the average score reached 96.25%, indicating that the booklet was highly suitable for use as a learning medium. These results show that the developed booklet received a very positive response from the teacher. The study by Situmorang et al. (2025) similarly showed that the teacher response test for the booklet reached 96.8%, categorized as very positive and highly feasible for use. It can therefore be concluded that the booklet developed in this study was also valid and received a highly positive response from the teacher.

Students' Response

In addition to the teacher's response, student responses were also collected to determine the feasibility of the *Rare Flora and Fauna of the Toba Caldera* booklet distributed at SMA Negeri 1 Lumban Julu. Individual trials, small-group trials, and limited-group trials were conducted to identify students' direct responses to the booklet, as illustrated in Figure 2.

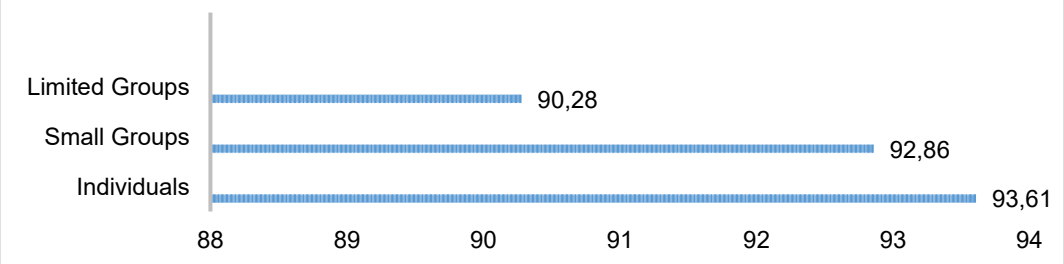

Figure 2. Graph of student response results at SMAN 1 Lumban Julu

The individual trial results showed that the booklet received a very good response from students, indicating that it was suitable for use in the learning process. After the

Rare Flora and Fauna of the Toba Caldera booklet had passed the validation stage and been revised according to suggestions from the material expert, layout design expert, and learning expert, as well as based on teacher and student responses, the next step was the effectiveness test. This test was intended to determine the effectiveness of the product in improving students' ecoliteracy knowledge before and after implementation.

Disseminate Stage

The dissemination stage was the final stage of this study. This stage aimed to determine the extent of differences in students' ecoliteracy knowledge outcomes when using the developed booklet and to assess the effectiveness of the booklet. The data analyzed consisted of the pretest and posttest results of students from classes X-A and X-B at SMAN 1 Lumban Julu. To measure differences between the pretest and posttest results, several statistical tests were conducted, namely normality and homogeneity tests. The normality test was used to determine whether the collected data were normally distributed. Normality was assessed using the Kolmogorov–Smirnov test (Oktavia & Teja, 2019). The results of the normality and homogeneity tests showed that the data were neither normally distributed nor homogeneous. Therefore, a non-parametric test, namely the Mann–Whitney test, was used to examine differences in students' ecoliteracy knowledge between the control and experimental classes.

1. Pretest and posttest results

At the beginning of the learning process, both groups of students, namely the control class and the experimental class, were given the same pretest questions to identify their initial abilities. The conditions of both classes at the initial stage were similar; therefore, no significant difference was observed. At the end of the learning process, a posttest was administered to examine the effect of using the *Rare Flora and Fauna of the Toba Caldera* booklet in the experimental class, whereas the control class used only the school textbook. However, because the posttest data were not normally distributed and not homogeneous, a non-parametric Mann–Whitney test was conducted. The analysis yielded a Mann–Whitney value of 17.000 with a probability value of 0.00, indicating a significant difference in ecoliteracy knowledge between the experimental and control classes. These results demonstrate that the use of the *Rare Flora and Fauna of the Toba Caldera* booklet in the experimental class was more effective than learning in the control class.

These findings are consistent with the study by Adriana et al. (2024), which reported a significant difference between students' pretest and posttest results regarding the effectiveness of a local potential-based booklet learning medium on biodiversity material in Grade X. This was also evidenced by the Mann–Whitney U result at a significance level of 0.5, which yielded a significance value of 0.005. Widuri & Ristiono (2025) also found that contextual learning, such as that implemented through a booklet on virus material, could improve students' understanding of the subject matter.

2. Students' ecoliteracy knowledge results

The data obtained in this study were in the form of total scores for students' ecoliteracy knowledge, measured from the cognitive aspect through pretest and posttest questions. These scores were then classified into three levels, namely high, moderate, and low (McBeth et al., 2008). The results of the descriptive statistical analysis of the total ecoliteracy knowledge scores of students at SMAN 1 Lumban Julu are presented in Table 7.

Table 7. Students' ecoliteracy knowledge results

No	Ecoliteracy Knowledge	Group	N	Mean	SD	Criteria
1	Pretest score	Control	36	53.36	7.52	Moderate
		Experimental	36	50.00	6.88	Moderate
2	Posttest score	Control	36	67.78	6.53	Moderate
		Experimental	36	86.64	4.90	High

Based on the statistical analysis presented above, it can be seen that the mean ecoliteracy knowledge score of students who used the *Rare Flora and Fauna of the Toba Caldera* booklet at SMAN 1 Lumban Julu increased to $\bar{x}$ = 86.64, which falls into the high category. In essence, the learning process in the experimental class used the booklet as a supplementary learning resource, whereas the control class used only the textbook.

3. N-Gain test results

The N-Gain test was conducted to determine the effectiveness of the *Rare Flora and Fauna of the Toba Caldera* booklet in improving students' biodiversity ecoliteracy knowledge. The N-Gain score was calculated by measuring the difference between the pretest and posttest scores. The N-Gain test results for students at SMAN 1 Lumban Julu are presented in Table 8.

Table 8. N-Gain test results at SMAN 1 Lumban Jul**u**

Class	N-Gain Score	Category	Criteria
Experimental	0.7	High	Effective
Control	0.2	Low	Ineffective

Based on the N-Gain analysis, there was a difference in students' ecoliteracy knowledge between the experimental and control classes at SMAN 1 Lumban Julu. The N-Gain score in the control class was 0.2, indicating that the learning process was ineffective. Meanwhile, the experimental class obtained an N-Gain score of 0.7, indicating that the use of the *Rare Flora and Fauna of the Toba Caldera* booklet was effective, as the booklet specifically presented material on the biodiversity of rare flora and fauna in the Toba Caldera area. This finding supports previous studies by Situmorang et al. (2025) and Idrus et al. (2023), which showed that the use of active learning media, such as booklets, is effective in improving students' ecoliteracy knowledge. Based on these data, it can be concluded that the use of the *Rare Flora and Fauna of the Toba Caldera* booklet was effective in improving students' ecoliteracy knowledge.

CONCLUSION

Based on the results of this study, it can be concluded that the developed *Rare Flora and Fauna of the Toba Caldera* booklet is feasible for use as a biology learning resource because it can improve students' ecoliteracy knowledge regarding the biodiversity of rare flora and fauna in the Toba Caldera. This feasibility is supported by the assessments of experts, teachers, and students, all of which fell into the very good category. In addition, the booklet was proven effective in improving students' ecoliteracy knowledge, as indicated by the increase in ecoliteracy knowledge to $\bar{x}$ = 86.64 and the significant difference between the class that used the booklet and the

class that did not. Therefore, this booklet can be utilized as a learning resource that supports a more effective biology learning process.

RECOMMENDATION

In addition to literature-based compilation, the development of the *Rare Flora and Fauna of the Toba Caldera* booklet requires further research based on field studies to strengthen the information on rare flora and fauna species in the study area, thereby improving the quality and completeness of future editions of the booklet.

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