Journal of Sustainability and Community Engagement

DOI: https://dx.doi.org/10.xxxxx/josuce.v1i1.43

Journal homepage: https://journal.sahabat-cendekia.com/index.php/josuce

Design and Evaluation of IbisPaint-Assisted Digital Comic to Strengthen Fifth-Grade Students' Ecoliteracy

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a r t i c l e i n f o

Article history:
Received: May 21, 2026
Received in revised form: July 22, 2026
Accepted: July 22, 2026
Available online: July 27, 2026

Keywords:
Digital comics;
IbisPaint;
Ecoliteracy;
ADDIE model;
Elementary school.

Published by Sahabat Cendekia Indonesia Publisher in Collaboration with the Center for Scientific Publications and Rankings Universitas Islam Negeri Siber Syekh Nurjati Cirebon, Indonesia.

a b s t r a c t

Background: Strengthening ecoliteracy from an early age is important to help students understand, care for, and apply behaviors that support environmental sustainability.
Aims: This study aims to design and evaluate of IbisPaint-assisted digital comic media that are valid, practical, and effective for strengthening fifth-grade students' ecoliteracy.
Methods: This study employed a Research and Development (R&D) method using the ADDIE model, which consists of the Analysis, Design, Development, Implementation, and Evaluation stages. The research subjects included one media expert, one material expert, one education practitioner, and involving 23 fifth-grade students at Public Elementary School 05 Indralaya, Ogan Ilir Regency, South Sumatera Province. Data were collected through observation, interviews, questionnaires, and tests. Validity and practicality data were analyzed using percentages, whereas media effectiveness was analyzed using the N-Gain score.
Results: The results showed that the IbisPaint-assisted digital comic learning media achieved a validity level of 96.73%, categorized as highly valid. The practicality test yielded a percentage of 95.57%, categorized as highly practical, indicating that the media were easy to use and received positive responses from students. Meanwhile, the effectiveness test produced an N-Gain score of 0.66, categorized as moderate, indicating an improvement in students' ecoliteracy after using the media. The highest improvement occurred in the knowledge aspect, with an N-Gain score of 0.72, followed by the care aspect at 0.64 and the practical competence aspect at 0.58.
Conclusion: Based on these results, the IbisPaint-assisted digital comic learning media were found to be valid, practical, and effective for strengthening ecoliteracy among elementary school students.

How to cite this article: Meardahena, P. L., Suratmi, S., & Susiloningsih, E. (2026). Design and evaluation of IbisPaint-assisted digital comic to strengthen fifth-grade students' ecoliteracy. *Journal of Sustainability and Community Engagement*, *1*(1), 24-40. https://dx.doi.org/10.xxxx/josuce.v1i1.43

1. Introduction

Education plays a strategic role in preparing generations capable of facing various global challenges, including increasingly complex environmental problems (Astuti, 2024). Issues such as environmental pollution, ecosystem degradation, and climate change indicate that students' awareness of the importance of protecting the environment still needs to be improved (Casfian et al., 2024). Therefore, education not only functions to develop students' academic abilities

but also plays a role in shaping character, attitudes, and behaviors that are responsible toward the environment (Suryanda et al., 2023). This effort can be carried out by strengthening ecoliteracy from the elementary education level (Rahayu et al., 2025).

Ecoliteracy refers to an individual's ability to understand basic ecological principles and apply them in everyday life as a form of environmental responsibility (Tyas et al., 2022). Ecoliteracy includes not only environmental knowledge but also aspects of care and practical competence in maintaining environmental sustainability (Taufik et al., 2024). Students with good ecoliteracy are expected to understand the relationship between humans and the environment, recognize the impacts of human activities on ecosystems, and apply behaviors that support environmental conservation in daily life. Strengthening ecoliteracy is important because elementary school is the initial stage of character formation among students. At this level, students begin to develop an understanding of their surrounding environment and form habits that will influence their behavior in the future (Ramadhan & Surjanti, 2022). Therefore, learning that integrates environmental values needs to be designed in an engaging manner and aligned with the developmental characteristics of elementary school students (Rahayu et al., 2025). One subject closely related to strengthening ecoliteracy is Natural and Social Sciences (IPAS), particularly the topics of ecosystems and food chains (Senda et al., 2023). These topics provide students with opportunities to understand interactions among living organisms and the importance of maintaining environmental balance.

However, the implementation of IPAS learning in elementary schools still faces various challenges. Based on observations and interviews conducted at Public Elementary School (SD Negeri) 05 Indralaya, Ogan Ilir Regency, South Sumatera Province, learning is still dominated by the use of textbooks and lecture-based methods. This condition makes students less active in the learning process and causes difficulties in understanding abstract concepts (Lestari & Suriani, 2025). In addition, the learning media used have not been able to visualize the material in an engaging way, resulting in low student interest in learning. Consequently, the learning process has not been optimal in supporting the strengthening of students' ecoliteracy.

The characteristics of elementary school students, who tend to enjoy pictures, colors, stories, and engaging activities, indicate that innovative learning media are highly needed (Dihyah, 2021). Learning media function as tools that can help teachers deliver material more effectively and facilitate students' understanding of the concepts being learned (Widari & Putra, 2022). The use of appropriate media can not only improve students' learning outcomes but also increase their motivation, attention, and involvement throughout the learning process.

The development of digital technology provides opportunities for teachers to create more creative and interactive learning media (Lasaiba, 2023). The use of technology in learning can help create learning experiences that are more engaging and aligned with the characteristics of today's digital generation (Rosiyani et al., 2024). One form of digital media that can be used in learning is digital comics. Digital comics are learning media that combine visual and verbal elements in story form, enabling information to be presented in an attractive and easily understood manner (Sapanca, 2021). Presenting material through images, illustrations, dialogue, and storylines can help students transform abstract concepts into more concrete understandings.

Digital comics have several advantages over conventional learning media. The use of attractive images and colors can increase students' attention to learning materials (Fitri et al.,

2024). In addition, contextual storylines can help students connect learning materials with experiences they encounter in everyday life (Anatasya et al., 2024). Through digital comics, students do not merely receive information passively but are also actively involved in understanding the story content and the messages conveyed (Miranda & Dafit, 2024). Therefore, digital comics have the potential to become effective media for supporting IPAS learning while strengthening students' ecoliteracy. In this study, the digital comic was designed and developed using IbisPaint. IbisPaint is a digital design application that provides various features for creating illustrations, characters, and attractive visual displays (Setiani et al., 2021). The use of this application makes it possible to produce learning media that align with the characteristics of elementary school students. In addition, the resulting media can be accessed digitally, making them more flexible for use in various learning situations (Dihyah, 2021). The integration of ecosystem and food chain materials into digital comics is expected to help students understand environmental concepts more easily while also increasing their care for the surrounding environment.

Previous studies have shown that digital comic media have strong potential to improve the quality of learning. Research indicates that the development of e-comics using the Ibis Paint X application achieved a high level of validity and was effective for use in learning (Alyas et al., 2023). Other studies have also shown that digital comics can increase students' motivation, learning outcomes, and engagement during the learning process (Widhinata & Ganing, 2022). Furthermore, digital-based learning media are considered more suitable for students' characteristics in the era of technological development because they can provide more interactive and enjoyable learning experiences. Nevertheless, previous studies on digital comic-based learning media have primarily focused on improving students' learning achievement, reading literacy, motivation, or conceptual understanding. Only a few studies have explored the use of digital comics to strengthen ecoliteracy, particularly by integrating the dimensions of ecological knowledge, environmental care, and practical environmental competence. Furthermore, the use of IbisPaint as a platform for developing digital comics that specifically promote ecoliteracy among elementary school students has received little attention. These limitations indicate a clear research gap that warrants further investigation. Most previous studies have focused on improving students' learning outcomes or literacy without comprehensively integrating ecoliteracy aspects. In addition, studies that utilize IbisPaint as a tool for developing learning media to strengthen ecoliteracy among elementary school students are still scarce. This condition indicates a research gap that needs further investigation.

Based on this research gap, the present study offers a unique contribution by developing an IbisPaint-assisted digital comic that not only delivers ecosystem learning content but also integrates the three core dimensions of ecoliteracy—ecological knowledge, environmental care, and practical environmental competence—into interactive digital storytelling. Unlike previous digital comic-based learning media that primarily emphasize cognitive learning outcomes, the proposed media are specifically designed to foster students' ecological understanding, environmental awareness, and environmentally responsible behavior simultaneously.

Therefore, the developed media are expected to provide a more meaningful learning experience that supports Education for Sustainable Development (ESD). This study aims to develop and evaluate an IbisPaint-assisted digital comic learning medium that is valid, practical, and effective in strengthening fifth-grade students' ecoliteracy. The media developed

do not merely focus on improving students' understanding of environmental concepts but are also designed to foster their care and practical competence in protecting the environment. Thus, the developed media are expected to contribute to creating more meaningful learning that is oriented toward sustainable development. This study aims to develop IbisPaint-assisted digital comic learning media that are valid, practical, and effective in strengthening ecoliteracy among fifth-grade elementary school students. The results are expected to serve as an innovative alternative learning medium for teachers in IPAS learning and to contribute to the development of technology-based learning media that support the strengthening of students' environmentally caring character.

2. Methods

2.1 Research design

This study employed a Research and Development (R&D) method using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2019). The ADDIE model was selected because it provides systematic development procedures and is appropriate for producing learning products that are valid, practical, and effective (Sagita, 2025). The product developed in this study was an IbisPaint-assisted digital comic intended to strengthen ecoliteracy among elementary school students.

2.2 Research procedure

The research procedure was carried out through the five stages of the ADDIE model. In the analysis stage, the researcher conducted a needs analysis through observation and interviews with the teacher. This activity aimed to identify learning problems, analyze the curriculum used, examine available learning media, and determine students' characteristics as the basis for product development. The design stage involved preparing the digital comic design, including determining learning objectives, selecting materials, integrating ecoliteracy aspects, preparing the storyline (storyboard), designing the media display, and developing research instruments used to measure product validity, practicality, and effectiveness. In the development stage, the digital comic was created using the IbisPaint application. The initial product was then validated by material experts, media experts, and education practitioners. Feedback and suggestions from the validators were used as the basis for revising and refining the product before it was tested. The implementation stage was conducted through gradual product trials, including individual trials, small-group trials, and field trials. At this stage, students used the digital comic in learning activities and then provided responses to the media used. The evaluation stage was carried out continuously at each stage of development. Evaluation aimed to improve product weaknesses based on expert validation results, student responses, and effectiveness measurements, resulting in a final product that was feasible for use in learning.

2.3 Participants

This study was conducted at Public Elementary School (SD Negeri) 05 Indralaya, Ogan Ilir Regency, South Sumatera Province in the even semester of the 2025/2026 academic year. The research subjects were 23 fifth-grade students (class VA). Purposive sampling was employed because the participants were enrolled in Grade V and were studying the ecosystem

topic during the 2025/2026 academic year. The product trials were conducted in three stages: an individual trial involving three students, a small-group trial involving six students, and a field trial involving fourteen students. In addition, the validation process involved media experts, material experts, and education practitioners who assessed the quality of the developed product.

2.4 Data collection

The data collection techniques employed in this study included observation, interviews, validation sheets, questionnaires, and tests. Observation and interviews were conducted during the analysis stage to identify learning conditions, students' characteristics, and the need for appropriate learning media.

Validation sheets were used to evaluate the quality of the developed IbisPaint-assisted digital comic. The validation process involved three experts, namely a media expert, a material expert, and an education practitioner. The media expert assessed the design, appearance, and usability of the digital comic, while the material expert evaluated the relevance, accuracy, and appropriateness of the learning content. The education practitioner evaluated the overall quality of the product, including material, media, and implementation aspects, using an instrument consisting of 16 assessment indicators. All validation instruments employed a four-point Likert scale ranging from 4 (Very Good) to 1 (Poor).

Student response questionnaires were administered after the implementation stage to measure the practicality of the developed digital comic. In addition, eco-literacy tests were conducted in the form of pretests and post-tests to measure students' eco-literacy before and after learning with the developed media

2.4 Data analysis

The collected data were analyzed using descriptive quantitative analysis. Expert validation data were converted into percentage scores to determine the validity level of the developed digital comic using the validity criteria presented in Table 1.

Table 1. Media Validity Criteria

Validity criteria description	Percentage score weight (%)
Highly valid	81–100%
Valid	61–80%
Fair	41–60%
Poor	21–40%
Invalid	0–20%

(Asih & Muslim, 2023)

Similarly, student response questionnaire data were analyzed using percentage scores to determine the practicality level of the learning media based on the criteria shown in Table 2.

Table 2. Practicality Criteria for Media Application

Practicality criteria description	Percentage score weight (%)
Highly practical	81–100%
Practical	61–80%
Fair	41–60%
Poor	21–40%
Not practical	0–20%

(Alyas et al., 2023)

The effectiveness of the digital comic in improving students' ecoliteracy was analyzed using the normalized gain (N-Gain) score calculated from the pretest and posttest results using the following formula:

$$\boldsymbol{N - gain = \frac{S\ Posttest - S\ Pretest}{S\ Max - S\ Pretest}}$$

N-Gain analysis was used to measure the improvement in students' ecoliteracy after participating in learning using the IbisPaint-assisted digital comic. The N-Gain calculation results were then interpreted based on predetermined improvement categories to determine the effectiveness level of the developed product.

Table 3. N-Gain Criteria

Gain value	Interpretation
$g > 0.7$	High Gain
$0.3 < g \leq 0.7$	Moderate Gain
$g \leq 0.3$	Low Gain

(Kurniawan & Hidayah, 2021)

The results of the validity, practicality, and effectiveness analyses were used as the basis for determining the feasibility of the IbisPaint-assisted digital comic as a learning medium for improving ecoliteracy among elementary school students.

3. Results

This study produced a learning media product in the form of an IbisPaint-assisted digital comic developed to strengthen ecoliteracy among fifth-grade elementary school students. The media were developed using the ADDIE model, which consists of the Analysis, Design, Development, Implementation, and Evaluation stages.

3.1 Analysis

The analysis stage was conducted through observations of the learning process and interviews with fifth-grade students and teachers at SD Negeri 05 Indralaya to obtain relevant data and information for developing IbisPaint-assisted digital comic learning media to strengthen students' ecoliteracy in IPAS learning on food chain material. The analysis revealed that IPAS learning in grade V was still dominated by textbooks and lecture-based methods, causing students to experience difficulties in understanding abstract ecological concepts. In addition, the learning media used had not optimally increased students' engagement in learning

or developed ecoliteracy aspects. Based on the needs analysis, IbisPaint-assisted digital comic learning media were developed by presenting ecosystem and food chain materials through attractive visuals, simple language, and storylines closely related to students' everyday lives.

3.2 Design

The design stage was carried out by designing digital comic learning media adjusted to the characteristics of elementary school students and the objectives of IPAS learning. At this stage, the researcher prepared the storyline, determined the characters, created the storyboard, and designed the visual appearance of the comic containing ecosystem and food chain materials. The selection of digital comics as learning media was based on the characteristics of elementary school students, who tend to enjoy pictures, colors, and engaging stories, thereby increasing their attention and interest in learning. In addition to considering visual aspects, the media design was also developed by integrating ecoliteracy indicators into the storyline and the characters' activities in the comic. This aimed to enable students not only to understand environmental concepts cognitively but also to develop care and awareness of the importance of protecting the environment. The use of the IbisPaint application made it possible to develop more attractive illustrations aligned with students' characteristics, allowing the material to be delivered more concretely and easily understood.

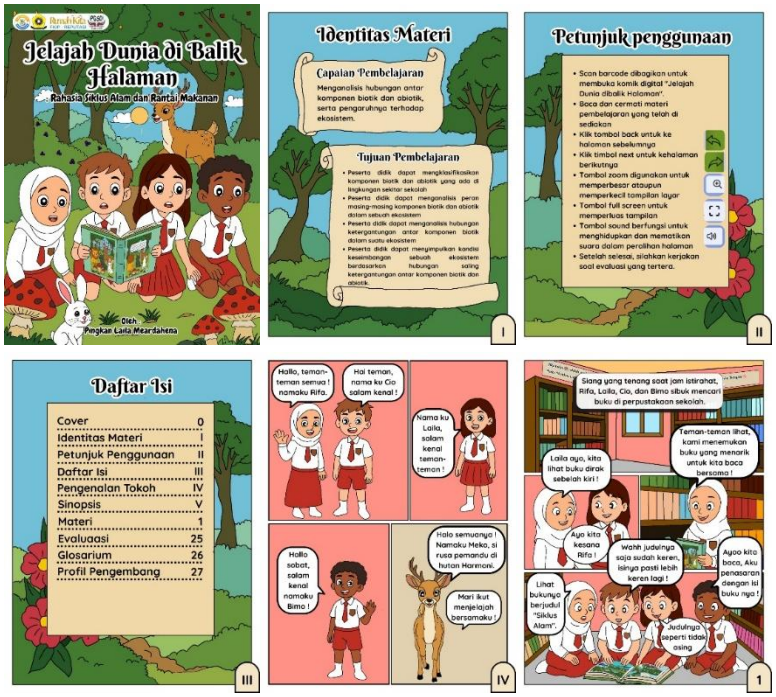


Figure 1. Digital comic design display

3.3 Development

The development stage was carried out by transforming the media design into a complete IbisPaint-assisted digital comic product ready for use in learning. The developed product was then validated by media experts, material experts, and education practitioners to assess the feasibility of the content, appearance, language, and media presentation. Table 4 presents the validation results of the developed learning media.

Table 4. Learning Media Validation Results

No.	Validator	Maximum Score	Obtained Score	Percentage (%)	Category
1	Media Expert	60	58	96.66	Highly Valid
2	Material Expert	60	57	95	Highly Valid
3	Practitioner	64	63	98.43	Highly Valid
	Total	184	178	96.73	Highly Valid

The validation results showed that the developed media were categorized as highly valid. The media expert assessment obtained a percentage of 96.66%, the material expert assessment obtained 95%, and the practitioner assessment obtained 98.43%, with an average percentage of 96.73%. These results indicate that the IbisPaint-assisted digital comic learning media met the feasibility criteria in terms of media, material, and learning aspects and were therefore suitable for use in learning.

3.4 Implementation

Implementation was carried out through learning activities to observe the direct application of the media and assess the practicality level of the digital comic. The media were then implemented with class VA students through practicality tests consisting of a one-to-one trial involving 3 students and a small-group trial involving 6 students. This stage aimed to determine the ease of media use and students' responses to the digital comic in learning. The results of the practicality test for the digital comic media are presented below.

Table 5. Practicality Test Results

No.	Assessment Component	Number of Students	Maximum Score	Obtained Score	Percentage (%)	Category
1	One-to-One trial	3 students	192	183	95.31	Very Good
2	Small-group trial	6 students	384	368	95.83	Very Good
	Total		576	551	95.57	Very Good

The practicality test results showed that the IbisPaint-assisted digital comic media obtained a percentage of 95.31% in the individual trial and 95.83% in the small-group trial. The average percentage was 95.57%, categorized as very good and highly practical.

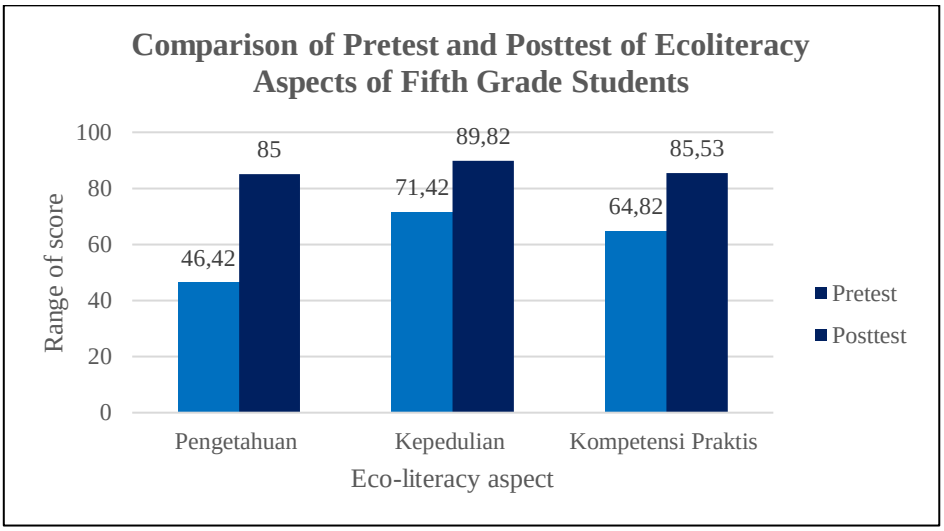
3.4 Evaluation

The evaluation stage was conducted through summative assessment to measure the effectiveness of the IbisPaint-assisted digital comic learning media in strengthening students' ecoliteracy. Data were collected through tests consisting of 10 multiple-choice pretest and posttest items, as well as a questionnaire containing 20 statements to measure students' care and practical competence aspects. The pretest and posttest results of 14 class VA students showed an improvement in ecoliteracy after the use of the developed media.

Table 6. Effectiveness Test Results

No.	Assessment Aspect	Pretest	Category	Posttest	Category
1	Knowledge	46.42	Poor	85	Very Good
2	Care	71.42	Good	89.82	Very Good
3	Practical Competence	64.82	Fair	85.53	Very Good
	Total	60.89	Fair	86.78	Very Good

Based on the pretest and posttest results for each ecoliteracy aspect, students' ecoliteracy improved after using the digital comic learning media. The improvement was observed in the knowledge, care, and practical competence aspects, indicating that the developed media were able to support the strengthening of students' ecoliteracy. The comparative diagram of the pretest and posttest results is presented below.



Graph 1. Comparison of Pretest and Posttest Results Based on Ecoliteracy Aspects

The figure shows an increase in pretest and posttest results across all ecoliteracy aspects after the use of IbisPaint-assisted digital comic learning media. In the knowledge aspect, the average score increased from 46.42 to 85.00. The care aspect increased from 71.42 to 89.82, while the practical competence aspect increased from 64.82 to 85.53. Overall, the average ecoliteracy score increased from 60.89 in the pretest to 86.78 in the posttest.

Furthermore, to determine the effectiveness level of the media, an analysis was conducted using the N-Gain score. The analysis results indicated that the IbisPaint-assisted digital comic learning media were effective in strengthening students' ecoliteracy after being implemented in learning.

Table 7. N-Gain Results for Each Ecoliteracy Aspect

Ecoliteracy Aspect	Score		Pretest–Posttest	Ideal Score (100)–Pretest	N-Gain	Description
	Pretest	Posttest				
Knowledge	46.42	85	38.58	41.67	0.72	High
Care	71.42	89.82	18.4	37.5	0.64	Moderate
Practical Competence	64.82	85.53	20.71	40	0.58	Moderate
Total	60.89	86.78	25.89	39.11	0.66	Moderate

The N-Gain calculation results showed that the IbisPaint-assisted digital comic learning media improved students' ecoliteracy across all measured aspects. The highest improvement occurred in the knowledge aspect, with an N-Gain score of 0.72 (high), followed by the care aspect at 0.64 (moderate) and practical competence at 0.58 (moderate). Overall, the average ecoliteracy score increased from 60.89 in the pretest to 86.78 in the posttest, with an N-Gain score of 0.66 (moderate category). These results indicate that the IbisPaint-assisted digital comic media were effective in strengthening students' ecoliteracy, particularly in the knowledge aspect.

4. Discussion

The development of IbisPaint-assisted digital comic learning media in this study was carried out through the five stages of the ADDIE model is used in research and development because it is systematic and suitable for producing valid and effective media products in the context of modern education (Oktavia et al., 2024). The strength of this model lies in its ability to ensure the validity of the resulting product, because each stage is based on comprehensive analysis, design, development, implementation, and evaluation processes (Sagita, 2025). According to several studies, the ADDIE model is a standard framework proven to improve the quality of digital comic-based learning media across various subjects, including IPAS in elementary schools (Septian & Oktaviarini, 2025).

4.1 Analysis

The Analysis stage is important for identifying the needs of students and teachers as well as the potential of the media to be developed. Digital comics have advantages in attracting interest, increasing student engagement, and presenting learning content in a contextual and narrative manner (Pratiwi et al., 2025). The previously used learning media were still conventional, making them less capable of encouraging students' involvement in science learning, particularly in understanding ecosystem concepts. Learning through conventional approaches tends to create a monotonous impression, which often leads to student boredom (Susanti et al., 2024). The use of interactive media can serve as an engaging and contextual learning solution to improve students' understanding of environmental issues. Active involvement through visual elements and participatory activities strengthens cognitive aspects, environmental care, and responsibility (Rahma et al., 2025). Other studies have also shown that digital comic media help increase students' interest and motivation to learn in elementary schools (Silaban et al., 2023). The analysis results indicated that students needed learning media that were attractive, interactive, and capable of helping them understand ecosystem and food chain materials more concretely (Na'miyah & Rahmawati, 2025).

4.2 Design

In the Design stage, the storyboard, storyline, characters, and visual appearance of the digital comic were prepared using the IbisPaint application and adjusted to the characteristics of fifth-grade elementary school students. The selection of visual design was an important

aspect because digital comics integrate text, images, and stories to help students understand complex ecosystem concepts, such as the relationship between biotic and abiotic components (Waisakanitri et al., 2023). In addition, the characteristics of fifth-grade students, who begin to enter the formal operational stage, enable them to understand concepts through contextual and engaging visual media (Mcleod, 2025). An appropriate comic design can also increase students' attention to and understanding of the learning material (Syilviana & Qurrotaini, 2024).

4.3 Development

The Development stage in developing digital comic learning media was carried out by constructing the storyline, creating character and background illustrations, and combining text and visuals so that learning material could be presented attractively and easily understood by students (Septian & Oktaviarini, 2025). The IbisPaint-assisted digital comic learning media developed in this study met the valid, practical, and effective criteria for strengthening ecoliteracy among elementary school students. The validity score of 96.73% indicates that the developed digital comic fulfilled the feasibility criteria in terms of content, media design, language, and learning presentation. This high score was achieved because the learning materials were systematically organized, aligned with the IPAS curriculum and learning objectives, and presented using language appropriate to the cognitive and linguistic development of fifth-grade students. Furthermore, the integration of contextual environmental issues with attractive visual illustrations and interactive storytelling enabled ecological concepts to be conveyed more clearly and meaningfully. These findings are consistent with previous studies, which reported that digital comic learning media with well-designed visual elements, age-appropriate language, and curriculum-aligned content tend to achieve high validity ratings from experts (Maulidah & Anshori, 2025; Dewi et al., 2025).

The high validity of the media was inseparable from the use of attractive visual illustrations and the presentation of material through a contextual storyline (Pramesti et al., 2024). The characteristics of digital comics allow students to obtain information through a combination of text and images, enabling abstract ecological concepts to be understood more concretely (Lestari & Suriani, 2025). Attractive visualization also helps increase students' focus and attention during the learning process (Payanti, 2022).

4.4 Implementation

The Implementation stage refers to the application of the learning media that had been established as the final product to students in order to observe its direct use in the classroom. The practicality score of 95.57% indicates that the developed digital comic can be implemented effectively in elementary school classrooms with minimal technical difficulties. This finding implies that students were able to use the media independently because of its simple navigation, clear language, and attractive visual presentation. For teachers, the media provides a technology-based instructional resource that can be easily integrated into IPAS learning without requiring advanced digital skills. Consequently, the digital comic can help create a more interactive learning environment, increase students' engagement, and reduce reliance on conventional textbook-based instruction. These practical advantages suggest that the developed

media has strong potential for regular classroom implementation. This result shows that students did not experience difficulties in using the developed learning media (Sapanca, 2021). Ease of access, simple language, and attractive visual appearance were the main factors influencing the high practicality level of the media (Nuriyah, 2022). This finding indicates that digital comics can serve as an alternative learning medium suited to the characteristics of the digital generation at the elementary school level (Putri & Sukasih, 2025).

4.5 Evaluation

The Evaluation stage was carried out to measure media effectiveness, as reflected in improved student learning outcomes, marked by an increase in the average pretest score from 60.89 to 86.78 in the posttest. The N-Gain score of 0.66 indicates a moderate improvement in students' eco-literacy. Although the developed digital comic effectively enhanced students' understanding of ecosystem concepts, achieving a high level of eco-literacy requires continuous learning experiences and repeated opportunities to apply environmental knowledge in real-life situations. In this study, the implementation was conducted over a relatively limited period; therefore, students had limited opportunities to develop environmental care and practical environmental competence, which generally require longer-term learning and habituation. These factors may explain why the improvement reached the moderate rather than the high category.

This finding suggests that the combination of visual illustrations, contextual storytelling, and dialogue helped students relate abstract ecological concepts to real environmental situations. Such learning experiences encouraged students not only to understand ecosystem concepts but also to recognize the importance of environmental responsibility in their daily lives. Therefore, the improvement in eco-literacy can be attributed to the meaningful integration of cognitive and contextual learning rather than to visual attractiveness alone. This interpretation is consistent with constructivist learning theory, which emphasizes that meaningful learning occurs when students actively connect new knowledge with their prior experiences (Tyas et al., 2022). Viewed from the eco-literacy aspects, the highest improvement occurred in the knowledge aspect, with an N-Gain score of 0.72. This finding indicates that presenting material through a combination of images, stories, and dialogue helped students understand ecological concepts more effectively (Suryanda et al., 2023). Meanwhile, the care aspect obtained an N-Gain score of 0.64 and practical competence obtained 0.58. Although both were in the moderate category, these results indicate that the developed media contributed not only to cognitive aspects but also to the formation of environmentally caring attitudes and students' skills in applying environmentally friendly behaviors (Rahmayani et al., 2024).

Overall, the findings demonstrate that the IbisPaint-assisted digital comic is a promising learning medium for IPAS instruction in elementary schools. More importantly, the findings address the research gap identified in the introduction by showing that digital comics can be developed not only to improve students' cognitive learning outcomes but also to strengthen multiple dimensions of ecoliteracy, including ecological knowledge, environmental care, and practical environmental competence. This extends previous studies, which primarily emphasized academic achievement or literacy skills without comprehensively integrating ecoliteracy into digital comic-based learning media.

Furthermore, the novelty of this study lies in the integration of IbisPaint-assisted digital storytelling with ecoliteracy-oriented learning content. The developed media combines contextual environmental issues, attractive visual illustrations, and interactive storylines to promote meaningful learning experiences that encourage students to understand environmental concepts and apply environmentally responsible behaviors in their daily lives. Therefore, this study contributes to the development of innovative technology-based learning media that supports Education for Sustainable Development (ESD) in elementary school education. findings indicate that IbisPaint-assisted digital comics are a potential learning medium (Astuti & Kowiyah, 2025). The integration of ecoliteracy materials into story-based visual media can create more meaningful learning experiences, increase student engagement, and support the achievement of learning objectives oriented toward environmental sustainability (Ramadhan & Surjanti, 2022). Thus, the developed learning media can serve as an innovative alternative for strengthening ecoliteracy among elementary school students.

5. Limitations

This study has several limitations that should be considered when interpreting the findings. First, the study was conducted in only one school, namely Public Elementary School (SD Negeri 05) Indralaya, Ogan Ilir Regency, South Sumatera Province, so the results cannot yet be broadly generalized to schools with different characteristics. Second, the number of research subjects involved was relatively limited, namely 3 students in the one-to-one evaluation stage, 6 students in the small-group evaluation stage, and 14 students in the field test. This limited sample size means that the findings still need to be tested with a larger number of subjects to obtain a more comprehensive picture of the media's effectiveness. Third, the development of IbisPaint-assisted digital comic learning media focused only on ecosystem and food chain materials in fifth-grade IPAS learning; therefore, its application to other materials or educational levels remains unknown. Accordingly, future studies are recommended to involve larger samples, be conducted in various schools with diverse characteristics, and develop media for other learning materials in order to obtain broader and deeper findings.

6. Conclusion

This study affirms that IbisPaint-assisted digital comics offer a viable pedagogical innovation for strengthening ecoliteracy among elementary school students in IPAS learning, demonstrating that visual-narrative digital media can effectively bridge the cognitive, affective, and behavioral dimensions of environmental education that conventional instruction often addresses separately. By transforming ecological content into an interactive storytelling experience, this medium reinforces the theoretical proposition that ecoliteracy is best cultivated through contextually relevant, narrative-based learning aligned with the principles of Education for Sustainable Development (ESD), while also offering elementary school teachers a practical, accessible alternative for enriching environmental education. These findings contribute to the growing body of literature on digital-based sustainability education and underscore the potential of visual-narrative media to foster environmentally responsible citizens from an early age, with future research encouraged to examine its long-term impact and adaptability across diverse educational contexts.

Author Contributions

The first author was responsible for conducting the research, collecting data, analyzing data, drafting the initial manuscript, and revising the manuscript based on the guidance and input of the other authors. The second author, as the supervisor, contributed to formulating the research idea together with the first author, designing the research, supervising the research implementation, validating the methodology, interpreting the results, and reviewing and refining the manuscript. The third author contributed by providing academic input, criticism, and suggestions regarding the research substance, methodology, and manuscript refinement. All authors have read, approved, and are responsible for the final version of the published manuscript.

Acknowledgments

The authors express their gratitude to all parties who made meaningful contributions to the implementation of this study. Special thanks are extended to the school, teachers, and students who participated in and supported the data collection process. The authors also thank the Elementary School Teacher Education Study Program, Universitas Sriwijaya, for the academic support and facilities provided during the implementation of this research. All assistance, input, and cooperation provided were highly meaningful to the success of this study.

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