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Development of Green Literacy Teaching Materials Based on Flipbook Maker in Elementary School Science Learning

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Abstract: The limited availability of digital teaching materials integrated with green literacy has reduced opportunities for elementary school students to develop environmental awareness and understand science concepts meaningfully. This study aims to (1) identify the characteristics and validity of Flipbook Maker-based Green Literacy teaching materials, (2) determine the practicality and student responses in learning Natural and Social Sciences (IPAS) at SD Negeri 2 Tanjoeng, Aceh Besar, and (3) evaluate its effectiveness in improving student learning outcomes. This study used a Research and Development (R&D) approach with the ADDIE model, which consists of the stages of analysis, design, development, implementation, and evaluation. The research participants were 35 fifth-grade students. Data were collected through expert validation sheets, questionnaires, interviews, observations, and pretest-posttest achievement tests. The developed teaching materials integrate four dimensions of green literacy (environmental knowledge, environmental awareness, environmental skills, and environmental participation) through interactive multimedia features, including text, illustrations, animations, videos, and contextual learning activities presented in Flipbook Maker format. The results of the study showed that the product has high validity, with an average Aiken's V value of 0.833 from material experts and 0.869 from media experts, indicating that the product is suitable for implementation in the classroom. The practicality results showed positive responses from students, especially regarding design, content completeness, language, attractiveness, and learning benefits. However, interaction and technology access were still limited due to students' digital literacy and internet limitations. The learning materials were also effective in improving student learning outcomes. Therefore, the developed Flipbook Maker-based Green Literacy learning materials are valid, practical, and effective in supporting meaningful basic science learning while fostering environmental literacy.

Keywords: green literacy, teaching materials, flipbook maker, science learning.

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INTRODUCTION

Education plays a fundamental role in shaping the quality of human resources, not only academically superior but also socially and environmentally conscious and responsible. Globally, various environmental issues such as climate change, water and air pollution, deforestation, and the biodiversity crisis are serious challenges facing humanity. In an era of rapid technological advancement and social change, the need for a fundamental shift in the educational paradigm is increasingly apparent (Isabirye et al., 2025). Furthermore, Bereczki & Karpati (2021) argue that sustainable professional development must prioritize the successful integration of digital tools and technologies into teaching methods. This situation demands a systematic effort through education to instill values of environmental concern from an early age. Elementary school, as the initial level of education, plays a strategic role in shaping students' character, including developing sustainable ecological awareness.

One relevant concept in addressing these challenges is green literacy, or environmental literacy. Green literacy serves as a foundation for

thinking that helps investors better understand and assess various green investment instruments (Wahyudi, 2026). Green literacy encompasses not only an understanding of environmental concepts but also attitudes, values, and skills that encourage individuals to act responsibly towards the environment. Students who possess green literacy are expected to understand the relationship between humans and the environment and be able to make informed decisions to maintain environmental sustainability. Therefore, integrating green literacy into learning is a necessity that cannot be ignored.

Within the Indonesian education curriculum, particularly in the Natural and Social Sciences curriculum in elementary schools, there is a significant opportunity to integrate green literacy values. Natural and Social Sciences learning is designed to provide students with an integrated understanding of natural and social phenomena. Interviews with teachers at Tanjoeng 2 Public Elementary School revealed that the school still uses limited textbooks, such as printed textbooks. They have not utilized digital references. Furthermore, the references or teaching materials used are limited to a single source and lack variety. This is consistent with observations in fifth-grade students at Tanjoeng 2 Public Elementary School, which showed that all students use the same teaching materials.

Teachers also reported a lack of enthusiasm for learning about the rain cycle, particularly when learning from textbooks alone. Interviews revealed that some students had not achieved satisfactory learning outcomes. Of the 35 students, 9 had not yet fully grasped the rain cycle. Teachers expressed the difficulty of explaining the rain cycle to students based solely on printed textbooks. However, the reality on the ground shows that IPAS learning still tends to be oriented solely toward cognitive aspects, such as mastery of concepts and memorization of material. Affective and psychomotor aspects, particularly those related to environmental awareness and behavior, have not received optimal attention.

Based on classroom observations and interviews with the fifth-grade teacher at SD Negeri Tanjoeng 2, students showed low enthusiasm when learning the water cycle using printed textbooks. The teacher reported that students tended to lose focus during explanations because the learning materials relied primarily on static text and images. Consequently, students experienced difficulty understanding abstract processes such as evaporation, condensation, and precipitation. These findings indicate the need for more interactive teaching materials that can visualize scientific concepts through multimedia. According to Mayer's Multimedia Learning Theory, combining text, images, animation, audio, and video facilitates meaningful learning by engaging multiple channels of information processing. Therefore, Flipbook Maker was selected as an appropriate digital platform to support elementary science learning.

This is reflected in the still low level of environmental awareness among elementary school students. Many students have not yet demonstrated environmentally friendly behaviors in their daily lives, such as littering, a lack of energy conservation habits, and minimal concern for the cleanliness of the school environment. This situation indicates that ongoing learning has not effectively internalized environmental values. In other words, there is a gap between the expected learning objectives and the actual results achieved.

Likewise, industrialization and high economic growth have led to environmental pollution and climate change, a global concern (Liu & Tobias, 2024). For example, the high frequency of flooding in the Bayat area of Klaten necessitates early ecological awareness (Hadiyati et al., 2020). Therefore, developing and fostering environmental literacy in elementary school students requires the commitment and support of various parties (Indrawan et al., 2022).

A gap in students' understanding of environmental literacy has been identified (Indrawan et al., 2022). Although various environmental education initiatives have been widely implemented in China, a persistent gap between knowledge and pro-environmental behavior remains (Ampofo et al., 2026). Similarly, various obstacles have been identified in fostering green literacy in elementary school students, such as time constraints, lack of facilities and infrastructure, and even a lack of preparedness within the school community to facilitate the implementation of green literacy (Indrawan et al., 2022). Therefore, it has become a global concern. To reduce environmental pressures and seek sustainable development pathways, green consumption has become a focus of attention (Liu & Tobias, 2024).

One contributing factor to this problem is the limited teaching materials used in the learning process. Teaching materials play a crucial role in delivering content and shaping students' learning experiences. However, the teaching materials currently used in elementary schools are still dominated by conventional textbooks, lacking contextualization, and not specifically designed to integrate green literacy. The materials presented tend to be theoretical and provide few opportunities for students to connect concepts to real-world conditions in their environment.

Furthermore, existing teaching materials have not fully utilized the rapid development of digital technology. In today's digital era, students are already very familiar with technology, so learning that utilizes digital media has the potential to increase interest and motivation to learn. The lack of innovation in the development of technology-based teaching materials makes the learning process less engaging and interactive, resulting in low student engagement.

The development of digital technology has brought changes to various aspects of life, including education. The use of technology in learning allows for the presentation of material that is more interactive, engaging, and easily accessible to students. One widely used innovation is multimedia-based digital teaching materials that integrate text, images, audio, video, and animation into a single learning medium.

The development of digital teaching materials needs to be based on theories that support the effectiveness of the learning process. One relevant theory is the Multimedia Learning Theory proposed by Richard E. Mayer. This theory explains that students learn more effectively when information is presented through a combination of words and images rather than through text alone. The integration of various multimedia elements can help students develop a better understanding, increase learning engagement, and facilitate information processing.

In the context of science learning in elementary schools, using Flipbook Maker as digital teaching material allows for the presentation of green literacy material in a more engaging and interactive manner. The multimedia features available in Flipbook Maker support the visualization of environmental concepts, thus helping students understand the material more meaningfully. Therefore, developing digital teaching materials based on Flipbook Maker needs to pay attention to the principles of multimedia learning so that the resulting media can optimally support the achievement of learning objectives.

To address these issues, innovation is needed in developing teaching materials that are not only oriented towards delivering material but also able to effectively instill green literacy values. One alternative solution is to develop digital-based teaching materials using Flipbook Maker. Hirsh-Pasek et al. (2020) proposed a new approach to educational reform by using a fun learning methodology that facilitates the development of 21st-century competencies. Flipbook Maker is a device or application that

enables the creation of interactive digital books that can integrate various multimedia elements, such as text, images, audio, video, and animation. Flipbooks based on a sustainable lifestyle (green literacy) can improve the science literacy of elementary school students; interactive digital media is highly relevant for 21st-century learning (Silalahi et al., 2026). The use of Flipbook Maker in learning can create a more engaging, interactive, and contextual learning experience. Based on the results of research conducted by Tirtawati et al. (2025), it was stated that problem-solving-based Flipbooks are effective in improving science learning outcomes, as well as being valid, practical, and increasing student engagement.

Flipbook Maker-based teaching materials have several advantages over conventional teaching materials. First, digital teaching materials can be easily accessed anytime and anywhere, thus providing flexibility in the learning process. Second, integrating multimedia into teaching materials can help students understand the material more deeply. Third, digital teaching materials can be designed contextually by linking learning materials to environmental issues around students, making them more relevant to everyday life. Nurhamidah et al. (2023) stated that Flipbooks are effective in problem-based learning (PBL)-based science learning.

Furthermore, the development of green literacy-based teaching materials through Flipbook Maker enables the integration of knowledge, attitudes, and skills in learning. Students are not only encouraged to understand environmental concepts but are also encouraged to develop a caring and responsible attitude toward the environment. Findings by Shancez-Cruzado et al. (2021) demonstrate the relationship between environmental literacy and environmental education and curriculum design, and underscore the need to integrate sustainability principles into the educational curriculum, as well as the integration of sustainability literacy and the Sustainable Development Goals (SDGs) in higher education. Thus, learning is not only informative but also transformative, meaning it can change students' behavior to be more environmentally friendly.

However, the development of green literacy-based teaching materials using Flipbook Maker is still relatively rare, particularly in elementary school science lessons. This highlights the need for research focused on developing innovative, relevant, and student-centered teaching materials. Furthermore, the developed teaching materials need to undergo validation and testing to ensure their quality, practicality, and effectiveness.

Based on the description above, it can be concluded that there are several main problems in science learning in elementary schools, namely: (1) the integration of green literacy in learning is not yet optimal, (2) low awareness and behavior of environmental care among students, (3) limited innovative and contextual teaching materials, and (4) the use of digital technology in learning is not yet optimal. Therefore, an effort is needed to develop teaching materials that can address these problems (Purnawati & Yakin, 2025).

Green literacy has become one of the essential competencies in elementary education because environmental problems require not only scientific understanding but also responsible behavior toward nature. In recent years, environmental literacy has shifted from being viewed merely as environmental knowledge to a multidimensional competence consisting of knowledge, environmental attitudes, values, critical thinking, and environmentally responsible actions. According to recent studies, green literacy enables learners to recognize environmental problems, evaluate their causes and consequences, and participate in sustainable solutions through informed decision-making (Sanchez et al., 2025). Consequently, elementary

education should not only emphasize mastery of scientific concepts but also facilitate the development of positive environmental behaviors through meaningful learning experiences.

Several previous studies have demonstrated that the cultivation of green literacy should begin at the elementary school level because environmental attitudes are more easily developed during childhood. Children who are exposed to environmental education at an early age tend to demonstrate stronger pro-environmental behavior, including conserving water, reducing waste, recycling, and protecting biodiversity. Moreover, elementary school students learn more effectively when environmental concepts are directly connected with their daily experiences. Therefore, environmental learning should be contextual, experiential, and integrated into regular classroom instruction rather than taught as a separate topic.

The implementation of green literacy in elementary schools generally covers three major dimensions, namely environmental knowledge, environmental skills, and environmental attitudes. Environmental knowledge refers to students' understanding of ecological concepts, environmental issues, and the interaction between humans and nature. Environmental skills involve students' ability to observe environmental phenomena, solve environmental problems, and apply sustainable practices in daily life. Meanwhile, environmental attitudes include awareness, responsibility, care, and willingness to participate in environmental conservation activities. These three dimensions complement one another and should be developed simultaneously to produce environmentally literate citizens. Consequently, learning resources should facilitate cognitive, affective, and psychomotor learning outcomes rather than focusing exclusively on conceptual understanding.

Numerous studies have also reported that integrating green literacy into science learning significantly improves students' environmental awareness and scientific understanding. Science learning naturally provides opportunities to discuss environmental phenomena such as ecosystems, climate, biodiversity, water resources, and environmental pollution. By integrating green literacy into science instruction, students are encouraged not only to understand scientific concepts but also to reflect on the environmental consequences of human activities and develop sustainable habits. Such integration aligns with the objectives of Education for Sustainable Development (ESD), which emphasizes empowering learners with the competencies required to achieve sustainable development goals.

Thus, this research focuses on the development of Flipbook Maker-based green literacy teaching materials for elementary school science lessons. This development is expected to produce teaching materials that are not only academically valid but also practical for teachers to use and effective in increasing students' understanding and environmental awareness. This research is crucial to meet the demands and developments of the digital era through online access to teaching materials. This allows elementary school students to acquire meaningful knowledge about science, particularly the concept of the water cycle. Generally, digital-based learning often neglects environmental awareness. Through the development of the green literacy flipbook, students gain in-depth knowledge with concrete descriptions of the water cycle. The focus of this research is how to develop flipbook maker-based green literacy teaching materials in science learning in elementary schools. Furthermore, this research is also expected to contribute to the development of technology-based learning innovations that

support sustainable education. The research questions are as follows:

1. What are the characteristics and validity of the developed media?
2. What is the practicality of and student response to the use of flipbook-based "Green Literacy" teaching materials in IPAS (Natural and Social Sciences) lessons at SD 2 Tanjoeng, Aceh Besar?
3. How effective is it regarding lerning outcomes?

METHOD

This research is a research and development (R&D) project aimed at producing a product in the form of Flipbook Maker-based green literacy teaching materials for Natural and Social Sciences (IPAS) learning in elementary schools. According to Sugiyono (2021), R&D is a study aimed at producing and testing the effectiveness of a product. According to Rayanto and Sugianti (2020), the ADDIE model consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen because it is systematic, flexible, and suitable for developing digital technology-based teaching materials.

Participants

The sample population in this study was all fifth-grade students and class teachers at Tanjoeng 2 Elementary School, Aceh Besar. The research sample in this study was 35 fifth-grade students and two class teachers at Tanjoeng 2 Elementary School, Aceh Besar. Students come from diverse social, economic, and cultural backgrounds and are from the surrounding school community. Academically, their abilities vary, ranging from high, medium, to low. Furthermore, their digital literacy levels also vary, depending on their experience and access to technological devices. These characteristics are important considerations in developing Flipbook Maker-based digital teaching materials to suit the needs, abilities, and learning characteristics of elementary school students. The number of students who became the research subjects was 35 people, consisting of 20 male students and 15 female students with an age range of approximately 10 to 11 years. At the school, the fifth grade consists of only one class, with 35 students. These students have been studying science from first to fifth grade. All students are Muslim.

The sample determination used saturated sampling because the total population of fifth-grade students at Tanjoeng 2 Elementary School was relatively small. The teacher sample was determined using purposive sampling, based on the consideration of teachers who teach Natural and Social Sciences (IPAS) in grade V at SD Negeri 2 Tanjoeng. Although grade V consisted of one class with 35 students, the IPAS learning activities in this class were handled by two class teachers who alternated teaching responsibilities according to the school's teaching schedule.

In this study, Teacher A taught during the first trial (limited trial), while Teacher B taught during the second trial (field trial). The involvement of two teachers was intended to obtain a broader evaluation of the practicality and implementation of the Green Literacy Flipbook Maker from teachers with different teaching experiences and instructional approaches. The two teachers did not teach the class simultaneously; rather, they taught the same class at different stages of the research.

Teacher A was 37 years old and held a Bachelor's degree (S1) in Elementary School Teacher Education (PGSD). The teacher had approximately 10 years of teaching experience in elementary schools and served as a class teacher at SD Negeri 2 Tanjoeng. In addition to teaching thematic learning, the teacher had experience teaching IPAS, Indonesian, Mathematics, and Pancasila Education according to elementary school learning needs.

Teacher B was also a class teacher in grade V and had approximately 5–7 years of teaching experience at the upper elementary level. The teacher had experience teaching IPAS and other elementary school subjects. The teaching experience of both teachers provided a good understanding of student characteristics, learning needs, and the use of appropriate learning media to support the learning process.

In general, students are at the concrete operational development stage, so learning Natural and Social Sciences (IPAS) requires a contextual, active, and experience-based approach so that the material can be understood well. Students live around the area of Sekolah Dasar Negeri 2 Tanjoeng Aceh Besar. Students have heterogeneous academic abilities, namely in high, medium, and low categories, so that the effectiveness of student learning outcomes can be measured comprehensively. The two teachers are class teachers who teach Natural and Social Sciences (IPAS) in grade V of the Elementary School. Their teaching experience is around 5 to 7 years at the upper grade level of elementary school.

In addition, this study also involved one media expert and one material expert as validators to assess the feasibility of the resulting product. The media expert has a doctoral background in learning technology. He has extensive competence and experience in teaching instructional media courses and is professional in developing digital learning media. The material expert has a master's background in natural science education. The material expert has experience teaching natural science courses in Elementary School Teacher Education.

The research object was the Natural and Social Sciences subject, using Flipbook Maker-based green literacy teaching materials. The chosen topic was "Ecosystems and the Environment." The topic was selected based on its suitability and accuracy with green literacy indicators, namely environmental knowledge, environmental attitudes, and environmental behaviors.

Instruments

The research data were collected using several research instruments, namely achievement tests, structured observation sheets, expert validation sheets, questionnaires, and interviews. The achievement test was used to measure students' cognitive learning outcomes and evaluate the effectiveness of Flipbook Maker-based green literacy teaching materials in science learning. The test consisted of 20 researcher-developed multiple-choice questions, with each correct answer scored 1 and each incorrect answer scored 0. The test items were developed based on the green literacy framework proposed by Cole (2019), particularly the dimensions of environmental knowledge and environmental awareness, which can be assessed through cognitive test items.

To complement the cognitive assessment, a structured observation sheet equipped with an assessment rubric was used to measure students' environmental skills and environmental participation during the learning process. Environmental skills were observed through students' ability to apply environmental concepts in learning activities, identify environmental problems, and demonstrate appropriate conservation practices. Environmental participation was assessed based on students' active involvement in discussions, collaboration with peers, willingness to express ideas about environmental issues, and participation in activities that reflected environmentally responsible behavior. The combination of cognitive tests and structured observations enabled a more comprehensive assessment of students' green literacy in accordance with the framework proposed by Cole (2019), encompassing

environmental knowledge, environmental awareness, environmental skills, and environmental participation.

The observation sheet was also used to document the implementation of the learning process using the developed teaching materials. In contrast, the interview sheet was employed to collect data for the initial needs analysis and to obtain teachers' and students' responses regarding the implementation of Flipbook Maker-based green literacy teaching materials in elementary science learning. In addition, validation sheets completed by media experts and material experts were used to evaluate the validity of the teaching materials before classroom implementation.

Table 1. Research instrument

No.	Research Instrument	Respondent	Measured Aspect	Indicator/Sub Aspect	Item Number
1	Learning Outcome Test (Pretest–Posttest)	Students	Green Literacy	Environmental Knowledge	Pretest: 1–5; Posttest: 2,4,6,8,10
				Environmental Awareness	Pretest: 6–10; Posttest: 1,3,5,7,9
				Environmental Skills	Pretest: 11–15; Posttest: 11,13,15,17,19
				Environmental Participation	Pretest: 16–18; Posttest: 12,14,16
2	Material Expert Validation Sheet	Material Expert	Material Feasibility	Material	1–5
				Language	6–7
				Presentation	8–10
3	Media Expert Validation Sheet	Media Expert	Media Feasibility	Design View	1,2,3,4,7
				Completeness of Materials	5,6,8,9,12
				Grammar	10–11
4	Teacher Response Questionnaire	Teacher	Product Practicality	Design View	1–4
				Completeness of Materials	5,20,21,22,23,24,25,26
				Grammar	6–10
				Interest	11,19
				Benefits/Conveniences	12,13,15,17
				Interaction	14
				Acceptance of Technology	16,18

Source: Adapted from Sriwahyuni (2021); Sari (2021); and Vitoria et al. (2018).

The observation sheet was used to observe the implementation of the science learning process using the developed teaching materials. It consisted of a checklist of implemented and non-implemented learning activities accompanied by detailed field notes. In addition, the observation sheet was designed to assess students' learning activities related to green literacy, particularly environmental skills and environmental participation. Environmental skills were observed through students' ability to apply concepts of the water cycle to environmental problem-solving, carry out simple environmental conservation activities, and use learning resources effectively. Meanwhile, environmental participation was observed through students' active involvement in discussions, collaboration with peers, willingness to express ideas related to environmental

conservation, and participation in classroom activities that promote environmental awareness and responsible behavior.

The interview sheet was used to obtain data for the initial needs analysis in developing the teaching materials and to gather information on the implementation of learning using Flipbook Maker-based green literacy teaching materials in elementary science classrooms. The interviews explored teachers' and students' perceptions of the learning process, the usability of the Flipbook media, students' engagement during learning activities, and the extent to which the teaching materials fostered students' environmental awareness, environmental skills, and participation in environmentally responsible practices.

Furthermore, a questionnaire was used to obtain student responses regarding the use of Flipbook Maker-based green literacy teaching materials. The questionnaire was in the form of a Likert scale questionnaire with a scale of very good (4), good (3), less good (2), and not good (1).

Data Collection Technique

Data was collected in five stages: analysis, design, development, implementation, and evaluation. The first stage was analysis, conducted through interviews prior to the development of Flipbook. The objective was to gather information about the use of instructional materials and to analyze their development. The next stage involved observation to gather information regarding the need to develop e-books tailored to students' characteristics in accordance with school-based learning. Next was the design stage, which involved designing the instructional materials. After designing the green literacy instructional materials using Flipbook Maker, expert validation was conducted on both the content and media, followed by revisions based on the feedback.

The implementation stage involved administering pre-tests and post-tests to pilot the instructional materials with both small and large groups. The pre-test was administered before students used the Flipbook Maker instructional materials to assess their initial proficiency. The post-test was administered after students finished learning with the Flipbook Maker teaching materials. Next, observational data were collected directly in the classroom during the field trial. Peer teachers conducted observations to monitor the implementation of instruction, student learning activities, and the use of Flipbook Maker-based green literacy teaching materials. A questionnaire was administered to students after they completed the entire learning sequence. The final stage assessed the effectiveness of using the Flipbook Maker-based green literacy teaching materials in the learning process.

The evaluation stage aimed to assess the overall quality of the product based on the aspects of validity, practicality, and effectiveness, both through formative evaluations at each stage and a summative evaluation at the end of the study to determine the suitability of the resulting product, as evidenced by pre-test and post-test results, observations, and questionnaires.

Research Procedures

This research procedure refers to the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation.

The analysis stage was conducted to identify the need for developing green literacy-based digital teaching materials. Activities at this stage included analyzing science and the science curriculum, student characteristics, teaching material needs, and learning problems occurring in schools. Data at this stage were obtained through observations and interviews with teachers and students. The instruments used were

observation sheets and interview guides to obtain information regarding learning conditions, the use of teaching materials, and the need to develop digital teaching materials appropriate to student characteristics.

The design stage focused on developing product designs and research instruments. Activities included developing learning outcomes and objectives, organizing materials, developing learning flows, creating e-book storyboards, determining display designs, selecting supporting media, and developing research instruments. The instruments developed included a validation sheet from subject matter experts, a validation sheet from media experts, a teacher response questionnaire, a student response questionnaire, an observation sheet for learning implementation, and pretest and posttest questions based on green literacy.

The development stage is the process of creating a digital teaching material product based on Flipbook Maker. The teaching material design was developed using the Canva application to compile various components, including the cover page, content, learning activities, evaluation, and closing page. All components were then integrated into Flipbook, resulting in an interactive digital teaching material. The developed product was then validated by subject matter experts and media experts using a validation sheet. The validation results were used as the basis for revisions to refine the product before it was piloted.

The implementation stage was conducted through a product trial with students. The trial was conducted in stages, namely a small group trial and a large group trial. During this stage, data were collected on the practicality and effectiveness of the teaching material. The instruments used included teacher response questionnaires, student response questionnaires, learning implementation observation sheets, and pretests and posttests to measure improvements in students' green literacy after using the developed teaching materials.

The evaluation stage aims to assess the overall quality of the product based on its validity, practicality, and effectiveness. Evaluation was conducted in two forms: formative and summative. Formative evaluation was conducted at each stage of development to improve the product based on observations, interviews, expert validation, and input from teachers and students. Summative evaluation was conducted after the implementation stage to determine the product's final feasibility. The instruments used in the evaluation stage included: (1) validation sheets from material experts and media experts to assess the product's validity, (2) teacher and student response questionnaires to assess the practicality of the teaching materials, (3) learning implementation observation sheets to determine the appropriateness of the product's use in learning, and (4) pretests and posttests to assess the product's effectiveness in improving students' green literacy. The results of all these instruments were analyzed and used as a basis for determining the level of feasibility of the Flipbook Maker-based digital teaching materials that were developed.

Data Analysis

The data analysis techniques in this study were both qualitative and quantitative. Qualitative data consisted of validation from material and media experts. Quantitative data collected included validity, practicality, and effectiveness data, obtained from student test results and teacher questionnaires. Validity refers to the suitability and accuracy of the product developed for the problem to be addressed; practicality refers to the usefulness and ease of use of the product developed; while effectiveness refers to the achievement of the product's development objectives.

The content validity of the instruments was evaluated by two material experts and two media experts. The material experts assessed the appropriateness of the learning content, language, and presentation, whereas the media experts

evaluated the design, usability, and visual aspects of the flipbook. To quantitatively determine the content validity of each instrument, Aiken's V coefficient was calculated based on the ratings provided by all validators. An Aiken's V value greater than 0.80 indicates that the instrument has high content validity.

Table 2. Aiken's V index criteria (Retnawati, 2016; Retnowati, 2019)

Index	Criteria
0.8 –1	Very high validity
0.6 – 0.79	High validity
0.40 – 0.59	Moderate validity
0.20 – 0.39	Low validity
0.00 – 0.19	Unvalid

The media feasibility test was conducted based on the validator's assessment results, which were then converted into a percentage. Learning media was deemed suitable for use if it achieved a minimum percentage of 61%, categorized as good, according to the criteria proposed by Riduwan (2017). The higher the percentage, the higher the feasibility of the developed media.

The validity test was conducted to determine the suitability of the test items as research instruments. An item was deemed valid if the calculated r value was greater than the table r (calculated r > table r) at a predetermined significance level. Conversely, if the calculated r value was < table r, the item was declared invalid and needed to be revised or discarded before being used in the research.

The reliability test was conducted using the Cronbach's Alpha coefficient to determine the level of instrument consistency. A Cronbach's Alpha value closer to 1 indicates a higher level of reliability, making the instrument reliable for use in research data collection.

The normality test was conducted to determine whether the research data were normally distributed. Data were deemed normally distributed if the significance value (Sig.) was greater than 0.05. Conversely, if the significance value is less than or equal to 0.05, the data are considered non-normally distributed.

Hypothesis testing is conducted using a t-test. The null hypothesis (H€) is rejected if the calculated t-value is greater than the t-table value or the significance value (Sig.) is less than 0.05, thus concluding that there is a significant effect of the treatment. Conversely, if the calculated t-value is less than the t-table value or the significance value is greater than 0.05, H€ is accepted, indicating no significant effect.

The effectiveness of learning media is determined based on the percentage of results obtained. A percentage of 81–100% is categorized as very effective, 61–80% as effective, 41–60% as moderately effective, 21–40% as less effective, and 1–20% as ineffective. The higher the percentage, the higher the level of effectiveness of the learning media developed.

■ RESULT AND DISCUSSION

Characteristics and Validity of the Developed Media

This study developed Green Literacy-based teaching materials in the form of e-books using Flipbook Maker for science instruction in elementary schools. The concept of Green Literacy in this study is developed through several main indicators, namely: (1) environmental knowledge, which includes students' understanding of basic environmental concepts; (2) environmental awareness, namely an attitude of caring for the condition of the surrounding environment; (3) environmental skills, in the form of students' ability to apply environmentally friendly behavior in everyday life; and (4) environmental participation, namely students' active involvement in protecting and preserving the environment. These four indicators are integrated into the Science material presented in the e-book.

The e-book development process involves several stages: needs analysis, design, development, and product testing. The resulting e-book is compiled using Flipbook Maker, which allows for interactive presentation of material through a digital display like a book with a page-turning effect. This e-book is also equipped with images, contextual illustrations, and navigation to facilitate student understanding. Cole (2019) explains that the terminology of green literacy refers to that used in environmental literacy, namely referring to four dimensions: knowledge, skills, influence, and behavior (Cole, 2019). The integration of Green Literacy indicators in the e-book is displayed through content based on environmental issues, real-life examples, and simple activities that students can do in their daily lives.

The results of this study cover several aspects, namely the level of effectiveness of the teaching materials, the suitability of the content, the consistency of use, and the influence of e-book use on student learning outcomes. The development of green literacy teaching materials based on Flipbook Maker for science learning was carried out through validation of the materials and media.

Thus, e-books serve not only as learning resources but also as a medium for developing environmentally conscious characters. This is in line with Rubini et al. (2023), who stated that green literacy can also be improved through picture books. Thus, e-books serve not only as learning resources but also as a medium for developing environmentally conscious characters. A study by Machsun & Indana (2023), which states that the use of flipbooks has met standards in terms of usability and time efficiency. This is in line with Rubini et al. (2023), who stated that green literacy can also be improved through picture books.

The material validator was selected because of his expertise in science and the development of learning materials and science teaching. In contrast, the media validator has competence in learning technology and educational media design. Therefore, the assessment provided meets the principles of content validity through the consideration of relevant experts.

This decision is reinforced by Sugiyono's (2021) opinion, which states that expert validation in development research aims to obtain a professional assessment of product feasibility before field testing is conducted.

Table 3. Material experts

Aspek	Item	Validator 1	Validator 2	Aiken's V	Category
Material	1	4	4	1.000	Very Valid
	2	4	4	1.000	Very Valid
	3a	3	4	0.833	Very Valid
	3b	3	4	0.833	Very Valid
	3c	3	4	0.833	Very Valid
	4	3	3	0.667	Valid
	5	3	3	0.667	Valid
Average				0.833	Very Valid
Use of Language	6	3	3	0.667	Valid
	7	4	4	1.000	Very Valid
	8	4	4	1.000	Very Valid
Average				0.889	Very Valid
Presentation	9	2	3	0.500	Valid
	10	3	4	0.833	Very Valid
	11	4	4	1.000	Very Valid
Average				0.778	Valid

Average Aiken's V = 0.833

The results of the material expert validation indicate that the developed teaching material has a high level of validity, with an overall average Aiken's V value of 0.833, which falls into the very valid category. The Material aspect obtained an average score of 0.833 (very valid), and the Use of Language aspect achieved the highest average of 0.889 (very valid). In contrast, the Presentation aspect obtained an average of 0.778 (valid). These findings indicate that the content, language, and presentation of the teaching material are appropriate for use with only minor revisions.

Table 4. Media experts

Aspect	Item	Validator 1	Validator 2	Aiken's V	Category
Design View	1	4	4	1.000	Very Valid
	2	4	3	0.833	Very Valid
	3	4	4	1.000	Very Valid
	4	4	3	0.833	Very Valid
	5	3	4	0.833	Very Valid
Average				0.900	Very Valid
Completeness of Materials	6	4	4	1.000	Very Valid
	7	4	4	1.000	Very Valid
	8a	3	3	0.667	Valid
	8b	4	4	1.000	Very Valid
	8c	3	4	0.833	Very Valid
	9	3	3	0.667	Valid
Average				0.861	Very Valid
Grammar	10	3	3	0.667	Valid
	11	4	3	0.833	Very Valid
	12	4	4	1.000	Very Valid
Average				0.833	Very Valid

Average Aiken's V = 0.869

The media expert validation results show that the developed media has a very valid level of validity, with an overall average Aiken's V value of 0.869. The Design View aspect obtained the highest average score of 0.900 (very valid), followed by the Completeness of Materials aspect with 0.861 (very valid), and the Grammar aspect with 0.833 (very valid). Overall, the media meets the validity criteria and is suitable for implementation in the learning process with only minor improvements if necessary.

Overall, the research results indicate that the Flipbook Maker-based Green Literacy learning materials developed are effective to very effective in supporting science learning in elementary schools. In addition to improving learning outcomes, the use of these e-books also strengthens students' understanding of environmental issues. It encourages the development of environmentally conscious attitudes and behaviors in accordance with Green Literacy indicators.

Table 5. Product revisions based on validator suggestions

Validator	Validator's Comments	Follow-up Revisions
Material Expert 1	The material should include more examples relevant to students' daily lives, be presented more systematically, and clearly show the relationship among subtopics. The language should	Additional real-life examples related to the water cycle were added. The material sequence was reorganized to improve coherence, and the language was simplified to

	also be adjusted to students' developmental level.	suit elementary school students.
Material Expert 2	Additional material on the utilization of water in daily life should be included.	A new section on the utilization of water in daily life was added.
Media Expert 1	Increase the font size, improve the consistency of icons and colors, add interactive elements to the homepage, and adjust the illustration layout.	Font sizes were enlarged, icons and color schemes were standardized, and interactive navigation buttons were added to the homepage.
Media Expert 2	Revise the font size, background color, and language used in the teaching material.	The font size and background color were adjusted to improve readability, and several sentences were revised for clarity and consistency.

Table 5 presents the revisions made to the product based on suggestions from the validators. The revisions focused on improving the quality of both the learning content and the media design. Material revisions included adding examples from students' daily lives, incorporating a section on the utilization of water in everyday life, reorganizing the material sequence, and simplifying the language. Media revisions involved increasing font size, standardizing icons and colors, improving the background and illustration layout, and adding interactive navigation elements.

Table 5 shows that the validators provided complementary suggestions to improve the product. Material Expert 1 emphasized the need for more contextual examples, a more systematic organization of the material, and language appropriate for elementary school students, while Material Expert 2 recommended adding content on the utilization of water in daily life. Meanwhile, Media Expert 1 focused on improving visual design and interactivity, whereas Media Expert 2 emphasized readability through adjustments to the font size, background color, and language. All suggestions were incorporated to enhance the content quality, visual appearance, and usability of the Green Literacy Flipbook. These revisions ensured that the teaching material became more engaging, easier to understand, and better aligned with the learning characteristics of elementary school students.

Figure 1. Product before revision

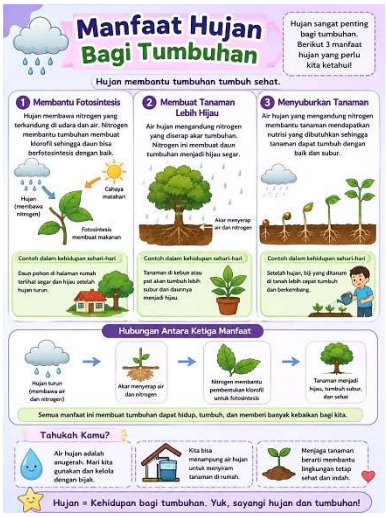

Figure 2. Product after revision

Figure 3. Product before revision

Figure 4. Product after revision

The green literacy aspect, namely environmental knowledge, is compiled in this teaching material. The green literacy-based flipbook maker displays material on the benefits of rainwater for plant growth, namely helping photosynthesis, making plants greener, and fertilizing them. This demonstrates students' understanding of basic environmental concepts. The presentation uses attractive illustrations and colors, making it easier for students to understand the relationship between rainwater and a green environment. The results of research by Rubini et al. (2023) also show that the development of interactive electronic teaching materials on climate change can improve students' ecological literacy. Students also responded very well to the use of these teaching materials.

In the teaching materials, the material is related to green building knowledge, specifically regarding green building design components such as vegetation and the use of natural resources. Plants in the green building concept function to improve air quality, reduce environmental temperatures, and create a healthier and more comfortable environment. Rainwater utilization is also an important part in supporting environmental sustainability. This material emphasizes green literacy in the following aspects: Environmental awareness. Students are given awareness so that they can have a caring attitude towards the condition of the environment around them. The more positive students' understanding of the role of plants and agriculture as well as green school management, the greater the relationship with increased student environmental awareness. The research findings of Dumaili & Prihtanti (2026) show that structured environmental education that focuses on the importance of plant ecology is a stronger predictor of high environmental awareness.

In addition to providing knowledge, the flipbook also develops students' skills in understanding the importance of preserving plants and the surrounding environment. Students will understand that reforestation is one form of implementing the green building concept that can be applied in everyday life, both at home and at school. This learning material also emphasizes green literacy, namely environmental skills. By reading this learning material, students are expected to be able to apply environmentally friendly behaviors in their daily lives.

Green literacy, which refers to knowledge and understanding of environmental issues, sustainable practices, and the impact of human activities on the planet, is a key component in

empowering individuals to make informed decisions and take actions that contribute to an environmental culture and a circular economy (Krajnc & Kova¡, 2022). Therefore, green school initiatives are supportive, with moderate effects, suggesting that the core of strong environmental awareness is largely driven by a deep scientific and ecological understanding (Dumaili & Prihtanti, 2026).

Thus, green literacy-based flipbook creation media not only helps students understand learning materials, but also instills knowledge and skills related to green buildings through the introduction of vegetation, natural water use, and sustainable environmental care behavior.

In addition to the knowledge aspect, the flipbook presentation also fosters students' affective dispositions towards the environment. Students are guided to develop a caring attitude, preserve nature, and recognize the importance of maintaining environmental balance to ensure the water cycle continues to function properly. Findings indicate that young people who are knowledgeable about greening and who value environmental protection and energy conservation are more likely to engage in waste sorting (Tran et al., 2024). Through this visualization, students can develop a sense of responsibility towards their surroundings. Previous research has shown significant improvements in knowledge, attitudes, and behaviors regarding green building literacy (GBL) in higher education (Cole, 2019). However, Shiao, In, and Sung (Cole, 2019) also found a gap between positive attitudes and actual behaviors regarding green buildings, which is associated with the appearance of environmentally friendly buildings.

Thus, green literacy-based flipbook not only help students understand condensation but also instill a positive attitude towards the environment and support the understanding of green building concepts. The visual and contextual presentation of the material can increase students' awareness of the importance of conserving natural resources sustainably. (Arthur & Fodouop, 2025) highlighted that educators recognize the need to integrate sustainability into the curriculum and actively use innovative methods, such as project-based learning and outdoor exploration, to engage students in literacy.

Overall, this teaching material page shows that the development of a green literacy-based Flipbook Maker has integrated cognitive, psychomotor, and affective aspects in one learning activity. The material begins with providing knowledge about the importance of maintaining water availability, followed by activities that train students' skills in identifying environmental conservation actions, and ends with strengthening environmental awareness through invitations to implement environmentally friendly behavior in everyday life. The integration of these three aspects is expected to shape students who have ecological knowledge, can take concrete actions, and have a character that cares about environmental sustainability in accordance with the objectives of science learning in elementary schools. This research is in line with the findings of the study by Tran et al., (2024), which integrates a multidisciplinary perspective and offers practical implications for policymakers, educators, and businesses seeking to promote green literacy and foster an environmental culture among the younger generation, contributing to the broader goals of green transformation and sustainable development related to the circular economy and green economy, especially in urban areas of developing countries and beyond. Hauke (2018) and Rubini et al. (2023) emphasize that green literacy has become a critical issue. Green literacy can be derived from sustainability literacy.

This insight can inform the design of professional development programs aimed at enhancing ecological literacy (Arthur & Fodouop, 2025). Therefore, a broader spectrum of pedagogical approaches to green building literacy is also needed. Green literacy knowledge can also be acquired through hands-on learning at home, in buildings, at school, in public buildings, and in community infrastructure (Cole, 2019).

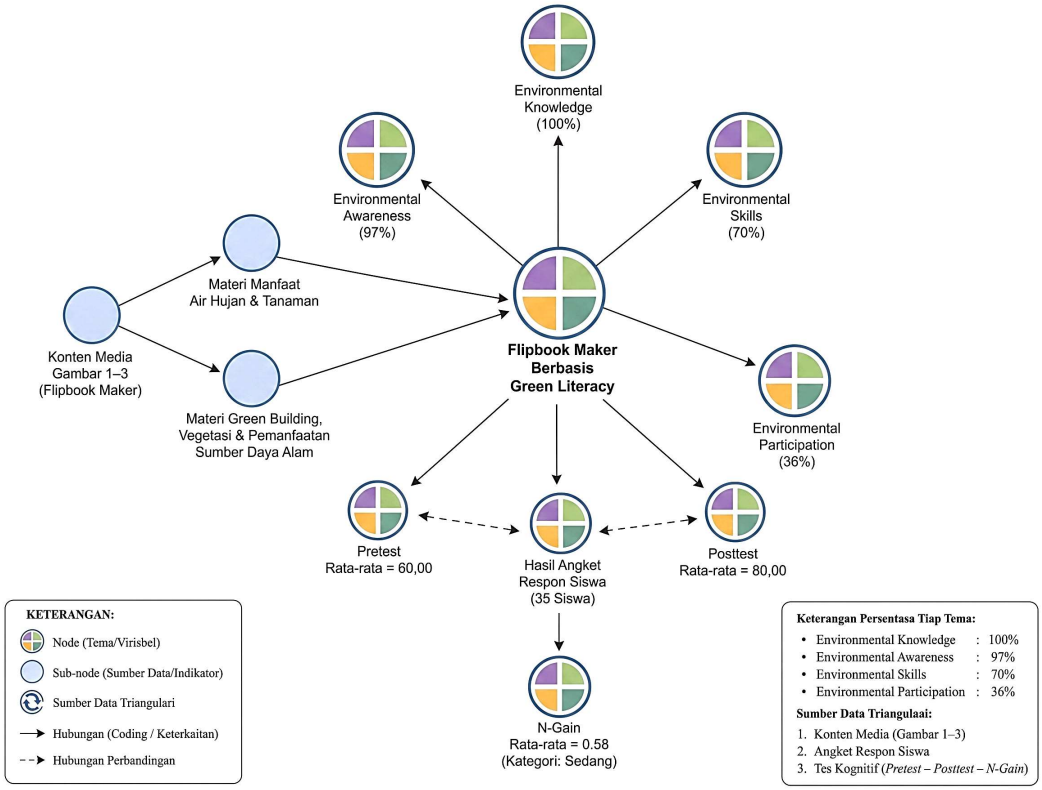

Figure 5. Map concept of green literacy-based flipbook maker

The visualization results using NVivo show that the Green Literacy-based Flipbook Maker is the main concept connecting all learning components, including materials, green literacy indicators, and implementation outcomes for students (Figure 5). The relationships between components are visualized through causal relationships (solid lines) and supporting relationships (dashed lines), thus demonstrating the link between teaching materials, the learning process, and learning outcomes.

In terms of materials, the flipbook was developed based on two main topics: Water Media Content 1–3 (Flipbook Maker) and Green Building, Vegetation, and Water Resource Utilization. These two topics complement each other, building students' understanding of environmental concepts and their application in everyday life. Furthermore, the materials include contextual examples of the benefits of water for life and plants, making it easier for students to connect learning concepts with real-life experiences.

NVivo analysis also shows that Flipbook supports the four main dimensions of green literacy: Environmental Knowledge, Environmental Awareness, Environmental Skills, and Environmental Participation. The Environmental Knowledge dimension achieved the highest percentage at 100%, indicating that all materials comprehensively encompass environmental knowledge concepts. Furthermore, Environmental Awareness achieved a score of 97%, indicating that the teaching materials were able to increase students' awareness of the importance of environmental protection. The Environmental Skills dimension achieved a score of 70%, indicating that students are beginning to apply simple skills in environmental protection through learning activities. Meanwhile, Environmental Participation achieved a score of 36%, indicating that students' active participation

in concrete actions still needs to be improved through further learning activities outside the classroom.

NVivo visualizations also demonstrated a correlation between the use of Flipbook and improved student learning outcomes. The average pretest score of 60.00 increased to 80.00 in the posttest, resulting in an N-Gain of 0.58, which is considered moderate. These results indicate that the use of Green Literacy-based Flipbook Maker has a positive impact on improving students' understanding of the science material while strengthening green literacy competencies.

Overall, the NVivo analysis results confirm that Green Literacy-based Flipbook Maker serves not only as a medium for delivering material but also as a means of integrating environmental knowledge, awareness, skills, and participation into a single learning unit. This integration contributes to improving student learning outcomes, although the environmental participation aspect still requires strengthening through more applicable and sustainable learning activities.

The analysis results using Project Map NVivo (Figure 6) show that the Green Literacy-

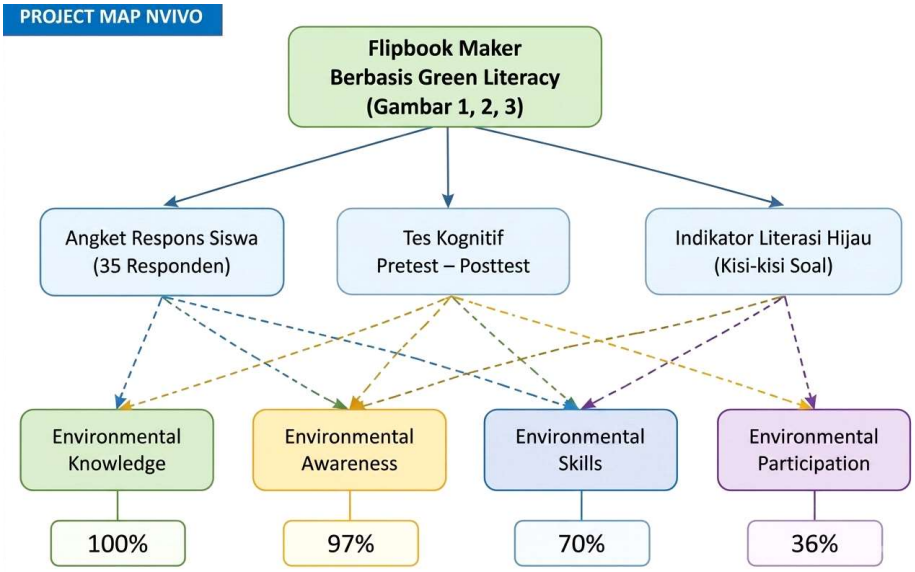

Figure 6. Project map of green literacy-based flipbook maker

based Flipbook Maker is the main component that integrates student responses, cognitive test results (pretest–posttest), and green literacy indicators in the learning process. This integration contributes to the achievement of four dimensions of green literacy, namely Environmental Knowledge (100%), Environmental Awareness (97%), Environmental Skills (70%), and Environmental Participation (36%). These findings indicate that the use of Flipbook is effective in improving students' environmental knowledge, awareness, and skills. However, the environmental participation dimension still shows relatively lower abilities, so it requires reinforcement through more contextual and practice-oriented learning activities.

The results of the NVivo Node Table analysis (Figure 7) show that the Environmental Knowledge dimension has the highest coverage rate, particularly in the sub-nodes on the benefits of rainwater for plants, green buildings, and vegetation, which each reached 100%. In the Environmental Awareness dimension, the highest achievement was in the environmental awareness and water conservation indicators, at 97.14%. Meanwhile, the Environmental Skills dimension

Node (Tema)	Sub-Node	Sources	References	Coverage (%)
Environmental Knowledge	Manfaat air hujan bagi tanaman	3	35	100,00
	Fotosintesis tanaman	3	34	97,14
	Green building dan vegetasi	3	35	100,00
	Pemanfaatan sumber daya alarm	3	33	94,29
Environmental Awareness	Kepedulian lingkungan	3	34	97,14
	Pelestarian tanaman	3	33	94,29
	Konservasi air	3	34	97,14
	Menjaga keseimbangan lingkungan	3	32	91,43
Environmental Skills	Mengidentifikasi tindakan pelestarian	3	25	71,43
	Menerapkan perilaku ramah lingkungan	3	24	68,57
	Pemanfaatan air secara bijak	3	23	65,71
Environmental Participation	Partisipasi penghijauan	3	13	37,14
	Keterlibatan menjaga lingkungan sekolah	3	12	34,29
	Kegiatan pelestarian lingkungan	3	11	31,43

Figure 7. NVivo node table analysis

showed achievement ranging from 65.71–71.43%, while Environmental Participation achieved the lowest percentage, at 31.43–37.14%. These findings indicate that teaching materials are more effective in improving environmental knowledge and awareness than in improving students' environmental participation.

MATRIX CODING QUERY - NVIVO

Node (Tema)	Sumber Data			Keterangan
	Media Flipbook (Gambar 1-3)	Angket Respons Siswa (35)	Tes Kognitif (Pre-Post)	
Environmental Knowledge	✓	✓	✓	Meningkat dari 97% → 100%
Environmental Awareness	✓	✓	✓	Meningkat dari 67% → 97%
Environmental Skills	✓	✓	✓	Meningkat dari 43% → 70%
Environmental Participation	✓	✓	✓	Meningkat dari 11% → 36%

Figure 8. NVivo matrix coding query

The results of the NVivo Matrix Coding Query (Figure 8) show that the four dimensions of green literacy, namely Environmental Knowledge, Environmental Awareness, Environmental Skills, and Environmental Participation, have a consistent relationship with the three data sources, namely Flipbook media, student response questionnaires, and cognitive test results (pretest–posttest). This data triangulation confirms that the use of Green Literacy-based Flipbook Maker contributes to improving all aspects of environmental literacy. The highest increase occurred in Environmental Knowledge (100%), followed by Environmental

Awareness, which increased from 67% to 97%, Environmental Skills from 43% to 70%, and Environmental Participation from 11% to 36%. These findings indicate consistent results across data sources, supporting the effectiveness of the developed learning media.

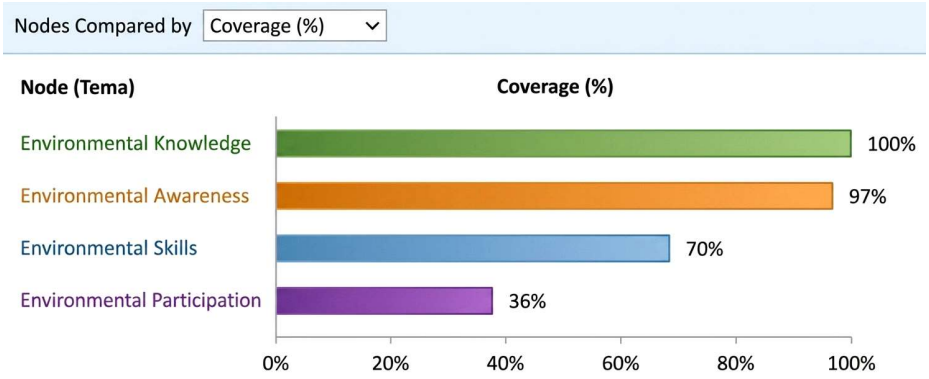

Figure 9. NVivo hierarchy chart

The NVivo Hierarchy Chart results show that the Environmental Knowledge dimension has the highest coverage rate at 100%, followed by Environmental Awareness at 97%, Environmental Skills at 70%, and Environmental Participation at 36%. This distribution indicates that the use of Green Literacy-based Flipbook Maker has made the greatest contribution to increasing students' environmental knowledge and awareness. Meanwhile, the skills aspect, especially environmental participation, still requires strengthening through more contextual, collaborative, and practice-oriented learning activities.

Practicality and Student Response

The practicality of using flipbook-based teaching materials was evaluated based on ease of access, ease of use, and student responses after using them in the learning process. Flipbook teaching materials are designed to be accessible via various laptops, computers, and smartphones, so students can study the material flexibly, both at school and outside of school. This flexibility allows students to learn anytime and anywhere, as long as a supporting device is available. In this study, students used flipbook teaching materials on laptops. Previous studies have shown that interactive digital learning resources improve accessibility, flexibility, and learner engagement in technology-supported learning environments. In this study, students accessed the flipbook using laptops (Getenet & Tualaulelei, 2023; Heard, 2023).

Student responses provide insight into the level of acceptance, ease of use, attractiveness of the display, and the usefulness of the materials in aiding comprehension. Overall, most students responded positively to the use of flipbooks, citing their attractive appearance, ease of use, and increased interest and understanding during the learning process.

These findings are consistent with previous studies reporting that interactive digital learning media enhance students' engagement, motivation, and learning experiences by providing meaningful and user-friendly learning interactions (Zainuddin, 2024; Getenet & Tualaulelei, 2023).

Based on the students' feedback regarding the use of green literacy-based teaching materials created using Flipbook Maker, students generally responded positively. In terms of interest, the majority of students (87%) agreed that the teaching materials created using Flipbook Maker increased their motivation to learn and made the learning process more engaging. They also

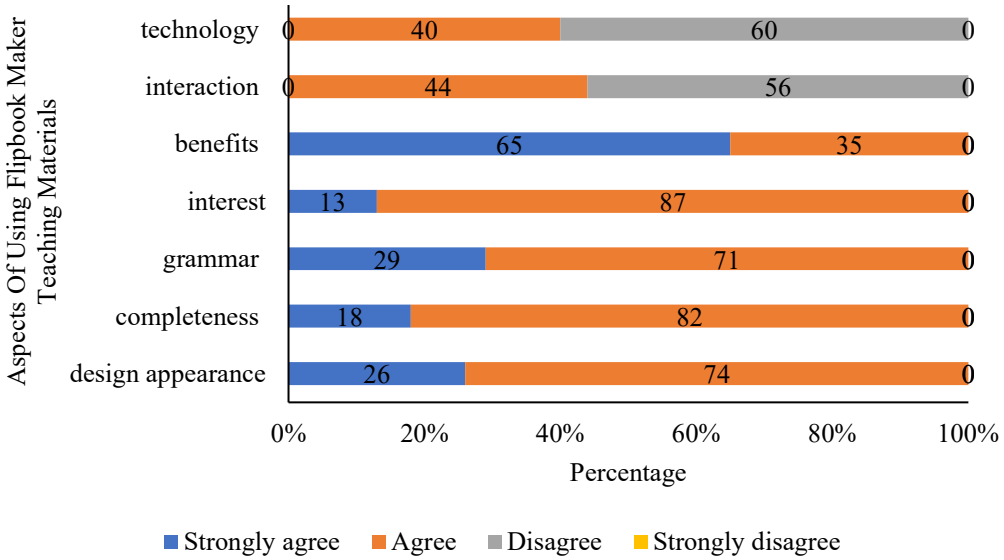

Figure 10. Questionnaire results

responded positively, noting that the videos included in the teaching materials created with the book creator helped them understand the water cycle. Furthermore, students responded positively to the availability and comprehensiveness of the green literacy-based Flipbook Maker teaching materials. The majority of students agreed (82%) that the teaching materials based on the book creator provided very comprehensive information regarding the source material. They noted that the teaching materials based on the book creator included videos that effectively supported the material on the water cycle.

Nevertheless, the aspects of interaction and technology use still require attention. A total of 56% of students disagreed regarding the aspect of interaction, and 60% regarding technology use. Most students disagreed that they could access Book Creator-based learning materials anywhere and anytime using a smartphone, computer, or laptop. Students also disagreed that internet connectivity was not an issue for them when accessing Book Creator-based learning materials. This indicates that students face obstacles in accessing Book Creator-based learning materials at school, at home, and in other settings. Similarly, the availability of an internet connection is a major issue in using Book Creator-based learning materials.

These findings are also supported by interviews with teachers, who stated that "Students have difficulty using laptops, so when reading flipbooks, they are not yet accustomed to using laptops for reading. For some students, this is their first time using a laptop to read a textbook." This statement suggests that the low ratings on both aspects are more influenced by the students' limited experience with digital devices than by the quality of the instructional materials.

In principle, flip books can be accessed both online and offline. However, students do not receive relevant information on how to access flip books either online or offline. Consequently, students assume that limited internet access prevents them from accessing flip book maker learning materials. This indicates the need for information and out-of-school learning applications that utilize various digital devices to support the effectiveness and flexibility of learning. Similarly, limited internet access outside of school can hinder students' ability to access various digital learning materials. Hardiansyah (2022)

emphasizes that flip book software can be downloaded for free and used offline, making it easier to implement, particularly in the learning process.

Overall, the survey results indicate that the Flipbook Maker-based teaching materials focused on green literacy received positive feedback. However, the aspects of interaction and technology use still need improvement to optimize the learning process. Thus, Flipbook Maker-based teaching materials are still considered practical for use in IPAS learning, particularly for the water cycle unit, as they generally feature excellent visual presentation, language, and benefits, with material completeness, student engagement, and interaction all rated as good. As students' digital literacy skills improve, the use of flipbooks is expected to become increasingly effective in supporting active, adaptive, and sustainable learning.

Effectiveness on Learning Outcomes.

The effectiveness of flipbook-based instructional materials in this study was measured based on the improvement in students' learning outcomes after participating in lessons using this medium. The results of the effectiveness analysis provide insight into the success of using flipbook instructional materials in achieving learning objectives. The greater the improvement in students' learning outcomes, the more effective the instructional materials are in helping students understand concepts, improve their mastery of the material, and support a more meaningful learning process.

The validity and reliability tests of the research instrument were conducted before the implementation stage using a sample that was different from the main research participants. The instrument was tested on 35 sixth-grade students at SD Negeri 2 Tanjoeng. In comparison, the implementation of the developed Flipbook Maker-based green literacy teaching materials was carried out with 35 fifth-grade students at the same school. Using a different sample for instrument testing was intended to avoid bias resulting from repeated exposure to the same test items and to ensure that the validity and reliability of the instrument were established prior to its use in the main study.

Table 6. Question validity test (pearson product moment

No	r count	r table	Information
1	0.52	0.334	Valid
2	0.48	0.334	Valid
3	0.55	0.334	Valid
4	0.46	0.334	Valid
5	0.60	0.334	Valid
6	0.51	0.334	Valid
7	0.49	0.334	Valid
8	0.57	0.334	Valid
9	0.62	0.334	Valid
10	0.58	0.334	Valid
11	0.54	0.334	Valid
12	0.47	0.334	Valid
13	0.59	0.334	Valid
14	0.53	0.334	Valid
15	0.56	0.334	Valid
16	0.61	0.334	Valid
17	0.50	0.334	Valid
18	0.48	0.334	Valid
19	0.57	0.334	Valid
20	0.63	0.334	Valid

All questions on the test had a calculated r value greater than the table value (0.334), so all questions were deemed valid and suitable for use. The reliability criteria were used to determine the level of consistency of the testing instrument. Based on the results of the reliability test, the research instrument obtained a Cronbach's Alpha value of 0.89, which falls into the high category. These results indicate that the instrument has good internal consistency, meaning that each item is

deemed reliable and suitable for use in the study. The reliability test results show that the instrument is highly reliable and can therefore be trusted to measure student learning outcomes.

Table 7. Normality test (shapiro-wilk)

Data	Sig.	Criteria	Information
Pretest	0.072	Sig > 0.05	Normal
Posttest	0.089	Sig > 0.05	Normal

Based on Table 7, the Shapiro–Wilk test produced significance values of 0.072 for the pretest and 0.089 for the posttest. Since both values are greater than 0.05, the data are considered normally distributed. Thus, the normality assumption was fulfilled, allowing the use of a paired-sample t-test for further analysis.

Table 8. t-Test (Paired t-Test)

Variabel	Mean	t count	t table	Sig.
Pre-test	61	11.5	2.03	0.000
Post-test	80	11.5	2.03	0.000
N-Gain (%)			0.487	

The pretest and posttest data are normally distributed and thus meet the requirements for a t-test. If the calculated t-value is greater than the critical t-value, then H0 is rejected. If Sig. is less than 0.05, then there is a significant effect. Based on the t-test results (Sig. = 0.000 < 0.05), the use of green literacy teaching materials created using Flipbook Maker can improve students' learning outcomes on the water cycle in elementary school IPAS classes.

To determine the magnitude of the improvement in students' learning outcomes after using the green literacy teaching materials developed with Flipbook Maker, an N-Gain analysis was conducted. The analysis showed that the average N-Gain score was 0.70, which falls into the great improvement category. This indicates that the implementation of the Flipbook Maker-based green literacy teaching materials effectively improved students' understanding of the water cycle concepts in elementary school science (IPAS) learning.

The high N-Gain score demonstrates that students experienced substantial learning progress after the intervention compared with their initial abilities measured during the pretest. The interactive features of the Flipbook, such as visual illustrations, animations, and contextual environmental literacy content, helped students understand abstract concepts more easily and increased their engagement during the learning process. Consequently, students were able to achieve better learning outcomes on the posttest than on the pretest.

Overall, the N-Gain results support the findings of the paired-sample t-test, which showed a statistically significant difference between pretest and posttest scores (Sig. = 0.000 < 0.05). Therefore, it can be concluded that the green literacy teaching materials assisted by Flipbook Maker are effective in improving elementary school students' learning outcomes on the water cycle topic.

The improvement in student learning outcomes through the use of green literacy teaching materials created using Flipbook Maker is attributed to several factors, namely the comprehensiveness of the content and descriptions related to the water cycle concept. Furthermore, it is also influenced by the attractive visual design of the teaching materials, which helps to increase students' interest in learning. Hardiansyah (2022) noted that the Flipbook can increase students' interest in learning compared to using non-digital teaching materials. This is because it can also provide instructional videos. Roemintoyo & Budiarto (2021) stated that learning media integrated with technology is an important learning resource in supporting the learning process.

Table 9. Result of aspects of green literacy

Aspects of Green Literacy	pretest	posttest
environmental knowledge	97	100
environmental awareness	67	97
environmental skills	43	70
environmental participation	11	36

The improvement in students' learning outcomes can be explained by recent research on concept learning through scientific visualization. Understanding the water cycle requires students to construct scientific concepts about processes that cannot be directly observed, such as evaporation, condensation, and cloud formation. Recent evidence suggests that visualization plays a fundamental role in concept acquisition because it enables learners to transform abstract scientific information into meaningful mental representations. A systematic literature review by Kim & Jin (2022) concluded that visual representations are particularly effective in supporting concept learning in science classrooms by helping students organize scientific processes,

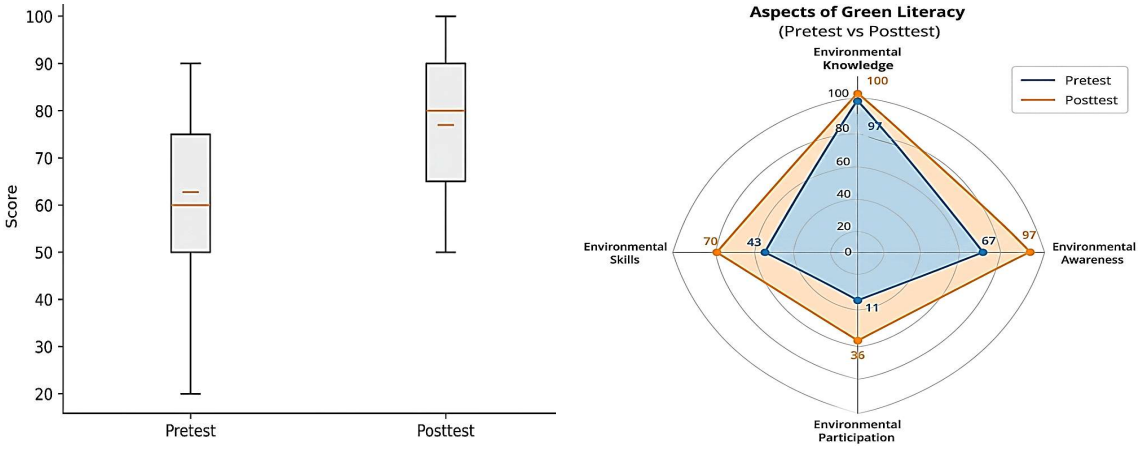

Figure 11. Aspects of green literacy

identify relationships among concepts, and construct coherent conceptual understanding.

The effectiveness of the Flipbook Maker is also supported by recent findings on multimedia learning. Interactive multimedia that combines text, illustrations, animations, and videos reduces the cognitive difficulty of understanding abstract scientific concepts and promotes deeper conceptual understanding than text-only learning materials. Systematic reviews have consistently shown that multimedia representations improve students' comprehension, engagement, and learning outcomes when they are designed according to multimedia learning principles.

These findings are particularly relevant for elementary school students because science concepts are more easily understood when presented through concrete visualizations and multiple representations rather than verbal explanations alone. Recent systematic reviews on elementary science education report that interactive visual media and multiple representations help students transform abstract concepts into observable learning experiences, thereby improving conceptual understanding, reasoning skills, and science learning outcomes. Therefore, the increase in students' posttest scores in this study can be interpreted not only as the effect of an attractive digital medium but also as evidence that the Flipbook facilitated students' concept acquisition through meaningful visualization and multiple representations of the water cycle.

Based on the results of the pretest and posttest analyses using green literacy indicators, all indicators showed improvement following the

use of teaching materials created using Flipbook Maker. The highest improvements, in descending order, were in environmental knowledge (100%), environmental awareness (97%), and environmental skills (70%). However, environmental participation fell into the low category (36%). Although it showed an increase, this indicator still had the lowest percentage compared to the other indicators. This indicates that fostering active participation in environmental conservation requires sustained practice and hands-on experience; classroom learning alone is insufficient. Overall, these results indicate that the use of green literacy-based teaching materials created using Flipbook Maker is effective in enhancing students' environmental knowledge, awareness, skills, and participation. However, participation still needs further development through more contextual and practice-oriented learning activities.

The use of Flipbook Maker-assisted teaching materials is supported by Piaget's cognitive development theory, which states that elementary school students are at the concrete operational stage, so it is easier to understand concepts through visual representations and concrete experiences than abstract explanations (Tursinawati & Widodo, 2019). This is in line with the Cognitive Theory of Multimedia Learning proposed by Mayer (2021), which explains that learning becomes more effective when information is presented through a combination of text, images, animations, and videos because it is processed through visual and verbal channels simultaneously. In the water cycle material, which is abstract because the processes of evaporation, condensation, and precipitation cannot be observed directly, Flipbook can present interactive visualizations that help students build a more concrete understanding of the concept. This finding is supported by recent studies showing that the use of digital flipbooks can improve elementary school students' conceptual understanding, learning motivation, and learning outcomes because they present material in a more interesting, interactive, and easy-to-understand manner (Mayer, 2021).

According to Machsun & Indana (2023), science literacy-based flipbooks are effective in improving students' scientific thinking skills. By using environment-based learning resources, social science instruction can enhance students' ecological literacy and is considered more effective than conventional teaching methods. Arga et al. (2019) reported findings consistent with student feedback regarding the use of Green Literacy teaching materials created using Flipbook Maker in science instruction.

This study has several limitations that should be considered when interpreting the findings. First, the study was conducted in only one elementary school involving a single fifth-grade class. Therefore, the characteristics of the participants, school environment, and learning context may differ from those of other elementary schools. Consequently, the findings cannot be generalized to all elementary school settings without further investigation.

Second, this study employed a one-group pretest-posttest design without a control group. Although the results demonstrated significant improvements in students' learning outcomes after using the Flipbook Maker-based green literacy teaching materials, the absence of a comparison group limits the ability to attribute these improvements solely to the intervention. Other factors, such as students' prior learning experiences, teacher support, or maturation during the learning process, may also have contributed to the observed gains.

Therefore, future studies are recommended to employ a more rigorous experimental design, such as a quasi-experimental or randomized controlled design involving experimental and control groups across multiple schools with larger and more diverse samples. Such studies would

strengthen the external validity of the findings and provide more robust evidence regarding the effectiveness of Flipbook Maker-based green literacy teaching materials in improving elementary students' green literacy and science learning outcomes.

Based on the research findings, the green literacy-based teaching materials created using Flipbook Maker were found to be valid, practical, and effective for use in IPAS instruction in elementary schools. The use of these teaching materials can improve learning outcomes and develop students' knowledge, awareness, skills, and participation in environmental conservation. Therefore, green literacy-based Flipbook Maker materials can serve as an alternative digital teaching resource that supports meaningful and sustainable learning. Humaira et al. (2025) also reported that the use of Flipbook Maker–based instructional materials can improve students' learning outcomes and is more effective than conventional learning materials.

Therefore, promoting green literacy and fostering an environmental culture among younger generations are essential for contributing to broader sustainability goals. These efforts support the transition toward green transformation and sustainable development by advancing the green economy, green literacy, and sustainable behaviors (Tran et al., 2024). Accordingly, knowledge and understanding of environmental issues, sustainable practices, and the impacts of human activities on the planet are key components in empowering individuals to make informed decisions and take actions that promote a creative and environmentally responsible culture (Liu & Tobias, 2023).

CONCLUSION

Based on the research findings, it can be concluded that the development of Flipbook Maker-based environmental literacy teaching materials for science instruction in elementary schools meets the feasibility criteria encompassing validity, practicality, and effectiveness regarding both content and media. These Flipbook Maker-based materials incorporate content covering environmental knowledge, awareness, skills, and participation. In terms of effectiveness, there was a significant improvement in student learning outcomes following the use of the developed materials. Therefore, these materials are suitable for use as an innovative instructional alternative to enhance science understanding while fostering environmental awareness among elementary school students.

Furthermore, these materials can boost student engagement in the learning process through an interactive and contextual presentation. Thus, the development of technology-based teaching materials such as those created using Flipbook Maker offers an effective solution to support learning that aligns with 21st-century needs and to strengthen environmental literacy from an early age.

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