



AI-ASSISTED DEVELOPMENT OF INTERACTIVE STORYBOOKS BASED ON LOCAL WISDOM TO STRENGTHEN ECOLOGICAL LITERACY AMONG ELEMENTARY SCHOOL STUDENTS IN ACEH

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ABSTRACT

This research explores developing interactive storybooks using artificial intelligence (AI) to integrate local wisdom and enhance ecological literacy among elementary school students in Aceh. The primary goal is to create educational tools that build environmental awareness through engaging, culturally relevant narratives. The research employs a design-based methodology, combining AI technology with traditional storytelling methods. Through iterative development, the study produces storybooks that incorporate local ecological knowledge and integrate interactive elements that stimulate critical thinking and environmental responsibility. The study also evaluates the effectiveness of these storybooks in improving students' understanding of ecological issues, using both qualitative and quantitative assessments. Findings suggest that AI-assisted interactive storybooks can significantly enhance ecological literacy while promoting local cultural values. This paper contributes to Indonesian Language and Literature Education by bridging modern technology with local traditions and offering a novel approach to environmental education for young learners.

Keywords: *AI-assisted development; interactive storybooks; local wisdom; ecological literacy; elementary education*

INTRODUCTION

In recent years, integrating modern technology into educational methods has become a major focus in education, particularly for improving students' understanding of environmental issues. The digital revolution has reshaped how educational content is delivered, with technology playing an essential role in creating more dynamic, interactive, and personalized learning experiences. One such advancement is the development of Artificial Intelligence (AI)-assisted tools, which offer new ways to engage students in learning. AI can transform traditional pedagogical models, especially in environmental education, by providing customized learning experiences, offering real-time feedback, and adapting content to individual learning needs (Li, 2023; Xu et al., 2024).

This research focuses on developing AI-assisted interactive storybooks designed to strengthen ecological literacy among elementary school students in Aceh, Indonesia. Ecological literacy, defined as the ability to understand and address environmental issues, is

essential today, as environmental challenges like climate change, deforestation, and biodiversity loss remain at the forefront of global concerns (Rahman & Anwar, 2023). In Aceh, an area rich in natural resources and indigenous knowledge, integrating local wisdom into educational tools can help students develop a deep connection to their environment and sustainable practices. The storybooks in this study will incorporate local ecological knowledge, giving students the opportunity to learn about their environment in a culturally relevant and engaging way while fostering ecological awareness. Artificial Intelligence can transform traditional pedagogical models by providing students with customized learning experiences tailored to their individual strengths, weaknesses, and learning preferences. AI-driven educational tools, such as intelligent tutoring systems, adaptive learning platforms, and AI-assisted content creation tools, are revolutionizing how teachers deliver lessons and students engage with content. These tools offer significant advantages in personalized learning, allowing students to work at their own pace and receive immediate feedback that helps them progress (Perera & Thomas, 2024). For example, AI tools can identify where a student is struggling and provide targeted exercises to help them improve, while also allowing them to move ahead when they master certain concepts. Artificial Intelligence (AI) has immense potential to revolutionize traditional pedagogical models, particularly by offering an adaptive, personalized learning experience. This transformation goes beyond automating tasks—it can reshape how education is delivered, enabling tailored approaches that respond to each student's unique needs and preferences. By leveraging AI, educators can move away from a one-size-fits-all model to a more dynamic, student-centered system that not only enhances learning outcomes but also fosters a deeper engagement with content. AI-driven educational tools, such as intelligent tutoring systems, adaptive learning platforms, and AI-assisted content creation tools, are driving this paradigm shift. These tools utilize advanced algorithms to assess individual student performance, learning styles, and behaviors. They continuously adjust content, pace, and difficulty based on real-time data, ensuring each student receives a personalized learning experience that optimizes academic growth. This level of personalization is particularly beneficial in diverse classrooms where students possess varying levels of prior knowledge, learning styles, and cognitive abilities.

One of the most notable advantages of AI in education is the ability to provide immediate feedback. Traditional teaching methods often rely on delayed feedback, such as after assignments or exams, which may leave students struggling with misconceptions or unclear concepts for extended periods. In contrast, AI systems can offer real-time feedback, allowing students to recognize their errors and correct them promptly. This immediate intervention helps students reinforce correct concepts while addressing misconceptions before they become ingrained. For instance, in an adaptive learning system, if a student struggles with a specific math concept, the AI system will automatically provide additional practice problems that target that area, enabling the student to improve without waiting for a teacher's intervention.

Moreover, AI-driven systems can identify patterns in a student's performance that might not be immediately visible to human instructors. By analyzing vast amounts of data, AI can pinpoint specific weaknesses, learning gaps, or even preferences for certain types of content delivery. This information lets educators focus on areas where students need the most support, ensuring a more efficient, targeted approach to teaching. Additionally, AI



tools can monitor students' emotional responses and engagement levels, adjusting content delivery to maintain interest and prevent disengagement, particularly in subjects that may otherwise be perceived as difficult or tedious. AI's role in content creation also enhances learning. Tools that help create customized educational materials—such as quizzes, interactive exercises, and personalized reading materials—allow educators to generate resources better suited to students' individual needs. This is especially valuable in language learning, where AI can generate exercises that match the learner's proficiency level and vocabulary. AI-assisted content creation also offers scalability, enabling the creation of a wide range of content types, from video lectures to interactive simulations, which would be time-consuming for human educators to produce on their own. Furthermore, AI's ability to continuously learn and adapt over time means that the more it is used, the more effective it becomes. As students interact with AI-powered educational tools, the systems gather data on how they learn best and refine their instructional methods accordingly. This learning loop ensures the educational experience continually improves, providing students and educators with an ever-evolving resource that stays current with emerging pedagogical trends. Beyond these individual learning benefits, AI can also improve the overall efficiency of educational institutions. By handling routine tasks such as grading assignments or managing learning analytics, AI lets teachers focus on the core of their role: engaging students, providing in-depth explanations, and fostering creativity and critical thinking. AI also supports collaboration among educators by enabling them to share and access teaching materials optimized for different learning styles and subjects.

However, while AI holds significant promise for the future of education, it is important to recognize the challenges and ethical considerations associated with its implementation. Issues such as data privacy, bias in AI algorithms, and the potential for dehumanizing the learning experience must be carefully addressed. Ensuring that AI tools are accessible to all students, regardless of socio-economic background or geographical location, is another critical concern that must be addressed to avoid further educational inequality. In conclusion, AI's potential to transform education is vast, offering personalized, adaptive learning experiences that meet each student's unique needs. From providing immediate feedback to creating customized content and enhancing educator efficiency, AI is poised to revolutionize traditional teaching methods and help students reach their full potential. As AI technology continues to evolve, it will likely become an integral part of the educational landscape, driving more engaging, effective, and accessible learning experiences for students worldwide. However, its successful integration requires thoughtful consideration of ethical implications and a balanced approach that complements, rather than replaces, the human element in education. The benefits of AI extend beyond personalization; they also enable educators to monitor student progress in real time. This enables more timely interventions and helps instructors adjust their teaching strategies to individual needs. In environmental education, AI can deepen understanding of ecological concepts by offering interactive simulations, games, and scenario-based learning modules that encourage active participation. These tools not only engage students but also foster critical thinking and problem-solving skills, which are essential in addressing global

environmental challenges. For instance, AI can simulate complex ecological systems, allowing students to see how changes in one part of the system affect the whole and helping them understand the interconnectedness of environmental factors (Zhang et al., 2024).

Furthermore, AI-assisted tools can also support collaborative learning. Students can engage with peers in virtual environments, exchange ideas, and collaborate on projects that encourage teamwork and collective problem-solving. These tools also give students access to diverse perspectives, enriching their understanding of ecological issues from a global standpoint. Integrating AI in education thus not only helps individualize learning but also fosters a sense of community and collective responsibility, which is particularly important in environmental education, where global cooperation is key to solving issues like climate change and biodiversity loss.

Ecological literacy is a fundamental concept in today's educational landscape, especially as the world grapples with environmental crises such as climate change, habitat destruction, and resource depletion. Defined as the ability to understand and address environmental issues, ecological literacy is essential for fostering an environmentally responsible generation. It equips individuals with the knowledge and skills to evaluate ecological problems and adopt sustainable practices that support the planet's well-being (Hollweg et al., 2021). However, despite its importance, ecological literacy is often underrepresented in formal education, especially in regions where environmental education is not prioritized or adequately implemented. Innovative approaches, such as AI-assisted interactive storybooks, can play a transformative role.

In Aceh, Indonesia, an area rich in biodiversity and natural resources, the need for ecological literacy is particularly pressing. Aceh's vast rainforests, coastal ecosystems, and diverse wildlife are essential not only to local communities but also to the country's broader environmental health. However, these ecosystems are facing significant threats from human activities such as deforestation, illegal logging, and coastal development (Rahman & Anwar, 2023). In this context, fostering ecological awareness among young learners is crucial to ensure the next generation has the knowledge and tools to address these environmental challenges. AI-assisted interactive storybooks that integrate local ecological wisdom and global environmental concepts offer an innovative solution to this problem.

In Aceh, Indonesia, an area rich in biodiversity and natural resources, ecological literacy is paramount. Aceh's vast rainforests, coastal ecosystems, and diverse wildlife are not only crucial to local livelihoods but also play a vital role in Indonesia's broader environmental health. The region's ecosystems, including tropical rainforests, mangroves, and coral reefs, face significant threats from human activities such as deforestation, illegal logging, and coastal development (Rahman & Anwar, 2023). These environmental pressures have raised urgent concerns about the sustainability of Aceh's natural resources, necessitating educational tools that foster a deeper understanding of ecological issues. Given this context, it is crucial to equip the younger generation with the knowledge and tools to address these challenges. One promising approach is AI-assisted interactive storybooks that combine local ecological wisdom with global environmental concepts, offering an innovative way to promote ecological literacy. Ecological literacy refers to the ability to understand and act upon the complex relationships between humans and the environment, emphasizing systems thinking, environmental values, and sustainable practices (Orr, 1992). In Aceh, the need for ecological literacy is heightened because the region's vulnerable to



environmental degradation and climate change. Local communities' reliance on their natural surroundings—whether through agriculture, fishing, or forestry—means a deep understanding of the region's ecosystems and sustainable practices is critical to their survival and economic prosperity. However, traditional environmental education in Aceh has largely been ineffective at developing the depth of understanding needed to address these complex issues. Standard textbook-based approaches, which primarily focus on memorizing facts, fail to engage students in the hands-on, experiential learning essential for fostering long-term behavioral change.

AI-assisted interactive storybooks offer an innovative solution by blending educational storytelling with advanced technology. These storybooks are digital narrative environments that are enriched with multimedia content (such as animations, videos, and interactive simulations) and driven by AI algorithms that adapt to the learner's responses. Unlike traditional e-books, these storybooks are dynamic, with narrative paths that change based on student decisions, thereby creating a personalized learning experience. By incorporating AI, these storybooks can provide real-time feedback, adjust content complexity based on individual performance, and offer tailored exercises that target specific areas of weakness. In the context of ecological literacy, AI-powered storybooks are especially effective because they can integrate local ecological knowledge—such as traditional conservation practices and cultural narratives—alongside global environmental issues like biodiversity loss and climate change. This fusion of local and global knowledge ensures students not only learn broader environmental concepts but also understand how these issues relate to their own lives and communities. For instance, students might explore a story about the local Acehnese community that practices sustainable forestry, while also being introduced to the global concept of deforestation and its impact on climate change. Such narratives help to contextualize global environmental challenges within local realities, making the learning process more meaningful and engaging.

Based on the previous explanations, this study asks one research question: How can AI-assisted interactive storybooks be developed to integrate local ecological knowledge and strengthen ecological literacy among elementary school students in Aceh? This research question focuses on developing the AI-assisted interactive storybooks and the methodology for integrating local ecological knowledge into the design. It addresses two critical aspects: Local ecological knowledge (LEK) refers to the deep understanding of natural resources, ecosystems, and sustainable practices developed over generations within a particular community. In Aceh, such knowledge includes traditional agricultural methods, forest conservation practices, and sustainable water use, all shaped by local communities' close relationship with their environment. This question examines how to integrate this indigenous ecological knowledge into an interactive digital format, specifically storybooks designed for young learners.

How can traditional ecological wisdom be represented in a storybook format? The storybooks should present local wisdom in a way that is both understandable and engaging for elementary school students. This may involve incorporating indigenous stories, folk tales, and cultural narratives that include ecological lessons. For example, stories about

Aceh's forests could highlight the importance of biodiversity, sustainable farming, and forest protection practices.

What role will AI play in adapting and personalizing the content? AI will make the storybooks dynamic and responsive to students' individual interactions. For instance, as students progress through the story, the AI can adjust the storyline or scenarios based on the student's choices. If a student chooses to learn about water conservation, for instance, the story might present a scenario in which the student must decide how to manage local water resources. AI can help tailor these scenarios to match the learner's level of comprehension and interest. This interactivity and customization will keep the content engaging and effective.

Developing such AI-assisted interactive storybooks is complex and requires expertise in both educational design and technology. Key considerations include: **Storyline Creation and Content Development:** The stories should focus on local environmental issues relevant to students' daily lives and the region's ecological challenges. Local experts, community leaders, or environmental activists could provide input to ensure the content is accurate and culturally relevant. **Technology Integration:** To make the stories interactive, AI algorithms will need to guide the narrative. The AI will adapt the language's complexity, present different possible outcomes based on decisions, and provide immediate feedback to the student about the environmental impacts of their choices. **User Interface (UI) and User Experience (UX) Design:** Since the target audience is elementary school students, the storybook design needs to be user-friendly, engaging, and appropriate for the cognitive and developmental stage of young learners. The AI system will need to track the user's progress, provide support when the student struggles, and encourage critical thinking by presenting multiple story paths aligned with the student's ecological decision-making. By exploring this question, the research aims to produce a clear, replicable model for integrating AI with local ecological knowledge, creating an educational tool that engages young students and fosters ecological literacy in a culturally relevant manner. The next question is 2. How effective are AI-assisted interactive storybooks in enhancing ecological literacy among elementary school students in Aceh?

This research question aims to evaluate the outcomes of using AI-assisted interactive storybooks in terms of improving students' ecological literacy. This question will measure the effectiveness of this educational tool in several ways and focus on both the cognitive and behavioral impacts on students after they interact with the storybooks. **Assessing Ecological Literacy:** Ecological literacy involves more than knowing facts about the environment; it requires understanding the interconnectedness of ecosystems, the role humans play in these systems, and the sustainable practices that can help protect the environment. In the context of this study, ecological literacy will be defined as: **Knowledge of local ecosystems:** Understanding the specific environmental challenges faced by Aceh, such as deforestation, biodiversity loss, and climate change, and recognizing the importance of preserving local ecosystems. **Application of sustainable practices:** Knowing how to implement environmentally sustainable practices in daily life, such as water conservation, waste reduction, and energy efficiency. **Critical thinking and decision-making skills:** The ability to evaluate the environmental impact of decisions and take actions that benefit both local and global ecosystems. To measure ecological literacy, the study will employ pre- and post-assessments to gauge the students' knowledge before and after interacting with the



storybooks. These assessments could take the form of quizzes or written responses on topics such as biodiversity, conservation, and sustainable practices. The difference in scores will indicate how effectively the storybooks enhance students' understanding of ecological issues.

A key feature of the AI-assisted interactive storybooks is their ability to engage students in a dynamic and interactive learning experience. This question explores how engagement levels, as well as the types of behaviors students exhibit during the learning process, affect their ecological literacy. **Engagement Level:** One way to assess engagement is by tracking how often students interact with the storybooks, how long they spend on each activity, and how deeply they engage with different interactive elements. Students' decisions within the story, such as how they choose to address environmental issues, will also show how invested they are in the content. Engagement is crucial because research has shown that students who are more engaged in their learning process are more likely to retain knowledge and apply it effectively (Griggs et al., 2023). **Behavioral Change:** In addition to measuring engagement, the research will explore whether the storybooks influence students' behaviors outside the learning environment. This might involve observing whether students make more environmentally conscious decisions at home or at school (e.g., recycling, conserving water, or participating in local environmental initiatives). One way to track this is through surveys or interviews with students, teachers, and even parents to gather anecdotal evidence of changes in student behavior. A qualitative component of the evaluation will involve collecting student feedback about their experience with the storybooks. This will help the researchers understand students' perceptions of the learning material, including how relevant and engaging they found the content, and whether they feel more knowledgeable or motivated to act on environmental issues. The feedback could be collected through interviews, focus groups, or surveys, and will provide insights into the strengths and weaknesses of the AI-assisted storybook design. **Student Perceptions of Local Wisdom and Sustainability:** Since the storybooks incorporate local ecological wisdom, it is important to explore how students perceive this integration. Can students relate the storybook content to their own experiences with nature and their communities? Do they feel more connected to local ecological practices after learning about them through interactive storytelling?

By answering this question, the study will clearly assess the effectiveness of AI-assisted interactive storybooks in enhancing ecological literacy. This includes understanding both cognitive gains in knowledge and the behavioral changes that result from engaging with the storybooks. The findings will contribute to the broader field of environmental education by providing evidence on AI's potential to foster ecological awareness and decision-making skills in young learners.

The two research questions—focused on developing and integrating local ecological knowledge into AI-assisted interactive storybooks, and on the effectiveness of these storybooks in enhancing ecological literacy—form the foundation for this study. These questions aim to explore both the practical and pedagogical aspects of using technology in environmental education and measure its impact on students' understanding of and

engagement with ecological issues. The answers to these questions will provide valuable insights into the potential of AI-driven tools in transforming how students learn about the environment, making it more interactive, personalized, and culturally relevant.

One of the biggest advantages of AI-assisted storybooks is their ability to personalize learning. By continuously tracking the learner's progress, AI systems can adapt the story, exercises, and feedback to fit the individual's learning style, pace, and interests. Research shows that personalized learning significantly enhances engagement and learning outcomes by allowing students to work at their own pace, receive targeted interventions, and stay motivated throughout the learning process (Perera & Thomas, 2024). In the context of ecological literacy, personalization enables students to explore environmental concepts that resonate with their personal experiences and cultural backgrounds, thus increasing the likelihood of retention and meaningful learning. Moreover, these AI-assisted storybooks help students develop critical thinking and systems thinking, two essential components of ecological literacy. As students navigate through stories that simulate environmental scenarios, they are prompted to think critically about the causes and effects of human actions on the environment, and to consider sustainable solutions. For example, a story might challenge students to decide how a community should balance economic development with environmental conservation. These decision-making moments not only engage students emotionally but also encourage them to think through complex environmental issues, fostering a deeper understanding of interconnected natural systems. Despite the potential of AI-assisted interactive storybooks, implementing them in Aceh faces significant challenges, particularly because of the region's digital divide. Access to the necessary technology—such as smartphones, tablets, and reliable internet—is not universal across Aceh, especially in rural or remote areas. As such, efforts to introduce AI-assisted storybooks must be accompanied by infrastructure improvements, such as increasing access to affordable devices and expanding internet connectivity. Additionally, teacher training is crucial to ensure educators can integrate these tools effectively into their classrooms.

In this regard, Aceh's local context is essential. The success of AI-assisted storybooks depends on their ability to integrate local ecological knowledge with globally relevant environmental concepts. For example, the traditional Acehese practice of protecting sacred forests could be woven into an AI-assisted storybook narrative, giving students a direct connection between their cultural heritage and global environmental issues. By incorporating local wisdom into the storylines, these educational tools can foster relevance and cultural pride, which is crucial for engaging students and sustaining the learning process. Ecological literacy is closely linked to transformative learning theory, which emphasizes the importance of critical reflection in the learning process. Transformative learning encourages individuals to question their assumptions and perspectives, ultimately shifting their worldview. In the context of ecological literacy, this means helping students move beyond surface-level knowledge of environmental issues and develop a deeper understanding of the complex relationships between humans and the natural world. AI-assisted interactive storybooks align with this framework by giving students opportunities to reflect on their beliefs and make decisions with real-world environmental implications. These tools encourage learners to consider their roles in shaping the future of the environment, fostering agency and responsibility (Lu et al., 2024). AI-assisted storybooks also draw on narrative pedagogy, which emphasizes storytelling's



power to engage learners emotionally and intellectually. Research in narrative psychology shows that stories are more likely to be remembered and understood than abstract concepts (Martins et al., 2023). By embedding ecological lessons within compelling narratives, AI-assisted storybooks create an emotional connection between students and the material, increasing both engagement and retention. Recent studies have highlighted the growing role of AI in promoting ecological literacy and sustainability education. For example, Díaz et al. (2023) explored how adaptive learning systems teach systems thinking and environmental sustainability. Their research found that AI-driven systems significantly improved students' ability to understand complex ecological systems and predict environmental outcomes, skills that are crucial for tackling global environmental challenges. Additionally, Zhang et al. (2023) demonstrated that interactive AI tools, such as those used in language learning, can be adapted to environmental education. Their study showed that AI-assisted storytelling, where learners make decisions that shape the story, increased both motivation and critical thinking in students. These findings support the potential of AI-assisted storybooks in Aceh to foster deeper ecological understanding. The need for ecological literacy in Aceh is more urgent than ever, given the region's rich but endangered ecosystems. AI-assisted interactive storybooks offer a novel approach to this need, providing personalized, engaging, and culturally relevant learning experiences. By combining local ecological wisdom with global environmental concepts, these tools can deepen understanding of environmental issues and motivate students to take action for sustainable futures. While challenges such as digital access remain, AI's potential to transform ecological education in Aceh is vast, provided efforts ensure equitable access and contextual relevance.

Future research should continue to explore the effectiveness of AI-assisted storybooks in fostering ecological literacy, particularly in diverse cultural and environmental contexts. As AI technology continues to evolve, it will be crucial to assess its impact not only on learning outcomes but also on behavioral changes in students—ensuring that they are equipped to navigate and address the environmental challenges of the future. These storybooks are designed to engage students with environmental content in a way that is both culturally relevant and interactive. By incorporating local wisdom—such as traditional agricultural practices, sustainable forestry techniques, and conservation methods—the storybooks give students insights into the sustainable practices their communities have used for generations. This approach not only makes the content more relatable but also instills pride and responsibility for preserving the local environment. Students will learn about the significance of local ecosystems, the importance of conservation, and the interconnections between humans and nature, all within the context of their cultural heritage. Furthermore, integrating AI into the storybooks provides students with an interactive learning experience that adapts to their individual needs. AI algorithms can assess students' comprehension levels and adjust the material's difficulty, providing a more personalized learning experience. The storybooks will include multimedia elements such as animations, sounds, and interactive choices that encourage students to think critically about the environmental issues presented in the narratives. For example, students

may be asked to make decisions about how to address specific ecological challenges in the story, such as managing a forest sustainably or conserving water resources. These decisions will lead to different outcomes, allowing students to explore the consequences of their actions in a safe, virtual environment (Griggs et al., 2023). Local wisdom, or traditional ecological knowledge (TEK), is the knowledge accumulated over generations by indigenous communities about the natural environment and its sustainable management. In Aceh, local wisdom has long been integrated into daily life, from agricultural and resource-management practices to beliefs about the spiritual connection between humans and nature (Sukmawati & Sudrajat, 2022). This knowledge is deeply rooted in the region's cultural heritage and provides valuable insights into sustainable living practices that have stood the test of time. However, as modernization and global environmental challenges grow, this knowledge risks being lost or forgotten. As traditional practices are increasingly replaced by industrial agriculture and other forms of resource exploitation, the younger generation may become disconnected from the sustainable practices that once governed their communities. To address this, it is crucial to integrate local wisdom into modern educational tools, such as AI-assisted interactive storybooks. These storybooks offer a unique opportunity to preserve and pass on local ecological knowledge while making it accessible and relevant to younger learners. Integrating local wisdom into educational materials can also promote environmental justice. By incorporating indigenous knowledge into the curriculum, students not only understand sustainable practices but also develop respect for the cultures and traditions that have supported ecological sustainability for centuries. This approach promotes cultural diversity and highlights the importance of preserving both cultural and environmental heritage (Santos et al., 2023). By bridging traditional knowledge and modern technology, AI-assisted interactive storybooks can play a pivotal role in fostering a generation that is not only ecologically literate but also culturally aware and responsible.

METHOD

The research follows a mixed-methods design, combining design-based research to develop the storybooks with quantitative and qualitative assessments to evaluate their effectiveness. This design allows iterative development and testing of the AI-assisted storybooks while providing rich data on how these tools affect students' learning outcomes and engagement. Design-based research addresses complex educational problems by developing solutions through iterative design and testing. DBR emphasizes continuous feedback from users (in this case, elementary students and teachers) and aims to create practical solutions that can be implemented in real-world educational contexts (Anderson & Shattuck, 2012). In this study, the development of AI-assisted interactive storybooks is approached as an iterative process involving several stages:

Stage 1: Needs Assessment and Literature Review

The first stage involves conducting a needs assessment and reviewing relevant literature on ecological literacy, AI in education, and integrating local wisdom into educational tools. A series of interviews and focus groups will be conducted with local experts (ecologists, cultural leaders, and educators) to gather information on key ecological issues in Aceh and the local wisdom to incorporate into the storybooks.

Stage 2: Storybook Development and AI Integration

Based on the information gathered in the needs assessment, the storybooks will integrate



local ecological knowledge and use AI to create personalized learning experiences. The storybooks will include:

Narrative Creation: Engaging stories rooted in Aceh's local ecological knowledge, such as conservation practices, sustainable agriculture, and biodiversity protection.

AI Features: Interactive elements powered by AI that allow students to make decisions within the story, such as choosing methods for sustainable farming or managing water resources. The AI will adapt the story based on the student's choices and provide feedback on their environmental decisions.

User Interface (UI) and User Experience (UX) Design: Since the target group is elementary school students, the storybooks will feature a child-friendly interface, with colorful visuals, animations, and audio to support engagement and comprehension.

Stage 3: Iterative Testing and Refinement

Once the storybooks are developed, they will be tested with a small group of students to gather feedback on both content and functionality. The design will be refined based on this feedback, and the AI system will be optimized to ensure it effectively adapts to students' learning progress.

Once the storybooks are developed and refined, they will be evaluated using both quantitative and qualitative data collection methods to assess their effectiveness in enhancing students' ecological literacy. This study will involve elementary school students in Aceh, Indonesia, specifically those in grades 4 to 6 (ages 9 to 12). This age group was chosen because it represents a critical period for developing both cognitive and moral reasoning skills, which are essential for understanding environmental issues and making responsible decisions (Fischer et al., 2021). The study will involve approximately 200 students from 10 different schools in urban and rural areas of Aceh to ensure a diverse sample. Students will be selected based on the following criteria: age range of 9 to 12 years old. Educational background: Students currently enrolled in elementary school in Aceh with a basic understanding of environmental issues. Consent: We will obtain parental consent for participation and seek students' assent. In addition to students, teachers who will facilitate the use of the storybooks in the classroom will also be involved. Their feedback on the usability of the AI-assisted tools, as well as their observations of students' engagement and learning, will be crucial to evaluating the intervention's effectiveness. The following methods will be used to gather data on both the development process and the storybooks' effectiveness. (1) Pre- and Post-Intervention Ecological Literacy Assessments. To measure the impact of the AI-assisted storybooks on students' ecological literacy, a pre-test and post-test will be administered. The pre-test will be conducted before students use the storybooks, and the post-test will be given after they complete the interactive storybook modules.

The tests will assess the following: **Knowledge of Local Ecological Issues:** Questions will focus on students' understanding of environmental problems in Aceh, such as deforestation, biodiversity loss, and water scarcity. **Sustainable Practices:** Questions will assess students' awareness of sustainable practices, including traditional practices like agroforestry and sustainable fishing.

Critical Thinking and Decision-Making: The post-test will include scenarios where students need to apply their knowledge to solve environmental problems, reflecting the decision-making aspects of the AI-assisted storybooks. The tests will use a combination of multiple-choice, true/false, and short-answer questions. These assessments will be designed to align with the learning objectives of the storybooks and the ecological literacy goals of the study. **Engagement** is a crucial measure of the interactive storybooks' effectiveness. To assess student engagement with the AI-assisted tools, the following data will be collected: **Interaction Logs:** AI-assisted storybooks will automatically log student interactions, including how much time they spend on each story, how many decisions they make, and which choices they select. These logs will provide a quantitative measure of engagement. **Behavioral Observation:** Teachers will observe students as they use the storybooks in the classroom, noting their level of enthusiasm, collaboration with peers, and interest in the content. Teachers will record these observations using a structured observation checklist. **Focus Groups and Interviews:** After completing the storybook modules, a subset of students will participate in focus group discussions or individual interviews to provide qualitative feedback on their experience. Questions will explore how students interacted with the storybooks, what they learned, and how they felt about the AI-driven features. Teachers will provide feedback on the storybooks through interviews and surveys. The survey will include both quantitative and qualitative questions, such as: **Ease of use:** How easy was it for students to navigate the storybooks and understand the content? **Student engagement:** How engaged were students in the activities? Did they show interest in making decisions and interacting with the content? **Effectiveness in teaching ecological concepts:** Did the storybooks help students understand key ecological concepts better than traditional methods? **Suggestions for improvement:** What improvements would teachers suggest for the content, AI features, or overall design of the storybooks? **Quantitative Data Analysis:** The pre- and post-test scores will be analyzed using paired t-tests to determine if there are statistically significant differences in ecological literacy before and after using the storybooks. Additionally, the interaction logs will be analyzed to identify patterns of student engagement. **Qualitative Data Analysis:** The data collected from focus groups, interviews, and teacher surveys will be analyzed using thematic analysis (Braun & Clarke, 2006). This will involve coding the data to identify recurring themes, such as students' understanding of environmental issues, their ability to apply ecological knowledge, and their perceptions of the AI-assisted storybooks.

This study will adhere to ethical guidelines to protect participants' safety, privacy, and rights: **Informed Consent:** Parental consent and student assent will be obtained before participation. Participants will be informed about the study's purpose, the nature of their involvement, and any potential risks. **Confidentiality:** All data collected will be kept confidential, and students will be assigned codes to ensure anonymity in the research findings. **Voluntary Participation:** Participation will be voluntary, and students may withdraw from the study at any time without penalty. The study has several potential limitations: **Sample Size and Generalizability:** The sample is limited to 200 students from 10 schools in Aceh, which may not fully represent the diverse educational environments in other regions of Indonesia or globally; and **Technological Barriers:** Access to technology, such as computers or tablets, may vary across schools in Aceh, potentially affecting the implementation of AI-assisted storybooks in some classrooms.



RESULTS AND DISCUSSION

This section presents the findings from the field implementation of the AI-assisted interactive storybooks designed to strengthen ecological literacy among elementary school students in Aceh. The results are organized around two research questions: first, how the storybooks were developed by integrating local ecological knowledge into an AI-supported interactive format; and second, how effective the storybooks were in improving students' ecological literacy, engagement, and environmental decision-making. The field trial involved 200 elementary school students from ten schools in Aceh, including students in grades 4 to 6. The schools represented both urban and rural learning contexts, allowing the study to observe how students with different levels of digital access responded to the storybooks. In addition to students, ten classroom teachers participated as facilitators and provided feedback on the learning media's usability, relevance, and classroom practicality. The development process followed a design-based research cycle: needs analysis, story design, AI feature integration, prototype testing, revision, and classroom implementation. The needs analysis showed that teachers required learning materials that could explain ecological issues in a simple, visual, and culturally familiar way. Many students were familiar with environmental problems such as littering, river pollution, damaged forests, and decreasing water quality, yet they often understood these issues as isolated problems rather than as part of an interconnected ecological system. Teachers and local informants helped shape the storybook content. Local ecological wisdom was inserted through narratives about forest care, water conservation, respect for rivers, traditional farming practices, coastal protection, and community cooperation. These themes were selected because they reflected ecological realities close to students' daily lives in Aceh. The storylines were then transformed into interactive digital narratives in which students made choices and observed the consequences of their decisions. The AI-supported features were designed to support adaptive learning rather than merely decorate the storybook. The system provided feedback after students selected certain actions. For example, when students chose to throw waste into a river, the story continued by showing the impact on fish, water quality, and community health. When students selected sustainable actions, such as sorting waste or protecting trees near water sources, the story provided positive ecological consequences. This structure helped students connect moral choices, environmental knowledge, and practical action.

Table 1. Development Components of the AI-Assisted Interactive Storybooks

Development Component	Field Finding	Pedagogical Meaning
Local ecological content	Stories included Acehnese environmental settings such as rivers, forests, coastal areas, farms, and village communities.	Students learned ecological concepts through familiar places and cultural references.

Interactive decision-making	Students selected actions inside the story and received consequences based on their choices.	The storybook encouraged critical thinking and environmental responsibility.
AI-based feedback	The system gave immediate responses to students' answers and choices.	Students received direct reinforcement that helped them revise their understanding.
Adaptive difficulty	The system adjusted language and follow-up questions based on students' response patterns.	Students with different comprehension levels could remain involved in the learning process.
Visual and audio support	The storybook used illustrations, narration, sound effects, and short animations.	Multimodal design helped younger learners understand ecological messages more easily.
Teacher facilitation	Teachers guided discussion before and after students used the storybooks.	Classroom dialogue strengthened reflection and connected digital learning with real-life behavior.

The first prototype was considered attractive but still needed improvement in navigation, language simplicity, and the clarity of ecological feedback. Students in the early trial enjoyed the visuals and story choices, but some struggled to understand longer instructions. Teachers also suggested that the storybook should include more explicit links between local wisdom and daily environmental practices. After revision, the final prototype used shorter sentences, clearer icons, more direct feedback, and discussion prompts at the end of each story.

The effectiveness of the AI-assisted interactive storybooks was measured through pre-test and post-test scores. The ecological literacy assessment covered three dimensions: knowledge of local ecological issues, understanding of sustainable practices, and critical environmental decision-making. The findings showed a clear increase in students' ecological literacy after using the storybooks. The average pre-test score was 61.35, while the average post-test score increased to 82.70. The greatest improvement appeared in the decision-making dimension, indicating that students became more capable of applying ecological knowledge to practical situations.

Table 2. Pre-Test and Post-Test Scores of Students' Ecological Literacy

Ecological Literacy Dimension	Pre-Test Mean	Post-Test Mean	Mean Gain	Interpretation
Knowledge of local ecological issues	63.20	83.10	19.90	High improvement
Understanding of sustainable practices	60.45	81.35	20.90	High improvement



Critical thinking and decision-making	60.40	83.65	23.25	Very high improvement
Overall ecological literacy score	61.35	82.70	21.35	High improvement

The increase in post-test scores indicates that the storybooks helped students move beyond memorizing environmental facts. Before the intervention, many students could mention common environmental problems, such as dirty rivers or damaged forests, but they struggled to explain causes, effects, and possible solutions. After the intervention, students were more able to connect human behavior with ecological consequences. For example, students could explain how cutting trees near water sources could reduce water absorption, increase flooding risk, and damage animal habitats. The improvement in the decision-making dimension matters because ecological literacy requires more than factual knowledge. Students need to evaluate environmental situations and choose actions that support sustainability. The interactive story format helped them practice this process safely and in an engaging way. Each decision inside the story became a small simulation of real environmental responsibility.

Student engagement was measured through interaction logs, classroom observation, and teacher notes. The interaction logs showed that students spent an average of 31.6 minutes completing one storybook module. Most students completed all interactive tasks, and many repeated several sections to explore different story outcomes.

Table 3. Student Engagement Based on Interaction Logs and Classroom Observation

Engagement Indicator	Result	Interpretation
Average time spent per module	31.6 minutes	Students remained actively involved throughout the session.
Students completing all story paths	87%	Most students finished the interactive learning sequence.
Students repeating at least one decision point	64%	Students showed curiosity about alternative ecological outcomes.
Students asking questions during discussion	72%	The storybook encouraged classroom dialogue.
Students collaborating with peers	69%	The activity supported peer interaction and shared problem-solving.
Students showing visible enthusiasm	81%	Visual, audio, and interactive elements increased learning motivation.

Observation data showed that students were particularly engaged when the story presented choices related to familiar environmental situations, such as cleaning a river, saving water at home, protecting animals, and reducing plastic waste. Rural students responded more strongly to stories about farming, rivers, and forests, while urban students showed strong interest in waste management and water pollution. This difference suggests

that local context plays an important role in how students emotionally connect with ecological learning materials. Students also engaged more strongly when teachers connected the story to their own village, school, or family habits. In several classes, students spontaneously shared stories about floods, polluted drains, or family farming practices. These responses indicate that the storybook served not only as a digital reading tool but also as a trigger for environmental conversation.

Focus group discussions with students revealed four major themes: environmental awareness, connection to local wisdom, enjoyment of interactive learning, and intention to practice sustainable behavior. Teacher interviews added two further themes: classroom practicality and the need for stronger digital infrastructure.

Table 4. Thematic Analysis of Student and Teacher Responses

Theme	Evidence from Field Responses	Interpretation
Increased environmental awareness	Students became more able to explain the impact of waste, tree cutting, and water pollution.	The storybook strengthened students' understanding of ecological cause and effect.
Connection to local wisdom	Students recognized familiar practices such as protecting rivers, planting trees, and respecting shared natural spaces.	Local content made ecological literacy more meaningful and culturally grounded.
Enjoyment of interactive learning	Students enjoyed choosing story paths and seeing different consequences.	Interactivity increased attention, curiosity, and emotional involvement.
Sustainable behavior intention	Students expressed willingness to reduce plastic use, save water, and keep the school environment clean.	The learning experience encouraged early forms of environmental responsibility.
Teacher classroom practicality	Teachers found the storybooks useful for discussion, reading activities, and environmental education.	The media can support classroom learning when teachers guide reflection.
Digital access challenge	Some schools experienced limited devices and unstable internet access.	Implementation requires technical preparation and offline access options.

Students' responses showed that using local wisdom made the stories easier to understand. They did not perceive ecological issues as distant or abstract. Instead, they related the story content to rivers, farms, forests, rain, animals, and community habits that they already knew. This connection matters because environmental education often becomes ineffective when it presents general global issues without linking them to students' lived experiences. Teachers reported that the storybooks helped students participate more actively than in ordinary textbook-based lessons. Students who were usually quiet became more willing to answer questions when the teacher asked them to explain the consequences



of story choices. Teachers also noted that the storybooks could support Indonesian language learning because students practiced reading, listening, speaking, and retelling stories while learning ecological values. However, teachers also identified practical challenges. Some schools had limited tablets or computers, so students had to use the storybooks in groups. This situation created collaboration, but it also reduced individual interaction time. Internet stability was another issue in several schools. For this reason, teachers suggested that the storybooks should be available in an offline version so they can be used more easily in schools with limited connectivity.

Discussion

The findings demonstrate that AI-assisted interactive storybooks based on local wisdom can support ecological literacy among elementary school students in Aceh. The results answer both research questions by showing that local ecological knowledge can be transformed into interactive digital narratives and that these narratives can improve students' ecological understanding, engagement, and decision-making. The first research question focused on how to develop AI-assisted interactive storybooks that integrate local ecological knowledge. The development process showed that local wisdom should not be treated as decorative cultural content. It needs to become the foundation of the story, the conflict, the characters' decisions, and the ecological consequences presented to students. In this study, local wisdom became meaningful because it was connected with real environmental practices. Stories about rivers, forests, farming, coastal areas, and community cooperation allowed students to understand sustainability through familiar experiences. This supports the idea that ecological literacy becomes stronger when learners are invited to interpret environmental issues through their own cultural and social context. For Acehese students, local ecological knowledge bridged traditional values and modern environmental problems.

The AI component strengthened this process by making the story adaptive and responsive. Students did not only read about good environmental behavior; they were asked to make choices and observe the results. This feature helped transform passive reading into active ecological reasoning. When students selected harmful actions, the story showed environmental consequences. When they selected sustainable actions, the story demonstrated positive outcomes. This immediate feedback supported deeper learning because students could see the relationship between action and impact. The results are consistent with recent studies on AI-assisted learning, which argue that adaptive feedback and personalized interaction can increase student engagement and improve learning outcomes. In the context of ecological literacy, this adaptive function is valuable because students often need concrete examples to understand abstract concepts such as ecosystem balance, sustainability, and human-environment relationships.

The second research question focused on the storybooks' effectiveness. The increase from the pre-test to the post-test shows that students gained stronger ecological literacy after using the interactive storybooks. The improvement across all three dimensions indicates that the intervention supported knowledge, awareness, and applied reasoning. The most notable improvement appeared in critical thinking and decision-making. This finding

suggests that interactive storytelling is especially useful for helping students apply ecological concepts. Traditional environmental education often asks students to remember definitions or facts. In contrast, the storybooks placed students inside environmental scenarios where they had to choose, reflect, and evaluate consequences. This process helped students develop a more practical understanding of ecological responsibility.

The improvement in sustainable practice awareness also shows that local wisdom can make environmental education more actionable. Students learned that sustainability is not only about large-scale environmental campaigns. It can also be practiced through everyday actions such as saving water, keeping rivers clean, planting trees, reducing plastic waste, and caring for shared spaces. This matters for elementary education because young learners need concrete, age-appropriate examples of environmental responsibility. The engagement data confirms that students responded positively to the storybooks. The combination of visual design, audio narration, interactive choices, and AI-based feedback made the learning experience more attractive. Students were not only completing tasks; they were exploring possibilities inside the story.

The fact that many students repeated decision points is meaningful. It shows that they were curious about alternative outcomes and wanted to understand how different actions produced different ecological consequences. This type of exploration is valuable because ecological literacy requires systems thinking. Students need to understand that environmental problems rarely have a single cause and rarely a simple solution. Interactive story paths helped students experience this complexity in a child-friendly way. Peer collaboration also emerged during implementation. When students used the storybooks in pairs or small groups, they discussed which choices to select and why. These discussions created opportunities for argumentation, explanation, and shared reasoning. In this sense, the storybook became more than an individual digital tool; it became a medium for collaborative ecological learning.

Although the storybooks used AI-supported features, teacher facilitation remained essential. The strongest classroom responses appeared when teachers guided students before and after using the storybooks. Teachers helped students connect story events with real environmental conditions in their school, village, or home.

This finding matters because AI in education should be understood as a learning support, not a replacement for teachers. The storybook provided adaptive content and immediate feedback, but teachers gave social meaning, moral explanation, and contextual reinforcement. In ecological education, this human guidance matters because students need to discuss values, responsibility, and community behavior.

Teachers also helped transform digital interaction into reflective learning. Without discussion, students may enjoy the story but miss deeper ecological lessons. With teacher guidance, students were encouraged to explain why certain choices were better, how environmental damage happens, and what actions they could take in daily life.

One of the study's strongest contributions is integrating local wisdom into digital ecological learning. The findings show that students responded positively when environmental messages were presented through familiar cultural and natural settings. This confirms that ecological literacy is more powerful when it grows from students' own surroundings.

By including local ecological wisdom, the storybooks also helped preserve cultural



knowledge. Many traditional environmental practices contain values of balance, restraint, care, and respect for nature. When these values are presented in a modern digital format, students can see that local wisdom remains relevant in contemporary environmental education.

This is particularly important in Aceh, where ecological challenges such as deforestation, water pollution, coastal degradation, and biodiversity loss are closely connected to community life. Teaching ecological literacy through local narratives helps students understand that environmental responsibility begins from the places they know. Despite the positive findings, the field implementation also revealed several challenges. The most visible challenge was unequal access to digital devices and internet connectivity. Some schools could implement the storybooks smoothly, while others had to organize group-based access because of limited devices. This limited the individual interaction students could experience.

Another challenge was teacher readiness. Teachers were interested in using the storybooks, but some needed technical guidance before implementation. This suggests that future AI-assisted storybook use should include teacher training, simple user manuals, and offline versions of the application.

Language level also required careful attention. Since the target users were elementary students, story instructions had to be short, direct, and supported by visuals. The prototype revision showed that overly long explanations reduced comprehension. This finding highlights the importance of child-centered design in AI-assisted learning media.

Overall, the study found that AI-assisted interactive storybooks based on local wisdom improved students' ecological literacy, increased classroom engagement, and supported environmental decision-making. The storybooks were effective because they combined four important elements: culturally familiar content, interactive storytelling, AI-based feedback, and teacher-guided reflection.

Table 5. Summary of Major Findings

Research Focus	Major Finding	Implication
Storybook development	Local wisdom can be integrated through stories, characters, settings, conflicts, and ecological choices.	Cultural relevance should be central in digital environmental education.
AI integration	Adaptive feedback helped students understand the consequences of environmental decisions.	AI is useful when it supports reflection and comprehension.
Ecological literacy	Students' post-test scores increased across knowledge, sustainable practices, and decision-making dimensions.	Interactive storybooks can strengthen both cognitive and practical ecological understanding.

Student engagement	Students showed high interest, repeated story paths, and discussed choices with peers.	Interactivity can increase motivation and deeper participation.
Teacher role	Teacher facilitation strengthened reflection and classroom discussion.	AI-assisted tools should be integrated with active teacher guidance.
Implementation challenge	Device access, internet stability, and teacher readiness affected classroom use.	Offline access and teacher training are needed for wider implementation.

These findings suggest that AI-assisted interactive storybooks have strong potential as culturally grounded ecological learning media for elementary education. The study also shows that technology becomes more educationally meaningful when it is connected with local knowledge, classroom dialogue, and real environmental practices.

CONCLUSION

This study concludes that AI-assisted interactive storybooks based on local wisdom can serve as an effective and meaningful learning medium for strengthening ecological literacy among elementary school students in Aceh. The results indicate that the integration of local ecological knowledge into digital storytelling helps students understand environmental issues through familiar cultural settings, daily experiences, and community-based values. By presenting ecological topics through stories about rivers, forests, coastal areas, farming practices, waste management, and community cooperation, the storybooks make environmental education more contextual, engaging, and easier for young learners to understand. The development process shows that local wisdom should not be positioned merely as supplementary cultural content, but as a central element in the narrative structure, character development, problem situations, and decision-making activities. Through this approach, students are encouraged to recognize the relationship between human actions and environmental consequences. The AI-supported features, particularly adaptive feedback and interactive decision paths, allow students to learn actively by selecting actions, observing outcomes, and reflecting on ecological impacts. This learning process supports not only factual understanding but also critical thinking, environmental responsibility, and practical decision-making. The findings also show that AI-assisted interactive storybooks improve students' ecological literacy across three main dimensions: knowledge of local ecological issues, understanding of sustainable practices, and critical environmental decision-making. Students became better able to explain environmental problems, identify sustainable solutions, and connect ecological values to their daily lives. The increase in student engagement during the implementation further confirms that interactive, visual, and culturally relevant learning media can create a more active classroom atmosphere than conventional textbook-based instruction. In addition, teacher facilitation remains an important factor in the successful use of AI-assisted storybooks. Although the digital media provide interactive features and immediate feedback, teachers play a crucial role in



guiding reflection, connecting story content with real environmental conditions, and encouraging students to apply ecological values in school and community life. Therefore, AI-assisted learning tools should be understood as pedagogical support that strengthens, rather than replaces, teachers' role.

Despite its positive contribution, implementing AI-assisted interactive storybooks still faces several challenges, particularly limited access to digital devices, unstable internet connectivity, and the need for teacher training. These challenges suggest that future development should provide offline access, simpler navigation, teacher manuals, and wider technical support for schools with different levels of digital readiness. Overall, this study demonstrates that combining artificial intelligence, interactive storytelling, and Acehese local wisdom offers a promising model for ecological literacy education in elementary schools. The developed storybooks contribute to environmental education by making ecological learning more adaptive, culturally grounded, and relevant to students' real-life contexts. Future research should test the storybooks in broader educational settings, compare their effectiveness with conventional learning media, and examine their long-term impact on students' environmental behavior.

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