

Encyclopedia: Nature-Based Learning Initiative to Enhance Students' Critical Thinking

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Abstract: This study aims to implement a Nature-Based Learning Initiative as an innovative solution to enhance students' critical thinking skills at SD Inpres Hiliwuku, East Sumba. The school faces significant challenges due to its remote location and a lack of electricity and internet access, which restricts conventional teaching methods. This approach utilizes the surrounding natural environment as a "living laboratory" and primary learning resource, supported by the use of a printed Nature-Based Encyclopedia as a physical reference for students to verify field findings. Data analysis results indicate a significant improvement in critical thinking abilities, where the average pre-test score of 49.75 (Insufficient category) increased drastically to 80.25 (Good category) in the post-test. All students showed improvement, with 70% reaching the "Good" to "Very Good" categories. In conclusion, nature-based learning supported by contextual encyclopedias is an effective, low-cost, and sustainable educational alternative that optimizes local potential to overcome infrastructure limitations in remote areas.

Keywords: Critical Thinking; East Sumba; Educational Innovation; Nature Encyclopedia; Nature-Based Learning

Introduction

Education plays a crucial role in advocating for equality and enhancing the quality of life through equitable access and quality learning (Rahma, 2024). However, global assessments like the Programme for International Student Assessment (PISA) indicate that many regions, including Indonesia, still face significant challenges in student academic achievement across mathematics, reading, and science (Widiastuti, 2020). Factors such as regional disparities and limited access to quality education continue to be major global concerns in the effort to improve human resource competencies (Anwar, 2022).

To address these challenges, the development of critical thinking skills has become essential for students to navigate an increasingly complex world. One effective medium for fostering these skills is the use of encyclopedias, which provide wide and verified access

to information, helping students develop systematic and evaluative information-seeking skills (Indriyani, 2022). By identifying, analyzing, and synthesizing information, students can build strong frameworks for scientific thinking and daily problem-solving (Saputri, 2023).

The importance of these skills, schools in remote areas like SD Inpres Hiliwuku in East Sumba face severe infrastructure limitations, including a total lack of electricity and internet access. These conditions prevent the adoption of conventional digital learning methods and restrict students to passive, teacher-centered learning based solely on limited textbooks. Consequently, students' initial critical thinking skills remain at a suboptimal or "Insufficient" level, as they lack the practical activities necessary to stimulate independent analysis and hypothesis formation.

While many educational innovations rely on digital technology, this research introduces a novelty

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by - transforming environmental limitations into a "living laboratory" through a non-digital Nature-Based Encyclopedia. This physical reference book systematically documents local biodiversity, allowing students to verify field observations without needing an internet connection. The purpose of this study is to implement a Nature-Based Learning Initiative to optimize local natural potential as a primary learning resource. The urgency lies in proving that pedagogical innovation rooted in local reality can be a sustainable and low-cost solution for producing competitive future generations in areas isolated from modern technology.

The limitations of modern facilities, particularly internet access, are a crucial challenge faced by many schools in remote areas, including SD Inpres Hiliwuku in East Sumba. Its geographical location far from urban centers and the minimal technological infrastructure prevent the school from adopting conventional learning methods that heavily rely on digital resources. Consequently, students and teachers have limited access to information, knowledge updates, and interactive learning models. This situation has the potential to hinder the development of essential skills, especially critical thinking, which are much-needed to face modern challenges. On the other hand, the rich and unique natural environment around the school is an invaluable "living laboratory," yet this potential has not been maximized.

Recognizing this gap, this initiative was designed as an innovative solution relevant to the local context. The main objective of this activity is to implement a Nature-Based Learning Initiative at SD Inpres Hiliwuku. This approach aims to utilize the abundant natural surroundings as the primary medium and learning resources to enhance students' critical thinking skills. Specifically, the program focuses on developing observational, analytical, and problem-solving skills through practical, outdoor activities. Through this initiative, we hope to turn challenges into advantages, create an interactive and sustainable learning model, and prove that infrastructure limitations are not a major barrier to producing competent and competitive future generations.

As a tangible outcome of this activity, the research and support team has compiled a Nature-Based Encyclopedia specifically designed for SD Inpres Hiliwuku. This encyclopedia is not a digital product; rather, it is a physical reference book that systematically documents the biological wealth and natural phenomena found around the school (Sumarti, 2021). Its purpose is to serve as a valid and easily accessible source of knowledge for teachers and students, overcoming the obstacle of no internet access (Amin Dwi Cahyanti, 2018).

This encyclopedia contains detailed descriptions of local flora and fauna species, ecological characteristics, and notes on natural cycles. With this encyclopedia, students can connect their findings from field observations with structured information, deepen their understanding of natural phenomena, and build a framework for scientific thinking. This encyclopedia serves as a solution to the limited access to digital information, ensuring that the learning process remains data-driven and verifiable without relying on an internet connection, and instilling in students a sense of ownership over their environment and local knowledge

Method

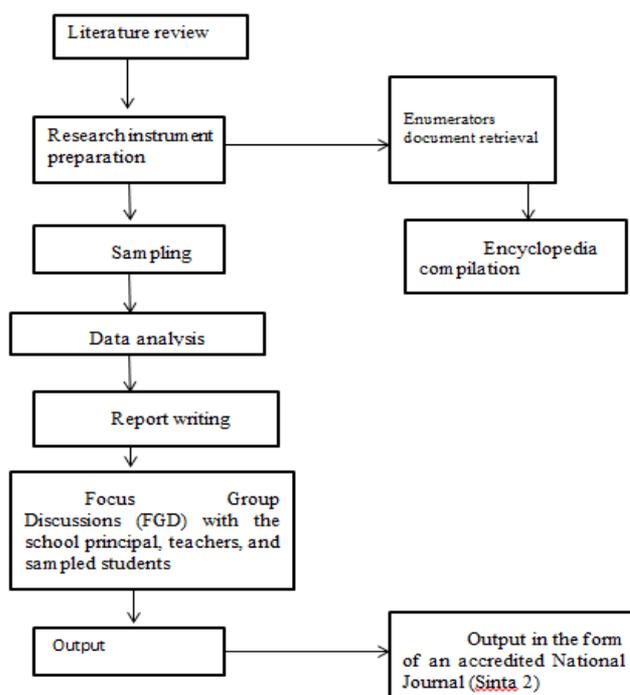


Figure 1. Research Flow

Based on the flow chart you provided, here is an explanation of the methodology used:

This methodology outlines a systematic and structured research process comprising two interconnected workflows: the core research process and the output development process (Adriani, 2018). The core research journey begins with a comprehensive literature review to gather relevant theories, concepts, and prior studies, which establishes a solid foundation for formulating the research problem and designing necessary instruments. Following this phase, the team proceeds to the preparation of research instruments, developing tools such as evaluation rubrics, interview guides, and questionnaires specifically tailored for data collection (Ichsan & Ali, 2020).

The process continues with sampling, where students and teachers are selected as research subjects based on established criteria. Once the data is gathered, it undergoes rigorous data analysis to identify significant patterns, trends, and key findings, which are then compiled into a structured research report. To ensure the quality and depth of the study, the process concludes with Focus Group Discussions (FGD) involving the school principal, teachers, and sampled students. These discussions serve a vital role in validating the initial findings, gaining in-depth insights, and enriching the qualitative data through the diverse perspectives of the stakeholders so that the data presented is valid as stated by (Achmad & Ida, 2018).

Parallel Process (Encyclopedia Development)

This is a specific workflow for producing the project's deliverable, the encyclopedia. The output development process involves a synchronized workflow where enumerators perform comprehensive document retrieval to collect data on local natural resources, flora, and fauna. This gathered information serves as the primary content for the encyclopedia compilation (Dama, 2025). This stage transforms the raw data into a structured printed encyclopedia, a process that runs in parallel with the core research workflow to ensure consistency between the findings and the final educational product (Nurdiansyah, 2021).

Outputs

Ultimately, both workflows converge toward a singular primary objective. The final output of this comprehensive series of activities is the publication of the research findings in an accredited National Journal (Sinta 2). This specific target represents the culmination of the study, where the data from the initial research report—further refined and validated through Focus Group Discussions (FGDs)—is synthesized into a high-quality scientific article to contribute to the national academic discourse (Falzon & Conrad, 2024). Overall, this diagram depicts a comprehensive research methodology that not only focuses on scientific data collection and analysis but also concurrently creates a tangible product (the encyclopedia) that is an integral part of the project's final outcome, which will ultimately be published in a scientific journal (Setyaningsih, 2024).

Result and Discussion

Results of the Pre-Test Data Analysis

A pre-test was conducted to measure students' critical thinking skills before the implementation of the Nature-Based Learning Initiative. This test was designed to identify the initial level of students in terms

of observation, analysis, and problem-solving abilities (Harahap, 2020). The results of the data analysis from the 20 students who served as the research sample are presented in Table 1.

Table 1. Student Critical Thinking Scores and Categories on Pre-Test

Student Initials	Pre-Test Score	Category
AW	55	Sufficient
BA	40	Insufficient
CL	60	Sufficient
DN	45	Insufficient
ER	50	Sufficient
FA	35	Insufficient
GN	60	Sufficient
HI	50	Sufficient
IR	45	Insufficient
JP	55	Sufficient
KA	65	Sufficient
LN	50	Sufficient
MI	40	Insufficient
NA	55	Sufficient
PA	60	Sufficient
QR	45	Insufficient
ST	50	Sufficient
UD	35	Insufficient
VR	60	Sufficient
WN	50	Sufficient
Average Score	49.75	Insufficient

Category Descriptions: Very Good (90-100), Good (75-89), Sufficient (60-74), Insufficient (<60)

Based on Table 1, the students' average pre-test score was 49.75, which falls into the "Insufficient" category. There were 6 students (30%) in the "Insufficient" category, and the rest were in the "Sufficient" category. Not a single student reached the "Good" or "Very Good" category. This data clearly indicates that before the intervention, students' critical thinking skills at SD Inpres Hiliwuku were at a suboptimal level.

Discussion of the Pre-Test

The low pre-test results can be directly linked to the limitations of facilities and teaching methods available at SD Inpres Hiliwuku. Without internet access and digital resources, learning tended to be centered on textbooks and verbal explanations from the teacher. This method provides limited space for students to think independently, form hypotheses, or analyze information from various sources (Sholeh, 2024). Their observational and analytical skills were

also underdeveloped due to the lack of practical, hands-on activities outside the classroom. These conditions confirm that the traditional learning model was not effective in stimulating critical thinking skills, thereby necessitating a new approach to overcome these constraints.

Results and Discussion of the Post-Test

Results of the Post-Test Data Analysis After the implementation of the Nature-Based Learning Initiative for a certain period, a post-test was conducted to measure the change in students' critical thinking skills (Susilowati dkk, 2017). The results of the data analysis are presented in Table 2 below:

Table 2. Student Critical Thinking Scores and Categories on Post-Test

Student Initials	Post-Test Score	Category	Improvement from Pre-Test
AW	85	Good	30
BA	70	Sufficient	30
CL	90	Very Good	30
DN	80	Good	35
ER	80	Good	30
FA	65	Sufficient	30
GN	95	Very Good	35
HI	75	Good	25
IR	80	Good	35
JP	85	Good	30
KA	90	Very Good	25
LN	75	Good	25
MI	70	Sufficient	30
NA	85	Good	30
PA	90	Very Good	30
QR	75	Good	30
ST	80	Good	30
UD	65	Sufficient	30
VR	90	Very Good	30
WN	80	Good	30
Average Score	80.25	Good	30.5

Based on Table 2, the students' average post-test score increased significantly to 80.25, which falls into the "Good" category. All 20 students showed an improvement in their scores, and not a single one remained in the "Insufficient" category. A total of 14 students (70%) successfully reached the "Good" and "Very Good" categories, which is evidence of the program's success in enhancing their critical thinking competencies.

More Concrete Discussion of the Post-Test

The significant improvement in post-test results is a direct consequence of implementing a concrete and relevant methodology that seamlessly integrates conceptual learning with the physical environment. By transforming the school grounds into a "classroom without walls," students moved beyond theoretical reading to direct observation of biodiversity, such as analyzing leaf textures and root shapes, which stimulated the mental mapping essential for critical thinking. This experiential learning was further bolstered by the nature-based encyclopedia, which served as a vital reference for students to verify, classify, and fact-check their field findings—effectively teaching them the fundamentals of data analysis (Luo, 2020). Furthermore, hands-on projects like creating herbaria or medicinal plant maps challenged students to identify problems and design systematic solutions, fostering analytical skills that conventional methods often fail to reach. Ultimately, as revealed in the Focus Group Discussions (FGDs), this approach repositioned students as "little researchers," whose heightened motivation and active participation directly led to superior knowledge retention and skill development (Nurjanah, 2024).

Overall, this data and discussion concretely prove that the Nature-Based Learning Initiative, supported by an innovative and contextual teaching medium like the Nature-Based Encyclopedia, is not just an alternative, but an effective and sustainable solution to improve the quality of education in schools with limited infrastructure.

The data analysis shows a remarkable increase in students' critical thinking skills at SD Inpres Hiliwuku. The average score, which jumped from 49.75 (Insufficient category) to 80.25 (Good category), is strong empirical evidence that this pedagogical intervention was effective. This improvement was not limited to a specific group of students but was widespread among all research participants, indicating the program's success in creating a transformative change. This discussion aims to deeply explore the causal factors responsible for this change, by highlighting the synergy between the learning methodology and the innovative teaching medium.

The significant increase in students' critical thinking scores was directly triggered by the shift in teaching methods from a conventional, passive, and teacher-centered approach to an active, exploratory, and student-centered one (Agustini, 2025). The "classroom without walls" concept implemented through the Nature-Based Learning Initiative effectively broke down the psychological and physical barriers that limited student curiosity. They were no longer just receiving information from textbooks but

were trained to become "little researchers" who actively collected data. For example, students were trained to differentiate flora species by observing the morphology of leaves and flowers, then categorizing them based on their unique characteristics. This hands-on activity aligns with constructivist theories, where knowledge is not transferred but is built by students through real-world interactions with their environment. Through collaborative activities like group projects, students also honed their soft skills such as communication, negotiation, and problem-solving, which are vital components of critical thinking.

A strategic role in this success was played by the Nature-Based Encyclopedia, a non-digital artifact specifically designed to overcome the challenge of a lack of internet access (Dhirtya & Warmika, 2019). This encyclopedia served as a bridge between field observation and a scientific knowledge framework. After conducting direct observations and collecting raw data, students used this encyclopedia as a primary reference to validate and interpret their findings (Dewi, 2024). For instance, a student who found an insect with certain characteristics would refer to the encyclopedia to identify its classification and understand its ecological role. This process of comparing their collected data with verified information in the encyclopedia directly trained their deductive and inductive reasoning, as well as analytical skills, which are the core of the scientific method. The presence of this encyclopedia ensured that even without an internet connection, the learning process remained structured, data-driven, and capable of developing students' scientific abilities in a concrete and measurable way (Agustin, 2022).

Furthermore, the success of this initiative demonstrates a synergistic effect between the method and the medium. Nature-based learning provided the real-world experience and raw data, while the encyclopedia provided the framework for organizing and validating that data (Ichsan & Ali, 2020). The two components complemented each other, turning an environmental weakness (a remote location with minimal technology) into a pedagogical advantage. This model is also proven to be sustainable because it is not dependent on large budgets for technology, but rather focuses on optimizing locally available resources (Astuti, 2020). The FGD results with the school principal and teachers reinforced these findings, with reports that students showed a significant increase in motivation, greater curiosity, and more active participation compared to before, which are key indicators of successful learning.

In conclusion, the findings of this research are not merely a success story for one school but a proof of concept for a new educational paradigm. The Nature-

Based Learning Initiative, combined with a contextual teaching medium like the Nature-Based Encyclopedia, offers a potent and sustainable solution for enhancing students' essential cognitive skills in environments with similar challenges. This research makes a significant contribution to educational literature by demonstrating that pedagogical innovation and the utilization of local resources can be a strong foundation for producing a generation that is not only knowledgeable but also possesses strong critical thinking skills and environmental awareness.

Conclusion

The Nature-Based Learning Initiative at SD Inpres Hiliwuku has empirically proven effective in enhancing students' critical thinking skills, as evidenced by the significant average score increase from 49.75 to 80.25. This success stems from the strategic synergy between innovative pedagogy and contextual media, specifically the Nature-Based Encyclopedia. These findings demonstrate that the most impactful educational solutions are often those rooted in local reality and sustainable low-cost resources.

Scientific implications of this study suggest a necessary shift in the educational paradigm for remote areas, moving away from a dependence on digital-centric models toward ethnopedagogical approaches. This research provides a foundational framework for "frugal innovation" in education, proving that critical thinking development is not contingent upon advanced technology but rather on the quality of interaction between students and their immediate environment. Such a model offers a scalable blueprint for achieving educational equity in regions facing severe infrastructure gaps globally.

Shortcomings of this study include the relatively small sample size and the short duration of the intervention, which may not capture the long-term sustainability of the cognitive gains. The focus was limited to a specific geographical context in East Sumba, potentially affecting the generalizability of the results to different ecological or cultural settings. Furthermore, the evaluation focused primarily on cognitive outcomes, leaving the social and emotional impacts of nature-based learning largely unexplored.

Future research should focus on longitudinal studies to assess the retention of critical thinking skills over several academic years. Expanding the scope to include a broader range of subjects and larger student populations across diverse remote regions would provide more robust data on the model's adaptability. Investigators are encouraged to explore the integration of local wisdom with formal science curricula more

deeply to create a more comprehensive hybrid educational framework.

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Author Contributions

Conceptualization, AM, JT, and FR; methodology, AM and MD; validation, JT and RA; formal analysis, MR and RA; investigation, MD and AM; resources, JT and FR; data curation, MR; writing—original draft preparation, MD and AM; writing—review and editing, JT and FR; visualization, RA and MR. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

There are no conflicts of interest.

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