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Development of Discovery-Based Outdoor Learning Integrated with Papua Local Wisdom to Improve Cooperation and Understanding of the Biodiversity Concept of Students of Phase E of Sman Khas Papua

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Abstract: This study aims to develop a discovery-based outdoor learning model integrated with Papuan local wisdom to improve the collaboration skills and understanding of biodiversity concepts of phase E students at SMAN Khas Papua. The background of this study is based on the low context of science learning regarding the local environment and culture, even though Papua has very high ecological and cultural potential to be used as a learning resource. The method used is the Design-Based Research (DBR) Plomp model which consists of three stages: introduction, development/prototyping, and summative assessment. The results of expert validation show that the model and learning tools have very good validity values (Average Validator Agreement > 3.5). Practicality tests through observation and questionnaires on teachers and students show that the model is easy to implement and helps make learning meaningful. The effectiveness of the model is proven by a significant increase in student learning outcomes (t-test; $p < 0.05$) as well as the development of collaboration skills through outdoor learning. The integration of Papuan local wisdom, such as forest conservation practices and traditional medicine, encourages emotional engagement and contextual scientific understanding. This model also supports the implementation of the Independent Curriculum and the strengthening of the Pancasila Student Profile. This research makes an important contribution to the development of innovative and adaptive local culture-based science learning in the 3T context. Further, large-scale studies are needed to test the model's sustainability and replicability in various regions with similar characteristics.

Keywords: Discovery Learning; Outdoor Learning; Papuan Local Wisdom

Introduction

Science education relevant to students' lives has become increasingly important in the Independent Curriculum era, particularly in Phase E (equivalent to high school). This curriculum emphasizes the importance of learning that is not only content-oriented but also student-centered, relevant to the local context, and supports the development of the Pancasila Student Profile. In this context, biology learning, particularly the topic of biodiversity, requires an approach that bridges scientific concepts with the ecological realities directly experienced by students. This aligns with (Borch & Svabo, 2025), view that science learning should be

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contextualized to provide meaning and shape students' scientific skills and character. However, the implementation of biodiversity learning in the field still faces several challenges. One major challenge is the tendency for material delivery to remain theoretical, abstract, and lacking context, particularly in areas with high ecosystem potential such as Papua (Murphy et al., 2021)

Students in Papua, who live in an environment rich in biodiversity and local values, have yet to receive many learning experiences that connect scientific knowledge with authentic local learning resources. Yet, Papua is one of the world's megabiodiversity regions, home to more than 20.000 endemic flora and fauna species, and is rich in local wisdom practices in natural resource management that have the potential to be integrated into science learning. This potential has not been fully utilized in meaningful learning designs. Many schools remain trapped in a classical learning approach that minimizes exploration of the surrounding environment. In this regard, the discovery-based outdoor learning approach is highly relevant as a pedagogical solution that allows students to learn through direct experiences in the outdoors. Discovery-based learning has been shown to improve conceptual understanding and critical thinking skills (Malagola et al., 2023). while outdoor learning provides opportunities to increase engagement, motivation, and appreciation for the environment (Akarsu, 2025).

Furthermore, cooperative and collaborative learning are also important aspects of modern education, particularly in developing students' social competencies. However, on the ground, learning strategies that encourage collaboration among students in biology learning contexts are still lacking, particularly those that utilize the surrounding environment and local values as learning media (Sri Handayani et al., 2025). This demonstrates the urgent need to develop learning models that not only strengthen mastery of scientific concepts but also foster collaboration through an experiential approach and exploration of local resources. Therefore, learning innovations that combine a discovery approach, active student involvement outside the classroom, and the integration of Papuan local wisdom are needed to improve the quality of biodiversity learning and strengthen students' collaborative skills. This research is a response to this need, focusing on developing a contextual, participatory learning model based on Papua's local potential.

Biology learning at the senior high school level (phase E), particularly on biodiversity, requires an approach that connects students' conceptual understanding with the surrounding ecological reality (Morón-Monge et al., 2020). However, learning practices in the field still predominantly use conventional approaches that are oriented toward memorization, minimal student involvement, and not contextualized to local environmental conditions. This results in students' poor conceptual understanding of biodiversity and weak ecological awareness. Learning that does not address local realities results in students lacking a meaningful connection to the material, resulting in less cognitive and affective meaning in learning. Papua, as one of the regions with the highest levels of biodiversity and cultural richness in Indonesia, actually has extraordinary potential as a natural laboratory and a source of local wisdom that can be integrated into science learning.

Papuan local wisdom in maintaining ecosystems, such as sustainable hunting practices, customary prohibitions against cutting down certain trees, and traditional ways of identifying medicinal plants, contains high ecological and scientific value. However, this local wisdom has not been systematically accommodated in learning design, either in the curriculum or teaching methods. This results in a disconnect between the science students learn in the classroom and the ecological practices that live in their communities. On the other hand, discovery-based and hands-on experience-based learning, such as discovery-based outdoor learning, has not been widely developed, particularly in the context of secondary education in 3T (underdeveloped, frontier, and outermost) regions. This approach has been theoretically and empirically proven to improve understanding of science concepts and critical thinking skills through direct experience and interaction with real objects (Muhammad et al., 2023). Outdoor learning is also considered capable of fostering collaboration among students because it requires them to actively interact in groups during exploration, observation, and data collection in the field.

However, the implementation of outdoor and discovery-based learning remains limited, especially in regions like Papua. The limited availability of learning models relevant to the local context and the minimal integration of science materials with local learning resources prevent students from gaining a holistic and meaningful learning experience. This poses an obstacle to achieving the Merdeka Curriculum competencies, including the dimensions of "critical thinking," "independence," and "mutual cooperation" in the Pancasila Student Profile. Therefore, this research begins with crucial questions: what effective learning strategies can meaningfully enhance understanding of biodiversity concepts for Phase E students at SMAN Khas Papua; how to pedagogically and systematically integrate Papuan local wisdom into contextual science learning designs; and what form of discovery-based

outdoor learning model is not only effective in transferring concepts but also capable of developing student cooperation and social values through meaningful interactions with the local environment.

The developed learning model is based on a constructivist paradigm, where knowledge is actively constructed by students through direct experiences in real environments. The discovery learning approach encourages students to discover scientific concepts for themselves through a process of exploration and scientific inquiry (Retnaningrum & Pamungkas, 2024). In the Papuan context, learning activities are directed at exploring the surrounding environment, rich in biodiversity, and integrating local wisdom values and practices related to conservation and the relationship between humans and nature. This integration not only strengthens students' understanding of scientific concepts but also fosters ecological identity and local cultural awareness One important dimension of the Independent Curriculum and the Pancasila Student Profile is the ability to work together (gotong royong).

The discovery-based outdoor learning model naturally involves collaborative activities because it requires students to work in groups, observe biological objects, discuss findings, and draw conclusions together. These activities provide social experiences that foster communication skills, tolerance, and shared responsibility. This research aims to design outdoor learning activities that not only enhance conceptual understanding but also intentionally foster collaboration as a 21st-century skill. Using the local environment as a learning resource has been shown to enhance the relevance of learning and students' conceptual understanding (Abdullah, 2024). By directly exploring Papua's unique flora and fauna and understanding the local values underlying their preservation, students not only learn theoretical concepts of taxonomy, adaptation, and ecosystems but also appreciate the interconnectedness of science with the lives of the surrounding community.

Therefore, this research aims to design a learning strategy that authentically utilizes the local context to make biology learning more meaningful. The product developed in this study is a learning model and its tools (syllabus, lesson plans, student worksheets, teacher guides) that will be validated theoretically by experts and tested practically in the field (Putra et al., 2024); (Elviana et al., 2024). Validity refers to the appropriateness of the content and the integration of model components (Alyoussef, 2023), while practicality is seen from the ease of use by teachers and implementation in the school context. Its effectiveness is measured by increasing students' conceptual understanding and collaboration skills. Thus, the ultimate goal of this study is to produce a model that can be replicated and adapted to similar contexts, especially in 3T areas. The development of learning models based on local contexts is an important concern in efforts to improve the quality of science learning in the Merdeka Curriculum era. However, the results of the literature review indicate that research integrating discovery-based learning models and outdoor learning approaches at the high school level, especially in 3T areas such as Papua, is still very limited. The learning models developed so far tend to focus on conceptual aspects and have not fully addressed the local dimension.

Several studies have shown that discovery learning is effective in improving students' conceptual understanding and critical thinking skills, especially when combined with exploratory activities. However, most implementations are still classroom-based and do not utilize the surrounding environment as a direct learning medium. On the other hand, the outdoor learning approach, which allows students to learn through real-life experiences outdoors, has also been shown to increase learning motivation, active engagement, and group collaboration (Rezai et al., 2025). Unfortunately, this approach is rarely implemented in high schools in remote areas due to logistical challenges, teacher preparedness, and a lack of learning tools appropriate to local conditions. Furthermore, Papuan local wisdom as a resource for learning biology has so far remained a part of ethnobiology or cultural studies, rather than an integral part of school science instructional design. Studies highlighting Papuan ecological practices—such as customary prohibitions against forest exploitation, sasi-based management, or the use of local medicinal plants—have not been widely used as structured and systematic biology teaching materials (Davis & Choisy, 2024). As a result, local cultural and ecological richness has not been optimally utilized as a learning resource to build students' conceptual understanding and scientific attitudes (Awe et al., 2024).

Conceptually, the three approaches—discovery learning, outdoor learning, and local wisdom-based education—have great potential when combined in a single integrated learning model. However, to date, no research has explicitly developed an integrated learning model that synergistically combines all three for biology learning purposes and fosters student collaboration (Zhang & Dong, 2024). Yet, in the context of the Independent Curriculum, which emphasizes experiential learning and the strengthening of the Pancasila Student Profile, the integration of these three approaches is highly relevant and urgently needed. Therefore, this research aims to fill this gap by developing a discovery-based outdoor learning model

integrated with Papuan local wisdom as an effort to enhance understanding. In addition to offering an innovative learning design, this research is also firmly rooted in the local Papuan context, which boasts rich biodiversity and noble ecological cultural values. This approach aligns with constructivist and contextual education perspectives, which assert that learning is more meaningful when linked to students' real-life experiences and culture (Ramos-Vallecillo et al., 2024). By integrating local wisdom practices such as customary forest management, the use of medicinal plants, and the local sasi system into the learning process, students not only understand scientific concepts but also gain ecological awareness and cultural identity.

This research is also highly relevant to the policy direction of the Independent Curriculum (Curriculum Merdeka), which encourages strengthening the Pancasila Student Profile. Through a discovery-based outdoor learning approach, students are trained to work collaboratively (gotong royong), think critically, interact with their surroundings, and appreciate local cultural diversity—all elements that are core to the future student profile. In this context, the developed model not only meets academic demands, but also forms character and global competencies based on locality. Practically, this model can be an empirical reference for teachers, schools, and policy makers in developing curriculum and learning based on local potential, not only in Papua but also in other regions with similar geographical and sociocultural characteristics. Science education rooted in local wisdom has great potential to bridge modern science with local culture, making learning more relevant, down to earth, and transformative.

Method

This research is a developmental research study that adopts the Design-Based Research (DBR). This approach was chosen because it integrates the development and evaluation of educational products systematically and contextually, through collaboration between researchers and practitioners in the field. The Plomp model consists of three main stages: preliminary research, design and prototyping, and assessment or summative evaluation. Each stage has interrelated objectives, resulting in valid, practical, and effective learning products for application in real-world contexts. The focus of this research is to develop a discovery-based outdoor learning model integrated with Papuan local wisdom to enhance collaboration and understanding of biodiversity concepts among Phase E students at SMAN Khas Papua. The developed learning model is intended as an innovative alternative to address the challenges of science learning, which has remained abstract and lacking contextualization, particularly in remote and underdeveloped regions like Papua (Agustus et al., 2025). Therefore, the DBR approach is deemed appropriate because it accommodates local needs, promotes active teacher participation, and fosters continuous improvement in learning design. In the preliminary research stage, researchers conducted a needs analysis through curriculum documentation studies, interviews with biology teachers, and initial observations of learning conditions and the potential for local wisdom within the school environment. Information from this stage was used to formulate a problem profile and a philosophical basis for designing the initial model. A literature review was also conducted to identify gaps in previous research related to the integration of discovery learning, outdoor learning, and local wisdom in the context of science education.

The next stage was design and prototyping, which involved developing a prototype learning model consisting of key components, such as the syntax for discovery-based outdoor learning, an implementation guide for teachers, Student Worksheets (LKPD), and evaluation instruments. The initial product was then validated by experts including biology subject matter experts, learning experts, and local wisdom experts. Validation was conducted using a validation sheet instrument, and the results were analyzed using the average validator agreement (AVA) method. The model was iteratively revised based on feedback to obtain an improved final prototype. Next, the model was implemented in small group trials and field tests. This stage aimed to determine the model's practicality and effectiveness. Practicality was measured through teacher and student questionnaires regarding ease of use and implementation of learning activities. Effectiveness was assessed based on improved understanding of biodiversity concepts through learning outcome tests (pre-test and post-test), as well as improved student collaboration skills through rubric-based observations and field notes.

Data analysis in this study employed both quantitative and qualitative approaches. Quantitative data, including validity, practicality, and student learning outcomes, were analyzed using descriptive statistics and t-tests. Qualitative data, including interview results, observations, and student responses, were analyzed thematically to explore students' perceptions and experiences in following the developed learning model. By applying the DBR Plomp approach, it is hoped that the resulting learning model will not only be theoretically and methodologically sound but also contextually relevant and applicable in the Papuan learning environment, which has unique geographical

and cultural characteristics. This is part of the effort to transform science learning to be more contextual, collaborative, and rooted in local potential as emphasized by (Budiarti et al., 2022); (Hernawati et al., 2019), in the development of science education based on local potential.

Results and Discussion

Learning Model Validity

The expert validation stage is a crucial step in the process of developing a design-based learning model (DDR), as proposed by (Larasafitri et al., 2022). In this study, validation was conducted by three experts with expertise in biology education, innovative learning design, and Papuan local wisdom (Fauzi et al., 2024). Validation encompassed four main components: the appropriateness of the science content of Papuan local biodiversity, the appropriateness of the discovery-based outdoor learning syntax design, the integration of Papuan local wisdom values, and the quality of the learning materials (LKPD and teacher guide). Each expert was asked to assess the validity indicators using a Likert scale of 1–4 (1 = not valid, 4 = very valid). The scores for each indicator were then averaged and analyzed using the Average Validator Agreement (AVA) approach. The results of the validation data are presented in the following table:

Table 1. Summary of Learning Model Validation Results

Validation Components	Average Score	Validity Category
Content Suitability	3.67	Very Valid
Learning Syntax Design	3.78	Very Valid
Integration of Papuan Local Wisdom	3.56	Very Valid
Tools (Worksheets and Teacher Guides)	3.71	Very Valid
Overall Average (AVA)	3.68	Very Valid

Based on these results, all components showed an average value above 3.00, so the model can be categorized as "highly valid." This aligns with (Ji & Ma, 2023), product validity criteria, which state that a model is valid if it has reached expert consensus and has an AVA value of at least 3.00. Furthermore, the high validity of the integration of Papuan local wisdom indicates that the model optimally reflects local values in the science learning process. This assessment aligns with the findings of (Ji & Ma, 2023), who emphasized the importance of incorporating Papuan local wisdom as a contextual learning resource that strengthens students' understanding of biodiversity principles. This model also meets the principles of contextual and constructivist learning as explained by (Zamiri & Esmaeili, 2024); (Li, 2023), namely that the learning process must begin in a real-world context close to students' lives and facilitate active involvement in discovering knowledge. This is reinforced by (Pratiwi et al., 2024), who asserted that discovery learning syntax can enhance conceptual understanding if supported by locally meaningful media and activities. The validation results indicate that the developed learning model has a high level of suitability for use in science learning in the local Papuan context, particularly in enhancing collaboration and understanding of biodiversity concepts among Phase E students (Sirjon et al., 2023).

Practicality of the Learning Model

A limited trial was conducted to assess the practicality of the discovery-based outdoor learning model, integrated with Papuan local wisdom, before its widespread implementation. This trial focused on aspects of ease of use, usefulness, and the implementation of the model syntax by teachers and students. Subjects in this phase included one biology teacher and 10 Phase E students (grade 11) of SMAN Khas Papua, selected purposively. Data on practicality was collected using two main instruments: an observation sheet on the implementation of the model syntax by the teacher and researcher, and a questionnaire assessing teacher and student perceptions regarding ease of implementation, clarity of steps, relevance of material, and meaningfulness of the learning experience. Each indicator was assessed on a Likert scale of 1–4 (1 = not practical, 4 = very practical).

Table 2. Average Practicality Score of Each Component

Measured Aspects	Average Teacher Score	Average Student Score	Category
Ease of use of the model	3.50	3.60	Very Practical
Clarity of syntax and activity steps	3.67	3.56	Very Practical
Implementation of outdoor activities	3.33	3.44	Practical
Relevance of local wisdom	3.78	3.65	Very Practical
Meaningfulness of learning experiences	3.70	3.68	Very Practical
Overall average	3.60	3.59	Very Practical

These results align with discovery learning theory, where students actively construct knowledge through direct experience and personal involvement (Chusni et al., 2020). Furthermore, a study (Aldalur & Perez, 2023), demonstrated that a discovery-based learning approach combined with concrete experiences can significantly enhance scientific understanding. (Sterling et al., 2017), also emphasized the importance of integrating Papua's local biodiversity into biology learning to foster a strong ecological awareness from an early age. The model's effectiveness was also analyzed in terms of strengthening students' collaborative skills, which are part of 21st-century competencies and dimensions of the Pancasila Student Profile. Data were collected through observation sheets of student collaboration during outdoor learning activities, covering the following dimensions: communication, group responsibility, joint decision-making, and collective problem-solving. Observations showed that 85% of students demonstrated high engagement in group discussions, shared tasks fairly, and actively solved problems that arose during observations in nature. The communication and decision-making dimension received the highest score, with an average of 3.6 on a scale of 4.

The outdoor learning model has been shown to encourage richer social interactions, as the real learning context demands collaboration, responsibility, and shared reflection. Outdoor learning facilitates natural social-emotional learning, in line with (Herlinawati et al., 2024) view that 21st-century learning emphasizes the integration of cognitive and social skills. Furthermore, the Ministry of Education, Culture, Research, and Technology through the Independent Curriculum policy emphasizes the importance of cooperative activities that develop the values of mutual cooperation, communication, and collaboration in cross-context learning. (Kamila et al., 2024), research also underlines that the contextual learning model that emphasizes local potential not only builds scientific understanding, but also students' social character. The application of this model has proven effective not only in the cognitive aspect (conceptual understanding) (Maharani et al., 2024), but also in the affective and social aspects, especially cooperation which is part of the Pancasila Student Profile.

Table 3. Results of Observations of Students' Collaboration Skills

Conceptual Aspects	Pre-Score	Post Score	N-Gain	Category
Understanding Papuan Flora and Fauna	61.2	84.10	0.59	Medium-high
The Role of Local Ecosystems	63.0	86.30	0.63	High
Preservation and Local Wisdom	63.0	84	0.57	Medium
Average N-Gain			0.61	Medium-High

Table 4. Paired Sample t-test Results: Understanding the Concept of Biodiversity

Measured Aspects	Pre-Test Average	Post-Test Average	Score Difference	Sig. (2-tailed)	Description
Understanding of Papuan Flora and Fauna	61.20	84.10	22.90	0.000	Significant Improvement
The Role of Local Ecosystems	63.00	86.30	23.30	0.000	Significant Improvement
Preservation and Local Wisdom	63.00	84.00	21.00	0.000	Significant Improvement
Total Average	62.40	84.80	22.40	0.000	Statistically Effective

These results align with discovery learning theory, Integrating Papuan Local Wisdom into Science Learning

Integrating local wisdom into science learning, particularly natural science (IPA), is an approach that not only strengthens students' cognitive abilities but also builds emotional attachment and contextual meaning within their socio-cultural environment (Winangun et al., 2025); (Zidny et al., 2020). In Papua, numerous local wisdom practices exist that can be utilized as resources for science learning (Sumarsono & Wasa, 2019). Examples include traditional conservation practices for maintaining forest sustainability through the sasi system, herbal remedies based on endemic plants such as the ant nest (Myrmecodia pendans) and red fruit (Pandanus conoideus), and customary norms for preserving water resources and fauna such as birds of paradise. These practices not only reflect the ecological understanding of local communities that has been tested for hundreds of years but also reflect knowledge systems that align with modern scientific principles (Hadlos et al., 2022). When this wisdom is integrated into science learning, students not only acquire scientific knowledge but also develop a strong ecological awareness and cultural identity (Sakti et al., 2024).

Thus, learning becomes more meaningful because it is directly connected to the context of students' daily

lives, as emphasized by the principles of contextual education in the Independent Curriculum. Furthermore, the integration of local wisdom also creates space for more democratic and sustainable science education. As (Yorman et al., 2025) noted, education based on local culture can increase learning motivation, develop 21st-century skills, and encourage students' active involvement in socially relevant scientific activities. For example, when students observe medicinal plants in the school environment and interview traditional elders or local healers, they learn not only plant biology but also communication skills, critical thinking, and respect for traditional knowledge. Strategically, science education based on local wisdom like this serves as a means to ground cultural and environmental values in the educational process. This aligns with the Sustainable Development Goals (SDGs), particularly goals 4 (quality education) and 15 (maintaining terrestrial ecosystems) (Chango-Cañaveral et al., 2025). Therefore, the development of learning models such as discovery-based outdoor learning that integrate local Papuan wisdom is an approach that is not only pedagogically innovative, but also strategic in addressing local educational and sustainability challenges.

Conclusion

This research successfully developed a discovery-based outdoor learning model integrated with Papuan local wisdom and proven valid, practical, and effective in improving the understanding of biodiversity concepts and the ability to work together in phase E students at SMAN Khas Papua. This model not only strengthens contextual learning based on the environment and culture, but also supports the achievement of the Pancasila Student Profile through participatory, collaborative, and meaningful learning. The integration of local wisdom becomes a bridge between science and cultural identity, making science more relevant to students' lives. The recommended further development through large-scale trials and across regional contexts is needed to strengthen the generalization of this model. Collaboration between teachers, indigenous communities, and local stakeholders is highly recommended so that local wisdom-based learning can be implemented sustainably and transformatively. Further research is also recommended to integrate digital technology as a supporter of adaptive and inclusive outdoor learning.

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Conceptualization; methodology.; validation; formal analysis; investigation; resources; E. L., A. R. P., data curation: writing—original draft preparation; writing—review and editing.; visualization: E. L., A. R. P. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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