Enhancing Outdoor Biodiversity Learning Through Permaculture-Based Teaching Modules

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Abstract

Indonesia, as a mega-biodiverse country, faces challenges in raising biodiversity awareness among students. Declining biodiversity knowledge, low vegetable consumption, and reduced interest in traditional medicinal plants highlight the need for innovative learning approaches. The COVID-19 pandemic further restricted outdoor learning. This study integrates permaculture principles into biology modules to enhance outdoor-based biodiversity learning for sustainable development. Using a qualitative experimental approach, 25 tenth-grade students from the UPI Laboratory Model Senior High School participated. The module, validated by experts, showed strong content (80%) and learning orientation (83%), with permaculture integration rated as highly relevant (90%). Implementation effectiveness reached 83%, supporting student-centered, practice-based learning. Findings emphasize permaculture's role in fostering critical and systemic thinking in sustainability education. Challenges include outdoor classroom management and students' unfamiliarity with scientific terms. Integrating permaculture into teaching modules proves effective for biodiversity education, aligning with Education for Sustainable Development (ESD) and Sustainable Development Goal (SDG)

Keywords: Permaculture, Biodiversity Learning, Outdoor Education, Teaching Module, Sustainable Education

1. INTRODUCTION

The learning process cannot be separated from the role of students in understanding the material and applying their knowledge to real-world contexts, especially in their social environment. One of the biology topics that is very relevant to be applied in students' daily lives is biodiversity. This learning is important considering that Indonesia is a mega-biodiversity country with abundant natural biological resources (Putra, Wiryono, & Apriyanto, 2012). Indonesia has 670 mammal species (10.5% of the world's total), 4,782 fish species (1.2%), 1,711 bird species (15.5%), 755 reptile species (6.7%), and 365 amphibian species (4.6%) (LIPI, 2020). The country is also home to 30,000 plant species, which includes three-quarters of the world's 40,000 plant species (Masyhud, 2010). However, despite this very rich biodiversity, its population continues to decline, and the utilization of biological resources is declining. For example, interest in medicinal plants is decreasing among the younger generation, who tend to prefer modern and instant medicines (Wijayakusuma, 2000). In addition, vegetable consumption in Indonesia is still low, only 43% (86 g/capita/day) of the WHO recommendation of 200 g/capita/day, which is at risk of causing degenerative

diseases due to unhealthy diets (Ani et al., 2022). In addition, the issue of unstable fruit supply and declining floriculture growth (Buku Atap Hortikultura, 2023) further highlights the challenges related to Sustainable Development Goal (SDG) 12 (Responsible Consumption and Production). According to the UN (2021), SDG-12 aims to ensure sustainable consumption and production patterns, which are critical to the well-being of present and future generations.

To address these challenges, this study aims to integrate permaculture systems into biology teaching modules to encourage sustainable learning. Permaculture is an outdoor-based learning approach, but this type of learning has become increasingly rare after the COVID-19 pandemic. The pandemic has led to online learning that relies on digital devices, reducing opportunities for students to actively interact with nature. In addition, parental concerns about the safety of children when they are outside the home have worsened this condition. As a result, opportunities to create, experiment, and build deep connections with nature are increasingly rare, potentially threatening the balance of children's holistic development. In fact, children's relationships with nature are instinctive and deep (Heidegger, 1962).

Furthermore, although the topic of biodiversity is covered in phase E learning, existing teaching practices have not effectively equipped students with practical skills to take meaningful action in conserving and utilizing biological resources. Therefore, integrating permaculture principles into biology education can provide students with direct experience in sustainable resource management. Permaculture, which comes from the words permanent and culture, refers to sustainable and continuous agricultural practices (Holmgren, 2011). This approach is in line with SDG-12, especially target 12.7 which encourages sustainable public procurement practices in accordance with national policies and priorities (UN, 2021). By embedding the permaculture system in the biology teaching module, this research is expected to empower students with the knowledge and skills needed to contribute to sustainable resource use and environmental conservation.

2. METHODOLOGY

This study uses a qualitative research method within the framework of experimental research (Creswell et al, 2018). The study employs a descriptive research design to describe the implementation and impact of integrating the permaculture program into biology teaching modules. The qualitative approach allows the researcher to deeply explore the experiences gained by the students and the results from the observations. The sample for this study consists of 25 students, who are students from class X at SMA Laboratorium Percontohan UPI.

The teaching module used will go through a validation test by experts consisting of 2 media and learning experts to obtain information from qualitative data in the form of input, responses, criticisms, and suggestions for improvement that have been provided in the questionnaire (Arikunto et al., 2019). The level of validation can be seen in table 2.

Table 2. Product Validation Level by Experts

Percentage (%)	Qualification	Description
90-100	Very Good	No Revision
75-89	Good	Minor Revision
65-74	Fair	Partial Revision
55-64	Poor	Major Revision
0-54	Very Poor	Total Revision

In addition, the observation sheet assessment used in this study employs a 0-1 scoring system. Processes that are not implemented are given a score of 0, while processes that are well implemented are given a score of 1. The implementation percentage data is analyzed using a formula adopted from Purwanto (2012). This scoring system is used to evaluate the extent to which the integration of the permaculture program into the biology teaching modules is carried out according to the established plan.

The percentage of achievement results obtained is then calculated by finding the average score and

matching the criteria based on the modified assessment guidelines from Purwanto (2012).

Table 2. Learning Achievement Categories

Score Range	Category
81 – 100	Excellent
61 – 80	Good
41 – 60	Fair
21 – 40	Poor
0 – 20	Very Poor

3. RESULTS AND DISCUSSION

This research goes through several stages such as literature study, preliminary study in schools regarding the materials to be used, the next stage is analyzing curriculum needs and the preparation stage is developing a program to produce outdoor learning resources that can be loaded into the teaching module. The level of validation of the teaching module from experts can be seen in table 3.

Table 3. Recapitulation of Needs Analysis Data for Learning Modules Integrated with the Permaculture System

Analysis Aspect	Percentage of Respondents (%)	Qualification	Description
Content Material	80%	Good	The permaculture system learning module is the simplest/practical approach in planning learning with a new paradigm that supports student-centered outdoor learning and
Learning Module Orientation	83%	Good	(1) Incorporates the Pancasila Student Profile, (2) Includes diagnostic tests to classify students' different learning styles, (3) Uses trigger questions to enhance student understanding, (4) Provides prerequisite knowledge as a foundation.
Urgency of Permaculture Integration	90%	Very Good	Highly urgent as an essential activity to equip students with critical, anticipatory, and systemic thinking skills in addressing environmental and sustainability challenges.

The permaculture learning module has been validated by experts and is considered good to very

good in various aspects. In terms of content material (80%), this module is considered a simple and practical approach that supports outdoor-based learning and is student-centered, increasing their active involvement. Students will get more information about the possible benefits that can be obtained, stimulating students to think and process the information obtained based on the knowledge they find themselves, students can also be assessed by exploring their knowledge of several species they encounter (Chairunnisa et al., 2022).

The orientation of the module (83%) shows strength in accommodating the Pancasila Student Profile, providing diagnostic tests to adjust learning styles, and using trigger questions and prerequisite knowledge to deepen students' understanding because Permaculture provides practical insights for students regarding the benefits and importance of preserving biodiversity around them (Ferguson & Lovell, 2014).

The aspect of the urgency of integrating permaculture into learning received the highest validation (90%), confirming that this module is very important in equipping students with critical, anticipatory, and systemic thinking skills in facing environmental and sustainability challenges. With a practice-based approach, this module contributes significantly to education for sustainable development, making it a relevant and strategic tool in learning. Because the principles of permaculture teach the importance of maintaining the balance of nature, reducing the ecological footprint, and using resources wisely. This is relevant in the context of curriculum education that emphasizes the importance of protecting the environment and supporting sustainable development (Smith & Williams, 2009).

The implementation of this learning is student-centered, assessing whether students are able to participate in the learning process and carry out activities related to the permaculture system. The results of the implementation of biodiversity learning through the permaculture system can be seen in Table 2.

Table 2. Results of the Implementation of Biodiversity Learning through the Permaculture System

No.	Assessment Component	Result (%)	Category
1	Alignment of implementation with the teaching module	100%	Excellent
2	Cooperation within the group	100%	Excellent
3	Understanding and implementation of the LKPD (Student Activity Sheet)	100%	Excellent
4	Understanding of permaculture and gamification	50%	Fair
5	Classroom atmosphere management and time allocation	50%	Fair
6	Learning evaluation and closing	100%	Excellent
Average Implementation		**83%**	**Excellent**

Based on Table 2, it is known that the implementation of the permaculture learning system received an overall response (83%) from students. The data can be interpreted very well in terms of material alignment, cooperation, utilization of LKPD, alignment with teaching modules, and game integration. Permaculture integration occurs at the second and third meetings where student activities at the first post conduct an inventory of existing flora and fauna, then continued at the second post where students utilize plant waste as food for maggots as organic waste decomposers and at the third post students learn that maggots that come out of the cage will be eaten by fish in the pond, then fish can be consumed by humans, from here students learn about sustainability in the permaculture system which can be seen in Figure 1.

Figure 1. A) activities in class, B) Learning outside the classroom, and C) Presentations in front of the class.

Reinforcement activities are carried out on biodiversity material in the classroom in accordance with the teaching module, where students get various information about flora and fauna so that students can ask, analyze and know their role in protecting the environment. At the next meeting in accordance with the teaching module that has been integrated into permaculutre students learn in 3 posts that teach sustainable systems in the planting process, decomposition carried out by maggots, students see the development process of maggots from eggs, to maggots and finally to black soldier flies, and maggots are also used as food for catfish in the pond. Then at the next meeting students will explain their experiences while in the permaculture system, presenting information, challenges and solutions provided. after learning the teacher and students give each other an evaluation of the learning

However, there are several aspects in the learning process that need to be considered for improvement, such as (1) less conducive classroom conditions, and (2) students have not utilized several new concepts as sources of information for further learning, such as pronunciation/mention of binomial nomenclature. First, it is a major obstacle to outdoor learning, which has requirements related to safety, scheduling, and curriculum regulations, as well as time and resource constraints (Dillon and Dickie, 2012). In addition, challenges related to planning outdoor time are related to weather conditions (Edwards-Jones, Waite, and Passy, 2018; Shume and Blatt, 2019). To gain the benefits of outdoor learning, educators must consider the cumulative effect of various obstacles and their impact on opportunities for all students (Patchen et al., 2024). Second, students have difficulty remembering the scientific names of species, so that information obtained during the permaculture learning process is not used as a source for further learning due to ignorance. In fact, scientific name recognition in science is difficult to learn, as shown by many studies on children's learning (Braun and Reiss, 2006).

Nevertheless, the concept of permaculture introduced in learning provides an opportunity for students to better understand the importance of sustainability, especially in responsible natural resource management. For example, through the introduction of plants and scientific names, students learn that biodiversity plays an important role in creating sustainable agricultural systems and strengthening food security in accordance with the principles of SDG 12. Students involved in this learning also begin to realize the importance of reducing waste in the consumption of food and other raw materials, and how to choose more environmentally friendly products. In the long term, this knowledge is not only beneficial for science learning, but also for fostering a sense of responsibility for the environment, which is in line with efforts to achieve SDG 12. With the integration of teaching modules that connect scientific knowledge with field practices, such as sustainable agriculture and efficient natural resource management, permaculture learning makes a significant contribution to sustainability awareness by encouraging students to explore, and creativity. This approach has been shown to develop children's love and responsibility for the environment in a sustainable manner (Garden & Downes, 2023; Wilson, 1984).

4. CONCLUSION

The integration of permaculture into biology teaching modules effectively enhances outdoor biodiversity learning and supports sustainable education, while also developing students' critical and systemic thinking skills. However, challenges such as less conducive outdoor classroom management and students' difficulties in recognizing scientific terms need to be addressed. To overcome these, it is recommended to improve outdoor classroom management by considering safety, weather, and scheduling factors, simplify the introduction of scientific terms for better student understanding, strengthen the application of permaculture principles to enhance students' understanding of sustainability, and provide teacher training to effectively manage outdoor learning and integrate permaculture

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