MANIFESTATION OF THE ECOSYSTEM LEARNING MODEL FOR BIODIVERSITY TO IMPROVE COMPETENCY-BASED ENVIRONMENTAL EDUCATION

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ABSTRACT

Integrating environmental education and increasing competency through the development program of educational ecosystem models and biodiversity education and learning ecosystems can effectively enrich materials and practices to increase students' knowledge, understanding, and skills. The embodiment of the Sensory Garden and Therapeutic Garden prototypes as natural laboratories and libraries will be an effective and adaptive way of developing competency-based education and learning models as well as the interests and talents of students.

INTRODUCTION

The world's critical challenges today are climate change, pollution, human population growth, over-exploitation of natural resources, and habitat loss by various factors such as expanding IAS in the terrestrial and aquatic ecosystem (Børresen et al., 2022). Together, these challenges threaten the existence and sustainable use of natural resources, including biodiversity, for present and future generations. This condition indeed endangers the sustainability of ecosystem services and biodiversity components at all levels because there is still a lack of awareness, knowledge, competence, and education about the importance of preserving the environment and biodiversity.

Environmental education is not only about the guiding principles of environmental education but includes understanding environmental education in a broader and more complex sense. How to learn about everything to understand the environment, protect the environment, and the components that affect the environment are an integral part. The educational process about the environment will include knowledge, ethics, and competencies on protecting the environment and its components, preventing ecological damage, and promoting actions that benefit environmental sustainability. Environmental education is not a scientific discipline to study the natural environment. However, environmental education is a plan of action to instill a sense of responsibility for nature and its components in individuals and communities to develop important attitudes and behaviors to promote a better environmental ethic. This action plan can be translated into an education and learning concept and model, which is expected to be integrated into the curriculum partially or wholly as part of educational advocacy on saving biodiversity. In ratifying the convention on biodiversity (CBD) in 1992, education was proposed as a key step and strategy for preserving biodiversity (Schneiderhan-Opel & Bogner, 2020).

As described in the Principles of Environmental Education (EE) (UNESCO, 1976), environmental education must be carried out sustainably, integrated, focused, and adaptive. Some things that need to be considered in implementing environmental education, as described in the Principles of Environmental Education (EE), are as follows:

- Environmental education must be mandatory and continuous. This principle emphasizes implementing environmental education from the basic education level to the higher level. The implication is that the components of education must adopt the concept of environmental education in learning activities as early as possible and continuously adapt it in various levels of education stages.
- Environmental Education must cover all aspects of the environment as a whole. Referring to the level of biodiversity protection, the process of protecting

biodiversity, which is a component of the environment, includes genetic, species, ecosystem, and global (ecoregion) levels.

- Environmental education must be carried out in an integrative and multi-disciplinary manner, which means that environmental education must have a clear framework for exploring the relationship between all components in nature. This attempt describes the importance of correlation and mutualism between environmental components.
- Environmental Education must focus on the complexity of issues and dynamic phenomena so that the principles of environmental education respond to the complexity of problems that occur in an environment. It aims to increase awareness about the complexity of environmental problems in order to explore and develop critical thinking and High Order Thinking (HOTs) to address these problems.
- Environmental Education should include a historical perspective to provide an overview of the basis, existing conditions and projections of the environment and its components. This is necessary to increase understanding of translating environmental education into miniature learning environments to facilitate the learning process.
- Environmental Education must be practical and problem-solving oriented. Practical environmental education is necessary if you want to achieve the goal of a cleaner, greener and safer environment. The principle of practicality ensures that learning activities within the scope of environmental education must include a problem-solving approach (Problem-based learning) and must consist of direct experience (Experience-based learning) and project-based activities (Project-based learning).
- Environmental education must teach about the importance of cooperation, such as cooperation between individuals, communities, and institutions to regional and international cooperation. Environmental education should focus on maintaining the environment together to achieve broader goals.

The manifestation of some of the environmental education principles above is a learning prototype developed by SEAMEO BIOTROP consisting of developing a Sensory Garden and Therapeutic Garden as a Nature Library and Smart Agriculture as a Nature Laboratory.

METHODS

The study activities were conducted in Bogor, Indonesia's educational zone and the BIOTROP experimental field. The data and tools used consist of primary and secondary data consisting of aerial imagery data, soil fertility data from direct measurements in the study area, morphological data, micro-climate data, existing biodiversity data in the BIOTROP area, drone, and soil automatic sensor.

The design of the study activities consisted of preparation and literature study, design and development, testing and adaption in learning and teaching activities. This method adopted, combined and modified from generic model educational design research (EDR) (McKenney & Revees, 2020), learning and teaching strategy for re-contextualizing biodiversity (Van Weelie & Boersma, 2018), CHAT Framework (Vygotsky, 1978; Engestrom, 1987; Kelly, 2015) and ADDIE model (Mollenda & Resier, 1990; Cahyadi R.A.H, 2019). This method is widely used in developing effective teaching materials to ensure the quality of the model in supporting the effectiveness of education and learning. The stages of the study activity process are carried out systematically by dividing the process into several systematic and structured stages so that it is easy to implement. In addition, it will form an education and learning cycle that is interconnected between one component of the prototype and the other components.

RESULTS AND DISCUSSIONS

The role of education is very important to maintain and use biodiversity sustainably. The erosion of knowledge and understanding of utilizing environmental resources and local wisdom threatens the community's contribution to achieving SDGs Number 4 (inclusive and quality education). Therefore, it is very important to integrate biodiversity into education and learning programs (UNESCO, 2022). One of the factors contributing to the accelerated loss of biodiversity is the lack of education about biodiversity. The lack of concern for the loss of biodiversity potential around us is caused by a lack of sense and interaction as well as prototypes of the biodiversity environment that function to stimulate the emotions, motivations and behavior of individuals as well as their understanding of key concepts for preserving biodiversity (Gehlbach et al., 2022).

Increased awareness of the importance of ecosystem services generated through educational programs, shows that educational programs can be important vehicles and tools in conservation biology. Therefore, the school curriculum must include educational programs related to biodiversity threats, especially for students and environments close to protected areas (Børresen et al. 2022). Environmental knowledge plays an important role in active participation because knowledge and competence determine the development of pro-environmental attitudes and behavior (Schneiderhan-Opel and Bogner, 2020).

In order to realize a comprehensive biodiversity environmental education and learning ecosystem, all components and processes of education and learning activities must be integrated by integrating curricula, competencies, resources and activities carried out on biodiversity objects. Building a direct link between the curriculum and methods, modules and good practices within the scope of the Biodiversity environment to increase the knowledge, understanding and competence of educators, education staff and student is important. How can the biodiversity environment be quantified to become an object of analysis and an interactive artificial environment to serve as a source of scientific literacy. The field laboratory is a prototype of an artificial ecosystem (ex-situ) representing the natural biodiversity environment (in-situ). In order to answer this, the purpose of this study is to build a "field laboratory" and "field library," which is manifested in several prototypes. Modified from Weeley 2014, the interpretation and quantification of the biodiversity environment are carried out by describing the environment into three main scopes: conservation scope, natural scope and learning and education scope (Figure 1).

The concept of this field laboratory is practical thinking, oriented towards project-based learning and hands-on trials that are open to individuals and groups in exploring the biodiversity environment and is transformed into a prototype of smart agriculture. At the same time, a natural library is a concept to make the biodiversity environment a source of literacy, data and information such as books. Its manifestation is the Prototypes Sensory Gardens, Therapeutic Gardens, and Smart Agriculture.

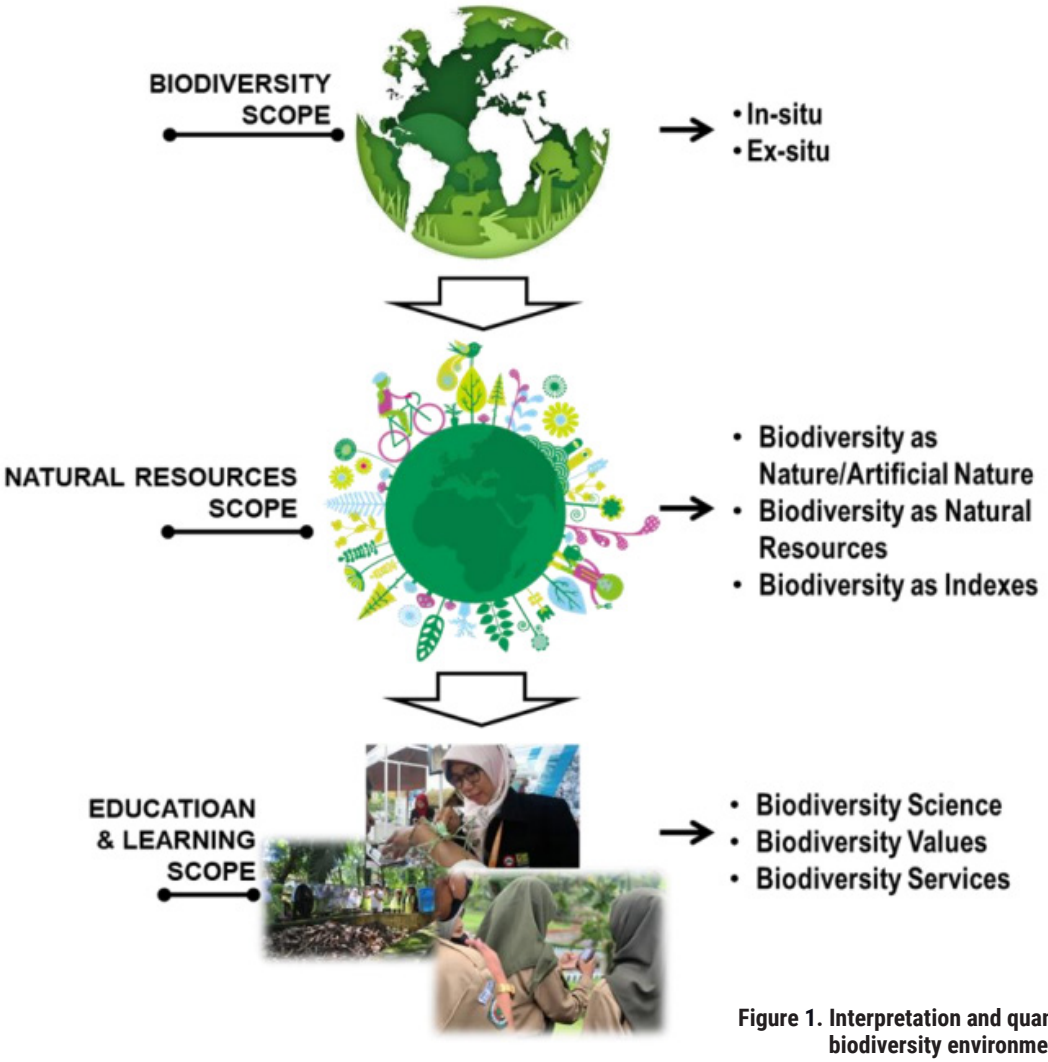

Figure 1. Interpretation and quantification of the biodiversity environment

SENSORY GARDENS

The sensory garden is a garden design concept that can be accessed by using the human senses as a medium to interact with the landscape components of the garden. Sensory gardens are spaces with a primary focus on sensory experience. The sensory experience in question involves the interaction of sensory components involving the five basic human senses: sight, touch-feel, smell-scent, sound and taste. Sensory garden landscapes are designed to connect people more closely to nature. Some landscapes are designed to provide a refreshing effect by enjoying natural components as part of therapy or relaxation.

In contrast, other components are designed to stimulate activity or for use in educational and learning programs. The development of a biodiversity education and learning ecosystem model will also base on the development of multi-literacy in a broad sense by utilizing the interpretation and quantification of the biodiversity environment as nature, the interpretation of the biodiversity environment

as a natural resource, and the interpretation of the biodiversity environment as an index. Detail of the themes of sensory garden explain below:

1. The Thing you can sight

   Landscape with the theme "Thing you can sight", is a sensory garden component designed to stimulate the senses of sight (eyes). In this theme, the garden component consists of various plants with aesthetic elements, both in color, shape and unique physiological representation. The plants developed in this theme are dominated by flower plants with striking and various colors, giving the impression and effect of relaxation for those who see them.

2. The thing you can smell

   Landscape with the theme "Think you can smell", is a sensory garden component designed to stimulate the five senses of smell. In this theme, the garden component consists of various plants with aromas that can be inhaled directly without touching the plants, or by touching the plants directly. Some of the plants planted include *Eucalyptus citriodora*, tea trees, citronella, rosemary and several other plants. Landscape with the theme "Think you can smell" will provide visitors and users a relaxing experience with the concept of natural aromatherapy.

3. The thing you can touch

   Landscape with the theme "Think you can touch", is a sensory garden component designed to stimulate the senses with touch. In this theme, the garden component consists of various plants and objects with unique textures and can provide experience and interaction by touching plants or objects. This theme will also be useful for studying the sensitivity of plants related to the response to environmental conditions

4. The Think you can taste

   Landscape with the theme "Think you can taste", is a sensory garden component designed to stimulate the senses of taste or taste buds. The garden component in this theme consists of various edible plants, both fruit and vegetable. In this theme, visitors can directly enjoy a variety of unique fruit flavors. Besides that, visitors and users will also learn about various types of fruits that are already in the rare category

5. The Think you can hear

   Landscape with the theme "Think you can hear", is a sensory garden component designed to stimulate the five senses of hearing. In this theme, the garden landscape consists of several plants and objects producing natural and artificial sounds. Details of the Sensory Garden prototypes are shown in Figure 2.

Figure 2. Sensory Garden Prototypes

a. Therapeutic Garden

Therapeutic Gardens are outdoor gardens designed and modified to meet garden users' and visitors' knowledge, practice, and psychological experience needs. This garden landscape design incorporates design principles to combine the therapeutic garden concept and practice, which consists of the following components:

b. Enabling Garden

Enabling Gardens, is a modified garden concept to stimulate visitors and users to practice how to reproduce plants, so that the motor aspect becomes an important component of this garden component. Plants planted are also herbal plants that have health benefits. In addition to increasing knowledge about various herbal plants, it will also stimulate the user's ability to propagate plants to create a genetic bank.

c. Rehabilitative and Restoration Garden

Rehabilitative and Restorative Gardens, are garden concepts that aim to stimulate and provide experience on how to carry out environmental rehabilitation. In this component, users and visitors can carry out planting activities and the multiplication of various plants, both herbal plants, rare plants as well as aesthetic and horticultural plants. Apart from that, rehabilitation practices were also given to marginal lands by using a variety of plants that are productive and have health benefits. Detail the prototype of therapeutic Garden shown in Figure 3.

Figure 3. Therapeutic Garden Prototypes

SMART AGRICULTURE

The Smart Agriculture installation is an Internet-based application of thoughts for smart agriculture that is implemented in greenhouses for farming with hydroponic and aquaponic systems. As for outdoor activities, it is carried out by integrating sensory parks and therapeutic parks as well as educational garden plots prototype equipped with sensors and digital measuring devices. There are 2 smart agriculture installation units that are used to monitor online, various parameters for growing hydroponic and aquaponics plants. There are two types of cultivated plants, namely vegetable plants, fruit plants and some herbal plants. Smart agriculture objects are tools aimed at increasing user competency in responding to the use and improvement of information technology. It is hoped that later it can become a vehicle for improving skills and competencies in terms of implementing technology 4.0. Smart agriculture installation details are presented in Figure 4.

HOW DOES IT WORK?

The operational and practices of the various prototypes above are based on the results of a study of biodiversity education and learning ecosystem models presented in the form of a multi-triangle model (Widodo, 2022). This model was adopted and modified from the concept of Cultural-Human Activity Theory (CHAT) (Vygotsky, 1920) and The Structure of Human Activity System (Engestrom, 1987) and the triangle method of training (www.trainglemethodtraining.com). This model focuses on implementing the 7 Cycle Learning which consists of the stages of elicit, engage, explore, explain, elaborate, evaluate and extend. The activities would be connected and integrated with the official curriculum and several levels of education, competency standards and industrial needs—details of the biodiversity education and learning ecosystem model presented in Figure 5.

Figure 5. Smart agriculture installation prototype

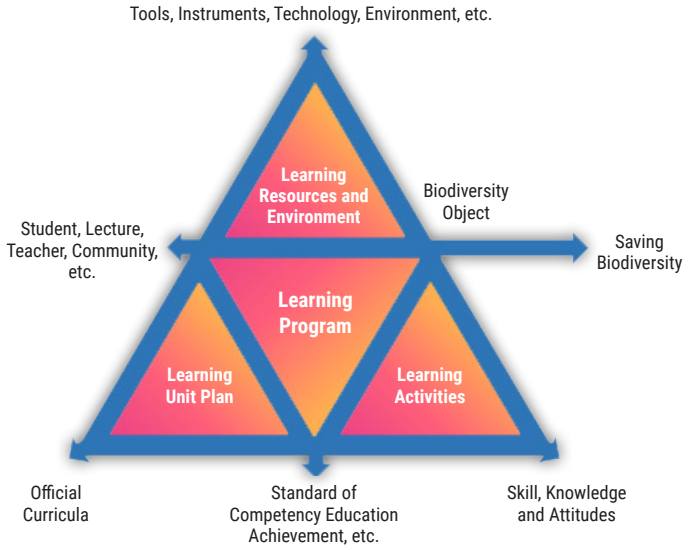

Figure 5. Biodiversity education and learning ecosystem model

CONCLUSIONS AND RECOMMENDATIONS

From the results of studies that have been carried out, in general the ecosystem model of biodiversity education and learning can be concluded as follows:

1. The biodiversity education and learning ecosystem model can be implemented for various users with good results, following the evaluation results.
2. Implementing the biodiversity education and learning ecosystem model can produce more diverse educational and learning prototypes.
3. The model can be implemented for various objects, users, and educational strata with different learning media and environments according to the desired output and outcome.

Some recommendations for the development of biodiversity education and learning ecosystem models on a wider scale and with more complex objects are as follows:

1. Replication and implementation of biodiversity education and learning ecosystem models are needed in a wider scope.
2. Method development, module development and integration into formal education curricula are needed according to educational levels.

Development and integration with existing and up to date technology is needed.

REFERENCES

Gehlbach H, Mu N, Arcot RR, Cornwall J, Nehring L, Robinson CD, Vriesema C. (2022). Addressing the vexing educational challenges of biodiversity loss: a photo-based intervention. Contemporary Psychology Journal. Elsevier. DOI.org/10.1016/j.cedpsych.2022.102096

Børresena ST, Ulimbokaa R, Nyahongob J, Rankec PS, Skjaervøa G and Røskaft E. (2022). The role of education in biodiversity conservation: can knowledge and understanding alter locals' views and attitudes towards ecosystem services?. Environmental Education Research. Informa UK Limited. Taylor & Francis Group

UNESCO. (2022). Education and awareness. UNESCO's role in education. Citied and accessed in 30 December 2022 from www.unesco.org

Widodo. (2022). School biodiversity development programme. Project presentation of management review. BIOTROP. 2022

Schneiderhan-Opel J., Bogner FX. (2020). The relation between knowledge acquisition and environmental values within the scope of a biodiversity learning module. Journal of Sustainability. MDPI. 12.2036; DOI:10.3390/su12052036

Chai W. (2020). Microlearning (microtraining). IT Management. Diakses pada 13 April 2022 https://www.techtarget.com/whatis/definition/microlearning

Daniel AF. (2019). Adaptive curriculum and its role in student success. 4500 East West Highway: Teaching Strategies, LLC.

Snow Storm Solutions. (2019). (2019). The triangle method. Accessed on 13 April 2022. www.trianglemethodtraining.com

Eco Services Network. (2019). Ecosystem services and biodiversity markets. Alberta. Canada: Eco Services Network. Diakses pada 13 April 2022 dari ttps://albertainnovates.ca/app/uploads/2019/09/ESBN_Creating_ES_B_Markets_in_Alberta_Final_2016_OP.pdf

Kelly PR. (2018). An activity theory study of data, knowledge, and power in the design of an international development NGO impact evaluation. Information Systems Journal. Published by John Wiley & Sons, Ltd. DOI: 10.1111/isj.12187

Van Weelie D., Boersma K. (2014) Recontextualising biodiversity in school practice, Journal of Biological Education, 52:3, 262-270, DOI: 10.1080/00219266.2017.1338596