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Ecopedagogy With a STEM Approach: Development of Inquiry-Based and Game-Based Learning Models in Elementary Schools

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ABSTRACT

This research aims to develop and explore the implementation of Integrated Ecopedagogy that combines the Science, Technology, Engineering, and Mathematics (STEM) approach with Inquiry-Based Learning (IBL) and Game-Based Learning (GBL) active learning methods for students at Sekolah Dasar Negeri 1 Pajerukan. This research uses Qualitative Studies with a Design-Based Research (DBR) and Phenomenology approach to gain an in-depth understanding of (1) the student interaction process, (2) teacher perceptions of the module, and (3) changes in student affective attitudes towards environmental issues after the intervention. Data were collected through participatory observation, in-depth interviews (teachers and students), and document analysis (student reflection journals). Preliminary results show that the integration of GBL successfully increased students' intrinsic motivation, while IBL-STEM facilitated critical thinking and real-world problem-solving skills related to sustainability issues. The developed modules proved capable of creating holistic, contextual learning experiences and promoting deep ecoliteracy.

Keywords: *Ecopedagogy; STEM; Design-Based Research; Phenomenology; Inquiry-Based Learning; Game-Based Learning.*

INTRODUCTION

The challenges of the climate crisis and global sustainability issues demand a paradigm shift in education from merely transferring knowledge to shaping *ecoliterate* and innovative citizens. Ecopedagogy is a philosophy that teaches that humans are an integral part of the ecosystem. Meanwhile, the STEM approach is a framework that trains 21st-century skills through the integration of scientific disciplines.



The integration of Ecopedagogy and *Science, Technology, Engineering, and Mathematics* (STEM), reinforced by *Inquiry-Based Learning* (for exploring real-world problems) and *Game-Based Learning* (for motivational engagement), is a potential curricular innovation at the elementary school level. Existing research is generally quantitative in nature. Therefore, this study focuses on Qualitative Research to:

- a) Explore students' experiences in participating in STEM learning presented through *games* and environmental investigations.
- b) Analyze the challenges and opportunities of implementing the learning model for elementary school teachers' teaching practices.

Understand changes in students' meaning and emotional connection to nature (*sense of place*) after the learning model intervention.

RESEARCH METHOD

1. Research Design

This research uses a **Pure Qualitative Study** approach with a combination of:

- a) **Design-Based Research (DBR) Early Development Stage:** To develop, test, and refine *inquiry* and *game* modules.
- b) **Interpretive Phenomenology:** To deeply understand the life experiences and meanings attributed to STEM Ecopedagogy by students and teachers.

2. Participants and Location

- a) **Participants:** 2 third-grade teachers and 42 third-grade students at State Elementary School 1 Pajerukan, Kalibagor District, Banyumas Regency. Selection was conducted using *purposive sampling* to obtain informants who were rich in information.
- b) **Location:** State Elementary School 1 Pajerukan, which has an Adiwiyata/Green School program.

3. Data Collection Techniques

- a) **Participatory Observation:** The researcher engaged directly in the educational process to observe classroom interactions, nonverbal communication, and student engagement. Participant observation is a technique used in social research that "... seeks to produce both practical and theoretical understandings of human life based on the truths of everyday experiences" (Jorgensen, 1989). Involving active participation in the daily activities of research subjects over long durations, it is closely linked to ethnographic



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research, especially in disciplines like anthropology. While participant observation has been utilized by anthropologists for many years, it has gained wider acceptance as a research method in the social sciences in more recent times. In his book from 1989 focused on participant observation, sociologist Danny Jorgensen stated that "It is not completely evident [...] what exactly is included in the humanistic approach of participant observation" (Jorgensen, 1989). Participant observation represents a powerful tool for invading other people's way of life. It reveals information that can be used to affirm their rights, interests, and sensitivities or to violate them. All informants must have the protection of saying things "off the record" that never find their way into the ethnographer's fieldnotes. (Spradley, 1980). Those employing humanistic and/or more interpretivist approaches argue that participant observation is particularly well suited to generating a more complete understanding of human meaning and interaction (Atkinson & Hammersley, 1998). Participant observation is widely regarded as a significant method for studying intricate human interactions. It depends on the usage of field notes and informal or unstructured interview methods for gathering data. (DeWalt & DeWalt, 2002).

- b) ***In-depth Interviews:*** Conducted with teachers and selected students to explore perceptions, motivations, and implementation challenges.
- c) ***Document Analysis:*** Analysis of concept maps, teacher reflection journals, and *game* result *logbooks*.

DISCUSSION

The Foundations of Ecopedagogy

Etymologically, ecopedagogy comes from a combination of the words ecology and pedagogy. Ecology is the science that studies the interactions between living things and their environment. Meanwhile, the term pedagogy can be interpreted as the science of education based on philosophical values to achieve the goal of educating students, both in terms of theory and practice. Based on this definition, ecopedagogy is a term that refers to an approach in education that aims to increase students' ecological awareness. Another view states that ecopedagogy is a type of learning that is delivered in a creative, innovative way, with deep understanding and active involvement of students in taking on roles related to the environment (Nafisah et al., 2020).



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An expert in ecopedagogy theory, Richard Kahn, also emphasizes that ecopedagogy has undergone changes in educational projects originating from the work of Paulo Freire, known as critical pedagogy. According to Kahn, *ecopedagogy* is a method that aims to combine the main objectives of humanizing experiences and achieving a just and free world, with a focus on a sustainable ecological future. Ecopedagogy, with its critical and innovative approach, brings hope for bridging the organization of local communities, where education serves as a tool for achieving social and ecological change (Kahn, 2011).

If we explore the core of this concept of ecopedagogy, there are three main aspects that are the focus of ecopedagogy, namely the concept of social-ecosystem flexibility, cultural literacy, and the use of technology in a critical and creative manner (Kahn, 2011). The educational process that adopts the principles of ecopedagogy should at least be able to:

- 1) Understand the basic principles of ecology integrated into the curriculum through ecoliteracy, as well as the impact of human behavior on the environment, both beneficial and detrimental;
- 2) Involve all parties in education through constructive and critical discussions about advances in technology and communication, while remaining focused on an environmentally friendly future through a critical ecoliteracy approach; and
- 3) Create a better sustainable life through understanding and awareness from various scientific perspectives regarding the relationship between humans and the environment (Nafisah et al., 2020).

Education is an effort to develop humans in accordance with their human nature as beings with various dimensions, one of which is establishing a relationship with nature or the environment (Herlambang, 2018). Therefore, education will always be closely related to space and time, where the relationship between humans and the natural environment has a real place. This shows the obligation of humans to always maintain balance, harmony, and sustainability with nature (Muhaimin, 2015). This is because humans are seen as part of planet Earth (Freire, 2010; Misiaszek, 2012).

In relation to this, the situation contradicts the current reality. Although nature is fundamentally recognized as having value and *urgency*, in reality, nature is often considered something that can be exploited by humans through pollution, destruction, and various other harmful actions. This condition reflects a lack of environmental awareness and a moral crisis



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within society. Therefore, it is important to make efforts to develop a critical attitude and concern in understanding various phenomena in life that are harmful to the environment. This can be achieved by restructuring the relationship between humans and nature/the environment, so that awareness of ethics and morals related to the environment emerges (Herlambang and Yunansah, 2017).

Environmental awareness must be the most important element in educational goals. Education should focus on developing individuals who have character and awareness of nature and the environment, not just trying to create individuals with a pragmatic-materialistic spirit. This is important to avoid the formation of a paradigm that is trapped in a flawed development process, which only views nature as a mechanistic, separate, and fragmented object (*maldevelopment*) from humans, thus facilitating domination and exploitation. Thus, it can be understood that ecological awareness is not only built through education that transfers knowledge, but also through a learning process that makes students active subjects in the process. Education that focuses on increasing environmental awareness and intelligence, with an emphasis on knowledge transfer, will only provide students with information about the environment, but will not build their awareness and attention to environmental issues (Muhaimin, 2015).

Synthesis of STEM, IBL, and GBL

- a) **STEM in Elementary School:** How scientific and engineering concepts can be simplified through real project activities
- b) ***Inquiry-Based Learning (IBL)*:** The role of IBL in encouraging students to formulate questions, design experiments, and find solutions to local environmental problems.
- c) ***Game-Based Learning (GBL)*:** The use of *game* elements (points, challenges, *levels*, *rewards*) to increase engagement, cooperation, and intrinsic motivation in STEM tasks. Ecopedagogy.

Research Findings

Learning activities at Pajerukan 1 Public Elementary School are oriented towards hands-on activities in the field, without excluding the provision of theory-based information. The implementation of learning is determined based on the major themes for each semester at each school level. Learning skills are honed by stimulating students' curiosity until they find answers to their questions through learning activities. Therefore, learning activities are student-oriented



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and guided by educators called facilitators. The role of facilitators is limited to providing learning facilities for students.

Unlike the continuous delivery of information based on textbooks, facilitators aim to help students identify their potential and interests. This is unlike the banking model of education, which tends to produce passive attitudes or blind obedience among students (Freire, 1985: 62). The concept of a facilitator eliminates the power and hierarchy relationship between teachers and students. Each facilitator manages 10 children so that they can focus more on the potential and interests of each student. This situation is different from public schools, where teachers are often limited in recognizing the interests and talents of each student because it is difficult to apply personalized learning methods (Nandini et al., 2024).

As an obligation, teachers should be able to recognize each student's potential and interests so that the learning process can take place optimally. Freire states that education as an effort to liberate includes a process of understanding that connects humans with the world as an interconnected whole (Freire, 1985: 66). Exploration activities are carried out so that students can observe and experience firsthand the topic being studied.

After the idea-gathering process, there is an initial theme presentation activity where one of the students gives a presentation to explain ideas or concepts that can be used as a reference for determining the main theme. The initial theme presentation takes the form of a discussion and exploration of the main theme for one lesson. The process of selecting the theme () begins with ideas or concepts from the students, which are then collected and formed into a discussion forum with the students to select the main theme. The selection of themes is based entirely on the ideas and concepts of the students, so that the facilitator acts only as an observer and collector of these ideas. This shows that there is good curriculum management at Pajerukan 1 Public Elementary School. According to Freire, teachers cannot think and impose their thoughts on students (Freire, 1985: 60). The absence of coercion in the teacher's thinking is a breakthrough for a more liberating education system. Thus, the realization of the concept of problem-based education can be achieved through a dialogical process that occurs in learning activities. In a problem-based education system, the learning theme is determined through group discussion, and the discussion topic is chosen by the participant group or students (Freire, 2001: 54). The freedom provided by Selasar nature school in determining themes shows an understanding that the interests and potential of each student are different. This is in line with Freire's statement

that curriculum design is based on the empirical reality experienced by students, not on the perspectives of teachers or other parties who do not understand the students' experiences in their daily lives (Abidin, 2022: 91).



Fig. 1. Environment-Based Learning (Ecopedagogy)

The learning activities that have been carried out contribute to increasing students' critical awareness, because they are carried out through activities that emphasize field practice and problem-solving skills. The effort to solve a problem by understanding its underlying causes is one sign of critical awareness. Critical awareness gives individuals the ability to analyze problems more deeply, be bold in expressing their opinions, and be able to accept or reject something (Lestari et al., 2023). Given its importance, efforts to increase critical awareness in society are very important (Qomarudin, 2021). People who possess this awareness can analyze situations, identify problems, and serve as agents of change in society. Critical awareness built through learning activities at Pajerukan 1 Public Elementary School can be seen in the campaign to use plastic bags to reduce plastic waste. In addition, recycled plastic is also used for *fashion shows*.



Fig. 2. Students Processing Plastic Waste for a Fashion Show

CONCLUSION

The IBL-STEM learning model integrated with GBL has been successfully developed and implemented efficiently, creating a comprehensive, motivating learning experience that focuses on the principles of sustainability. The qualitative approach emphasizes that eco-pedagogy not



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only improves STEM skills but also strengthens students' emotional connection with their environment.

It is recommended that curriculum developers incorporate the IBL/GBL Eco-pedagogy-STEM learning model as a new standard for appropriate environmental education. Comprehensive training is needed for teachers on facilitating IBL and effectively implementing GBL, so that it becomes the primary method, not just an addition. Further research is recommended to conduct comparative qualitative studies between different locations or longer ethnographic studies to monitor the internalization of students' environmental responsibility over a longer period of time.

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