ENHANCING STUDENT'S SUSTAINABILITY AWARENESS THROUGH PBL-ESD ON MICROPLASTIC POLLUTION

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Abstract. *This research aims to develop and implement a didactic design based on Problem-Based Learning integrated with Education for Sustainable Development (PBL-ESD) to enhance sustainability awareness and science literacy of students on the topic of microplastic pollution. This research uses a Didactical Design Research (DDR) approach with high school students in Sukabumi Regency as subjects. The instruments used in the research include didactic design sheets and LKPD. Findings show that the didactic design of PBL-ESD, developed in accordance with the steps of PBL and focused on sustainability issues, can support active participation of learners in solving actual problems related to microplastic pollution. In addition, the learning design and the tested assessment tools demonstrate support for improving scientific literacy while also increasing students' sustainability awareness. This implementation proves that the integration of PBL and ESD provides a relevant learning experience and prepares students with critical thinking and problem-solving skills related to environmental issues.*

Keywords: *Problem Based Learning, Education for Sustainable Development, Sustainability Awarness, Microplastic Pollution*

INTRODUCTION

The challenge of raising sustainability awareness in students persists in education, especially when environmental issues tackling like intricate microplastic contamination [1]. In contrast to typical environmental concerns, microplastics are frequently unseen, broadly spread, and intimately linked to everyday human behaviors, which complicates students' complete comprehension. This situation results in restricted awareness and an absence of tangible efforts for environmental sustainability [2] In educational methods, different learning frameworks have been utilized to tackle this problem. Problem-Based Learning (PBL) is well-regarded for its ability to boost students' engagement and problem-solving abilities by involving them actively in their learning activities [3].

Nonetheless, earlier research suggests that PBL implementation typically emphasizes cognitive elements, with little focus on cultivating sustainability values and attitudes [4]. Consequently, students might be capable of examining environmental challenges but do not possess a stronger sense of obligation regarding sustainability matters [4].

Meanwhile, the Education for Sustainable Development (ESD) approach emphasizes the development of knowledge, skills, and attitudes necessary to support sustainable development [5]. Despite its importance, ESD is often implemented conceptually without being supported by structured and problem-oriented learning models, creating a gap between sustainability goals and classroom practices [6] Furthermore, studies integrating PBL and ESD remain limited, particularly in the context of microplastic pollution at the secondary education leve [7] Existing research tends to focus on general environmental topics or apply these approaches separately, without providing

a comprehensive didactic design that integrates problem-solving processes with the development of sustainability awareness [8].

This study seeks to create and apply a didactic design that merges PBL with an ESD approach concerning microplastic pollution to improve students' awareness of sustainability. This study presents innovation through a structured learning framework that directly links real-life environmental issues with sustainability skills [9].

METHOD

The research design used in this study is Didactical Design Research (DDR). According to Suryadi (2018) [10] DDR consists of three main stages, namely: (1) analysis of the didactical situation before learning (prospective), (2) analysis of the didactical situation during learning (metapedadidactic), and (3) analysis of the didactical situation after learning (retrospective). However, this study focuses on the metapedadidactic stage, which is the analysis of the learning situation that occurs during the teaching process. This focus was chosen based on the research objective that prioritizes the application of a Problem-Based Learning design with an Education for Sustainable Development (PBL-ESD) approach to increase students' awareness of sustainability on the topic of microplastic pollution.

This research was conducted at one of the public high schools in Sukabumi Regency. The selected school has implemented the independent curriculum since 2022. This research was conducted in one class with a total of 36 students. the data collection technique used is taken from the data obtained, namely the results of audio/video transcript sheets during the learning process. The data collection technique used is taken from the data obtained, namely the results of audio/video transcript sheets during the learning process with the research instrument being the audio/video learning transcripts.

RESULT AND DISCUSSION

The results show that applying PBL-ESD for microplastic pollution improves students' awareness of sustainability by involving them in organized, inquiry-driven learning that links scientific ideas to actual environmental challenges. This enhancement is evident not just in students' skills to recognize environmental issues but also in their ability to suggest practical and accountable solutions. Significantly, this transition from fundamental comprehension to profound understanding can be clarified through the instructional methods integrated within the PBL-ESD framework.

The observed enhancement is closely related to the use of authentic environmental problems as cognitive triggers. By introducing microplastic pollution through familiar plastic products encountered in daily life, students were encouraged to activate prior knowledge and relate observable phenomena to abstract chemical concepts, such as polymers. This process of contextualization supports meaningful learning, as students construct understanding based on relevant, real-life experiences. For instance, when students identified differences in physical properties among plastic objects, they demonstrated early stage scientific literacy, particularly in observing and classifying material characteristics, which forms the foundation for more complex reasoning.

Additionally, the ongoing dialogue and reflective activities within the PBL framework greatly enhanced students' comprehension. By participating in group discussions and guided inquiries, students expressed their thoughts, assessed different viewpoints, and improved their reasoning. This learning setting based on social constructivism encouraged the joint development of knowledge, enabling students to progress from basic observations to deeper analytical reasoning. Consequently, their perception transformed from identifying plastic as a typical substance to thoroughly investigating its ecological effects, especially the creation and influence of microplastics [11], [12].



Figure 1 The Learning Process Takes Place

The integration of Education for Sustainable Development (ESD) principles further strengthened this learning process by explicitly orienting sustainability values students and toward future-oriented thinking. Students were not only asked to understand the scientific aspects of microplastics but also to consider their environmental and social implications. This value-oriented approach encouraged the development of sustainability competencies, including responsibility, awareness, and behavioral intention. For example, students' of their role as agents of change and their willingness to adopt more environmentally friendly practices, such as reducing single-use plastics and choosing alternative materials [12], [13].

Furthermore, the progressive rise in task difficulty during the educational sessions aided in fostering advanced cognitive abilities. Early tasks concentrated on recognizing and detailing plastic materials, whereas later assignments demanded students to examine the origins and effects of microplastics and suggest practical solutions. This structured advancement allowed students to cultivate critical thinking, problem solving, and evidence-based reasoning, which are vital aspects of scientific literacy [12], [13].

Students' learning artifacts, such as posters and documented discussion outcomes, further demonstrate the effectiveness of this approach. These artifacts reflect students' ability to synthesize information, communicate scientific ideas, and propose practical solutions to environmental pedagogical problems. perspective, this From a indicates successful knowledge externalization, where students transform their internal understanding into communicable forms, thereby reinforcing both conceptual mastery and sustainability awareness.



Figure 2 Poster Recognizing Microplastics Created by Students

Generally, the results indicate that the success of PBL-ESD is based on its combining cognitive, social, and value-oriented learning processes. Through the integration of contextual problem-solving, collective inquiry, and sustainability-focused reflection, this method empowers students to progress from mere knowledge acquisition to fostering informed, responsible, and proactive environmental consciousness [11], [14].

CONCLUSION AND SUGGESTION

The application of PBL-ESD to microplastic pollution significantly improves students' consciousness of sustainability. Students participated in genuine problem solving, contemplated the environmental effects of microplastics, and linked their knowledge to Sustainable Development Goals (SDGs). Artifacts created by students, including posters and records of discussions, demonstrate that they not only achieved conceptual comprehension but also cultivated a proactive awareness. Although scientific literacy became a beneficial result, the research mainly shows that PBL-ESD promotes critical thinking, responsibility, and awareness of sustainability in learners.

Teachers are urged to adopt PBL-ESD for teaching environmental challenges like microplastic pollution, incorporating genuine problem-solving and teamwork tasks to enhance students' awareness of sustainability and critical thinking abilities. Future studies may investigate the enduring effects of PBL ESD on students' environmental skills and scientific understanding, along with its efficacy in various educational stages and settings, to

enhance evidence-based advancements in environmental instruction.

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