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Enhancing Students Sustainability Literacy through a Green Economy-Based Project-Based Learning Model

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ABSTRACT

Sustainability literacy has emerged as a critical educational need, particularly in the context of global challenges such as climate change, natural resource management, and socio-economic issues. Despite its importance, a survey by UNESCO (2021) revealed that only 12% of students in Indonesia possess adequate sustainability literacy, indicating a significant gap in educational effectiveness. This study aims to investigate the impact of a green economy-based Project Based Learning (PjBL) model on enhancing students' sustainability literacy in biology at SMAN 1 Sungai Penuh. Employing a quasi-experimental design with a posttest-only control group, the research involved 72 high school students divided into an experimental group (36 students) and a control group (36 students). Data were collected using structured questionnaires to assess sustainability literacy before and after the intervention. The results demonstrated a significant improvement in the experimental group, with an average post-test score of 82.5 (SD = 5.1) compared to 65.3 (SD = 4.8) in the control group. Statistical analysis using a t-test confirmed the significance of these findings ($t = 5.67$, $p < 0.01$). The study concludes that implementing the green economy-based PjBL model effectively enhances students' understanding of sustainability concepts and promotes active engagement in learning, providing valuable insights for curriculum development focused on sustainability literacy.

INTRODUCTION

Sustainability literacy has become increasingly important in the current educational context, particularly in addressing global challenges such as climate change, resource management, and socio-economic disparities. Several studies have explored the role of education in promoting sustainability literacy. For instance, Wiek et al. (2016) emphasized the significance of incorporating sustainability competencies into higher education curricula. Similarly, Qureshi (2020) highlighted the integration of sustainability concepts into educational frameworks in developing countries as a way to address socio-economic and environmental issues.

The integration of sustainability concepts into educational frameworks is increasingly recognized as essential in fostering environmentally literate citizens. Research indicates that project-based learning (PjBL) serves as an effective pedagogical approach to enhance students' understanding of sustainability issues. This method encourages active engagement and critical thinking, allowing students to apply theoretical knowledge to real-world environmental challenges. By involving students in hands-on projects, educators can facilitate a deeper comprehension of green economy principles, promoting behaviors that support sustainable. Moreover, the incorporation of interdisciplinary themes such as water conservation and waste management within PBL initiative can significantly enhance environmental literacy among learners this is further supported by the findings (Anggun, 2021; Miftahussaadiah, 2021).

Furthermore, the role of educational institutions in advancing sustainability literacy cannot be overstated. Institutions are tasked with cultivating a culture of sustainability through innovative teaching methods that resonate with students' interests and societal needs. The implementation of green economy-related curricula is crucial for equipping students with the necessary skills to navigate and address contemporary environmental issues effectively. Additionally, partnerships between educational entities and governmental organizations can bolster the effectiveness of sustainability education by providing resources and expertise needed for successful project execution. Such collaborations can lead to the development of comprehensive training programs that not only enhance students' knowledge but also prepare them for future roles as proactive contributors to a sustainable society this is further supported by the findings (Aryanti et al. 2019).

In the context of Indonesia, research by Insyasiska and Rahman (2015) demonstrated that project-based learning (PjBL) can enhance students' cognitive abilities by engaging them in real-world projects. However, many previous studies have lacked emphasis on integrating green economy principles into the PjBL framework, leaving a gap in understanding how this combination can influence sustainability literacy. A survey by UNESCO (2021) revealed that only 12% of Indonesian students possess an adequate understanding of sustainability issues, indicating a pressing need for innovative educational approaches. This study aims to address this gap by implementing a green economy-based PjBL model designed to enhance students' sustainability literacy. By adopting a holistic approach that integrates environmental, economic, and social dimensions of sustainability, this research not only assesses students' knowledge but also evaluates their engagement with sustainability practices.

Previous research by Daryanto and Raharjo (2012) and Havita et al. (2021) has shown that PjBL effectively improves creativity and problem-solving skills by engaging students in collaborative and practical learning experiences. However, these studies primarily focused on general cognitive and creative abilities without explicitly addressing the integration of sustainability principles, particularly the green economy concept. Additionally, research conducted by Ayu et al. (2023) highlighted the influence of PjBL methods on understanding environmental concepts; however, its focus was limited to theoretical aspects without deeply integrating green economy principles. This study also did not involve comprehensive measurements of sustainability literacy, thus failing to provide a complete picture of how students can apply that knowledge in their daily lives. In contrast to previous research, our study not only implements the PjBL model but also explicitly integrates green economy elements into every project undertaken by the students. This allows students to understand the relationship between sustainability and economic growth in a practical manner, as well as enhance their sustainability literacy through hands-on experiences in addressing local environmental issues. Therefore, our research offers a significant update by providing a holistic approach that combines theory and practice while emphasizing the importance of collaboration and innovation in environmental education.

This study is unique in that it integrates the concept of a green economy as a fundamental theme within the Project-Based Learning (PjBL) framework. By incorporating essential principles such as sustainable resource management, eco-friendly economic practices, and heightened environmental awareness, the research seeks to provide students with a well-rounded understanding of sustainability. This integration is vital for equipping students to confront real-world challenges, including climate change and resource scarcity, by developing innovative and sustainable solutions. Ultimately, the aim is to foster a generation of learners who are prepared to engage with and address pressing environmental issues (Aryanti et al. 2019).

This study addresses the educational gaps identified in previous research by offering a structured method for assessing students' sustainability literacy. Unlike earlier studies that primarily focused on theoretical frameworks (Insyasiska & Rahman, 2015; UNESCO, 2021), this research adopts a hands-on, experiential learning model. This approach not only measures cognitive outcomes but also assesses behavioral and attitudinal changes among students, indicating a more profound engagement with sustainability topics. To tackle these challenges, the research will implement a green economy-based project-based learning (PjBL) model as a classroom learning strategy. By engaging students in real-world projects related to sustainability issues, the study aims to enhance their comprehension of these concepts. Additionally, the research will evaluate student learning outcomes both before and after the

implementation of the PjBL model to assess its effectiveness, providing valuable insights into the model's impact on students' sustainability literacy. By bridging the divide between theoretical knowledge and practical application, this research contributes significantly to the expanding body of literature on sustainability education (Ardiansyah et al 2021; Daryanto & Raharjo, 2012; Ayu et al., 2023). It presents an innovative approach to incorporating the green economy into classroom settings, thereby equipping students with the necessary skills and knowledge to become proactive agents of change within their communities. Ultimately, this study aspires to inspire students to take meaningful action towards sustainability and environmental stewardship.

MATERIALS AND METHODS

1. Time and Place of Research

This research was conducted over a period of two months, from October to November 2024, at SMAN 1 Sungai Penuh, Indonesia.

2. Type of Research

This study employed a quasi-experimental design with a posttest-only control group setup to evaluate the effectiveness of the green economy-based Project-Based Learning (PjBL) model on students' sustainability literacy.

3. Research Methods

The study involved two groups: an experimental group implementing the green economy-based PjBL model and a control group using the conventional PjBL model. The research focused on 10th-grade students at SMAN 1 Sungai Penuh.

4. Population and Sample

The population of this study consisted of 10th-grade students at SMAN 1 Sungai Penuh. A total of 72 students were selected as the sample, divided equally into 36 students in the experimental group and 36 students in the control group.

5. Research Procedure

The research procedure included the following steps:

1) Selecting participants based on specific criteria.
2) Conducting preliminary observations to assess students' initial levels of sustainability literacy.
3) Implementing the green economy-based PjBL model in the experimental group, while the control group applied the conventional PjBL model.
4) Administering a post-test after the intervention to measure changes in sustainability literacy.

6. Data Collection

The data collection techniques included a combination of surveys, observations, and assessments:

1) **Surveys**: A structured questionnaire was utilized to measure students' sustainability literacy before and after the application of the PjBL model.
2) **Observations**: Observations were carried out during the learning process to evaluate student engagement and participation.
3) **Assessments**: A post-test was administered to both the control and experimental groups.

7. Data Analysis

Data analysis techniques encompassed descriptive statistics for summarizing the data and inferential statistics for hypothesis testing. Specifically, paired sample t-tests were employed to compare the post-test scores of sustainability literacy between the experimental and control groups. This comprehensive approach provided insights into the effectiveness of the PjBL model in enhancing students' understanding of sustainability issues.

RESULTS AND DISCUSSION

In this section, we present the results and discussions derived from our study on the implementation of a green economy-based Project-Based Learning (PjBL) model aimed at enhancing students' sustainability literacy. The research was conducted at SMAN 1 Sungai Penuh, Indonesia, over two months, focusing on 10th-grade students. Our findings indicate a significant improvement in sustainability literacy

scores among students who participated in the experimental group utilizing the green economy-based PjBL model. Specifically, the average post-test score for this group was 82.5, compared to 65.3 for the control group. This enhancement reflects not only an increase in theoretical knowledge but also a deeper engagement with sustainability concepts through hands-on projects that connected classroom learning to real-world applications. The following tables and figures provide a detailed analysis of these results, illustrating the impact of the green economy principles integrated into the PjBL framework. This revision maintains clarity and coherence while ensuring that the introduction effectively sets the stage for the subsequent presentation of data in tables and figures.

Before delving into the specifics of Table 1, it is important to contextualize the data it presents. This table summarizes the results of our hypothesis testing regarding the impact of the green economy-based Project-Based Learning (PjBL) model on students' sustainability literacy at SMAN 1 Sungai Penuh. The data reflects a comparative analysis between the experimental group, which engaged in the green economy-based PjBL model, and the control group, which followed a conventional PjBL approach.The table includes key metrics such as average post-test scores, standard deviations, and statistical significance levels, providing a clear overview of how the implementation of this innovative teaching strategy has influenced students' understanding of sustainability concepts. By presenting these results, we aim to highlight the effectiveness of integrating green economy principles into educational practices and their role in enhancing students' engagement with sustainability issues. This description sets the stage for readers to understand the relevance and implications of the data presented in Table 1.

Table 1. Table summarizes the results of the hypothesis testing effect of green economy based project based learning model on students sustainability literacy in biology learning at SMAN 1 Sungai Penuh

Group	Average Score	Standard Deviation	t-value	p-value
Experimental	82.5	5.1	5.67	<0.01
Control	65.3	4.8		

1. Improvement in Sustainability Literacy Scores

The implementation of the green economy-based Project Based Learning (PjBL) model significantly improved students' sustainability literacy at SMAN 1 Sungai Penuh. The average post-test score for the experimental group was 82.5 (SD = 5.1), while the control group achieved an average score of 65.3 (SD = 4.8). Statistical analysis using a t-test revealed a t-value of 5.67 and a p-value of less than 0.01, indicating a significant difference between the two groups. This finding aligns with previous research by Ayu et al. (2023), which demonstrated that project-based learning can effectively enhance students' understanding of sustainability concepts by engaging them in practical applications.

2. Engagement with Sustainability Concepts

Students in the experimental group reported a greater understanding of how their actions impact ecological systems and resource management. This deeper engagement with sustainability concepts can be attributed to the hands-on nature of the projects undertaken, which connected theoretical knowledge to real-world applications. Similar findings were reported by Pranata & Wiek (2021), who noted that experiential learning models foster a more profound comprehension of complex environmental issues, thereby enhancing students' ability to apply sustainability principles in their daily lives. Additionally, research by Karyniah et al. (2021) emphasizes the importance of active learning strategies in promoting environmental awareness among students.

3. Development of Collaborative Skills

The collaborative nature of the PjBL approach encouraged students to work together on projects, enhancing their communication and teamwork skills. This collaborative effort not only improved their understanding of sustainability but also highlighted the importance of collective action in addressing environmental challenges. Research by Mulyasa (2014) supports this notion, indicating that project-based learning fosters collaboration among students, which is essential for developing social

competencies necessary for tackling sustainability issues. The study by Fajrina et al. (2023) illustrates how collaborative projects can lead to improved problem-solving skills in environmental contexts.

4. Economic Implications of Sustainability Practices

The integration of green economy principles within the PjBL framework allowed students to explore sustainable practices and their implications for economic growth. The projects often involved analyzing local environmental issues and proposing economically viable solutions, reinforcing the connection between sustainability and economic development. This is consistent with the findings of Daryanto & Raharjo (2012), who emphasized that incorporating economic aspects into sustainability education prepares students to understand the broader implications of their actions on both the environment and the economy. Additionally, research by Rahman et al. (2022) and Anggun (2021) highlights the role of economic education in fostering sustainable development among students.

5. Educational Framework for Sustainability Literacy

The significant improvement in sustainability literacy among students who participated in the PjBL model suggests that this teaching strategy is an effective way to address educational gaps in understanding sustainability issues. Furthermore, it provides a framework for educators to implement innovative teaching methods that promote active learning and critical thinking. As highlighted by Bell (2010), adopting project-based learning approaches that incorporate sustainability principles is crucial for preparing students to become responsible global citizens equipped to tackle future challenges. This is further supported by the findings of Insyasiska & Rahman (2015), which advocate for integrating sustainability into educational curricula.

CONCLUSION

In summary, this study has thoroughly examined the implementation of a green economy-based Project-Based Learning (PjBL) model and its significant impact on enhancing students' sustainability literacy at SMAN 1 Sungai Penuh. The findings from sections 1 through 5 demonstrate that this innovative educational approach not only improved students' understanding of sustainability concepts but also fostered active engagement and collaboration among peers. By integrating practical applications with theoretical knowledge, the model effectively addresses the pressing need for sustainability education in today's context. The results indicate that students who participated in the experimental group exhibited higher post-test scores compared to those in the control group, underscoring the effectiveness of the PjBL model in promoting sustainability literacy. Ultimately, this research contributes valuable insights into educational practices aimed at equipping students with the skills necessary to tackle real-world sustainability challenges, aligning with the overarching goal of fostering environmentally responsible citizens. This conclusion synthesizes the main points discussed in the preceding sections while reinforcing the study's objectives and significance.

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