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Effectiveness of Interactive Student Worksheets Based on Discovery Learning to Improve Ecosystem Learning Outcomes in Grade X Students of SMAN Arjasa Jember

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Abstract (11 pt)

Learning about ecosystems often faces challenges such as low student engagement and the lack of media that facilitates independent concept discovery. This study aims to analyze the effectiveness of interactive Student Worksheets (LKPD) based on the Discovery Learning model in improving the learning outcomes of tenth-grade students at SMAN Arjasa Jember. The research employed a quasi-experimental method with a pretest-posttest control group design. The subjects consisted of two classes: the experimental class used interactive LKPD based on Discovery Learning, while the control class used conventional LKPD. Learning outcomes were measured using a validated multiple-choice test and analyzed with an independent t-test at a 5% significance level. The results indicated that the experimental class achieved significantly higher posttest scores than the control class ($p < 0.05$), with a high category gain score in the experimental class and a medium category in the control class. These findings demonstrate that interactive LKPD based on Discovery Learning is effective in enhancing student learning outcomes on the ecosystem topic. The application of interactive learning media aligned with active learning approaches is recommended to improve the quality of biology instruction.

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1. INTRODUCTION

Curriculum is a crucial component of the education system, serving as a flexible framework that can adapt to societal changes. Its primary goal is to ensure that education meets the needs of students, communities, and subject content. Therefore, policymakers must periodically revise and develop curricula in line with contemporary demands (Safira et al., 2021). In Indonesia, the Merdeka Curriculum emerged as a response to the challenges

faced during the COVID-19 pandemic, providing more flexible and student-centered learning opportunities (Festiyed et al., 2019). This curriculum emphasizes active student participation, encouraging learners to explore topics of interest while developing relevant future skills. Such an approach fosters not only knowledge acquisition but also critical thinking, creativity, and adaptability (Maharani & Irsadi, 2023).

In biology education, active participation is essential due to the abstract nature of many concepts (Maysara et al., 2023). One particularly complex yet vital topic is the ecosystem, which involves understanding interactions between living organisms and their environments. Traditional lecture-based methods are often insufficient to promote deep comprehension. Instead, contextual and exploratory approaches, such as observations, experiments, and guided inquiry, are necessary to enhance students' conceptual understanding.

Discovery Learning, a student-centered model rooted in constructivism, encourages learners to actively construct knowledge through observation, experimentation, analysis, and conclusion drawing (Fatqurhohman & Huda, 2025; Hermawan et al., 2025). However, its success heavily depends on the quality of learning media provided. Ineffective or unengaging media can hinder students' ability to explore and discover independently.

Interactive Student Worksheets (LKPD) present a promising solution by integrating technology with active learning strategies. These digital worksheets incorporate interactive features such as hyperlinks, navigation buttons, instructional videos, animations, and auto-graded quizzes, providing immediate feedback and supporting step-by-step concept discovery. In the context of ecosystem learning, such tools can bridge the gap between theory and practice, fostering both engagement and achievement.

This study aims to examine the effectiveness of interactive LKPD based on Discovery Learning in improving the ecosystem learning outcomes of Grade X students at SMAN Arjasa Jember. It specifically investigates how this integration of technology and inquiry-based learning influences student engagement and cognitive achievement, measured through pretests and posttests. The findings are expected to contribute to the development of innovative, technology-driven biology teaching strategies.

2. METHOD

This study employed a quasi-experimental method with a pretest–posttest control group design to examine the effectiveness of interactive Student Worksheets (LKPD) based on the Discovery Learning model in improving the cognitive learning outcomes of Grade X students at SMAN Arjasa Jember. This design is widely used in educational research to compare the effects of instructional interventions while controlling for initial differences in student ability (Abdulah et al., 2021).

The participants consisted of 32 students from class X.8, divided into six groups: five groups of five students and one group of six students. The experimental group was provided with interactive LKPD specifically designed to enhance student engagement and facilitate independent exploration and concept discovery. These worksheets incorporated digital features such as navigation buttons, embedded instructional videos, animations, and auto-graded quizzes to guide students step by step in the learning process (Setyaningrum, 2020;

Wiwik Maladerita et al., 2023). The control group used conventional printed LKPD without interactive features.

Table 1. Syntax of Discovery Learning

Syntax	Description
Stimulation	Providing relevant resources to introduce and connect students with the learning topic
Problem Identification	Guiding students to formulate questions or problems to be solved.
Data Collection	Gathering information or data through observation, experiments, or literature review.
Data Processing	Analyzing and organizing collected data to develop understanding
Verification	Testing or confirming hypotheses using data or additional experiments
Conclusion	Summarizing findings and presenting answers to the identified problems

Data collection involved a cognitive learning outcomes test in the form of multiple-choice questions, administered as both pretest and posttest. The pretest was conducted prior to the intervention to assess students' initial knowledge, while the posttest was conducted after the intervention to evaluate improvements in understanding. The test items were validated for content and reliability before use.

Data were analyzed using an independent t-test at a 5% significance level to determine whether there was a statistically significant difference in learning outcomes between the experimental and control groups. This statistical approach is appropriate for comparing the mean scores of two independent samples. The analysis aimed to provide empirical evidence on the effectiveness of interactive LKPD in the context of biology learning, particularly in the ecosystem topic.

3. RESULTS AND DISCUSSION

3.1. Results

This study successfully developed a Student Worksheet (LKPD) consisting of three main sections. The first section addresses the interaction between components within an ecosystem, the second discusses various types of ecosystems, and the third focuses on energy flow, food chains, food webs, and ecological pyramids. Each LKPD was systematically designed based on the six phases of the Discovery Learning model: stimulation, problem identification, data collection, data processing, verification, and conclusion drawing (Nababan et al., 2023; Yerimadesi et al., 2023). This structured approach ensures that students are actively engaged in the learning process rather than passively receiving information.

In the stimulation phase, students are provided with reading materials, visual media, and relevant information to trigger curiosity about ecosystems. The problem identification phase guides students to formulate questions or issues related to ecological interactions. They then proceed to the data collection phase, where they gather information through observation, small-scale experiments, literature review, or interviews. The data processing phase involves analyzing and organizing the collected data, interpreting results, and

connecting findings with theoretical concepts. In the verification phase, students test their hypotheses or temporary answers through further investigation, ensuring the validity of their conclusions. Finally, in the conclusion phase, they summarize their findings and reflect on the learning outcomes.

The implementation of Discovery Learning through the LKPD was found to significantly enhance student engagement. For example, when learning about ecosystem interactions, students conducted direct observations in their schoolyard or nearby environments, recorded their findings, and compared them with scientific references. In some cases, students created dioramas illustrating relationships among ecosystem components, fostering creativity while reinforcing conceptual understanding.

The LKPD also incorporated cooperative learning strategies, enabling students to work in groups to study specific ecosystem types such as forests, rivers, and coastal areas. Group discussions encouraged knowledge sharing and peer-to-peer learning. Additionally, field observations, such as visits to parks or conservation areas, were integrated to bridge classroom theory with real-world ecological systems. This experiential learning helped students perceive the interconnectedness of ecological concepts and apply them in daily life.

Overall, the integration of Discovery Learning within the LKPD not only improved students' conceptual understanding of ecosystems but also developed their critical thinking, creativity, and scientific inquiry skills. The combination of structured learning phases, hands-on exploration, and collaborative activities proved effective in deepening comprehension and supporting improved academic achievement.

Table 2. Component Activities Student

Component	Session 1	Session 2	Session 3
Average LKPD	92,48	85,82	92,10
Average Pre-test	85.00	70,20	85,00
Average Post-test	84,84	72,86	85,00

The analysis of learning outcomes across the three meetings revealed noticeable fluctuations in student performance. In Meeting 1, the average LKPD score reached 92.48, while both the pretest and posttest averages were 85.00, indicating strong initial comprehension and retention of the material. In Meeting 2, however, a significant decline was observed: the average LKPD score dropped to 85.82, with pretest and posttest scores falling to 70.20 and 72.86, respectively (Nurhayati & Dewi, 2023). This decline was likely influenced by the complexity of the topic, Types of Ecosystems, which may have been less engaging in its delivery. Contributing factors could include student fatigue, reduced focus, teaching strategies less aligned with learning preferences, and classroom conditions that limited interaction and concentration. In Meeting 3, performance rebounded, with the average LKPD score increasing to 92.10 and both pretest and posttest scores returning to 85.00 (Hanatan et al., 2023). This recovery suggests that students regained both their engagement and mastery of the content.

When comparing experimental and control groups, the experimental group's pretest average of 58.13 rose to 85.94 in the posttest, yielding a gain score of 0.71 (high category). The control group improved from 57.81 to 74.38, with a gain score of 0.39 (medium

category). An independent t-test confirmed a significant difference in posttest scores between the two groups ($p < 0.05$), demonstrating that the interactive LKPD substantially enhanced cognitive learning outcomes. These findings align with prior research affirming the benefits of Discovery Learning in science education. Emphasized that active participation in problem-solving promotes deeper conceptual understanding (Swastika et al., 2022; Yerimadesi et al., 2023), so that Discovery Learning-based LKPDs improve analytical and reasoning skills. Structured worksheet phases help students link theory to real-world applications. Similarly, (Nababan et al., 2023; Setyaningrum, 2020) found that Discovery Learning fosters independent information-seeking and verification, skills also evident in this study's results.

The integration of Discovery Learning into LKPD design offers several benefits:

a) Enhanced Engagement: motivating students to take ownership of their learning.
b) Theory–Practice Connection: through field observations, creative projects, and real-world case studies.
c) 21st-Century Skills Development: strengthening critical thinking, collaboration, creativity, and problem-solving.
d) Curriculum Adaptability: easily applicable to other science topics.

The developed interactive LKPD comprises three sections: (1) interactions between ecosystem components, (2) types of ecosystems with examples and characteristics, and (3) energy flow, food chains, food webs, and ecological pyramids. Each section follows the six phases of Discovery Learning: stimulation, problem identification, data collection, data processing, verification, and conclusion drawing, ensuring that learning occurs through active inquiry rather than passive reception. This structure not only improves academic performance but also builds environmental awareness, equipping students with the skills and mindset needed to address ecological challenges.

3.2. Discussion

The findings of this study indicate that the Interactive Student Worksheet (LKPD) based on the Discovery Learning model effectively improved students' learning outcomes in the topic of ecosystems. The experimental group demonstrated a higher posttest score (85.94) compared to the control group (74.38), with a large gain score of 0.71, categorized as high. In contrast, the control group achieved a moderate gain score of 0.39. The independent t-test confirmed a significant difference between the two groups ($p < 0.05$), suggesting that the implementation of interactive LKPD had a substantial positive impact on cognitive achievement.

A closer examination of the meeting-by-meeting performance revealed notable fluctuations. In Meeting 1, students achieved an average LKPD score of 92.48, supported by consistent pretest and posttest averages of 85.00, indicating a strong grasp of the introductory material. However, in Meeting 2, scores declined significantly, with the LKPD average dropping to 85.82 and posttest scores falling to 72.86. This decline may be explained by the complexity of the topic, "Types of Ecosystems," which required higher-order conceptual processing. When such material is presented in a less engaging or accessible manner, students may experience reduced comprehension. Additional factors such as fatigue, lack of

focus, misalignment between teaching strategies and learning preferences, or limited classroom interaction could have further contributed to the decline. In Meeting 3, performance rebounded, with the LKPD average rising to 92.10 and the posttest score returning to 85.00, indicating that adjustments in instructional delivery successfully restored engagement and comprehension.

These results align with previous studies emphasizing the benefits of Discovery Learning in fostering deeper conceptual understanding. Asserts that active participation and inquiry-based approaches enhance long-term retention (Setyaningrum, 2020), Discovery Learning-based LKPD improves analytical and reasoning skills (Maysara et al., 2023). Similarly, (Nababan et al., 2023; Setyaningrum, 2020) reported that structured learning phases in worksheets help students connect abstract theories to real-world contexts. In the context of biology education, (Ningsih & Jayanti, 2022; Sariam & Harahap, 2022) highlighted that Discovery Learning encourages self-directed exploration and verification of information, a pattern also observed in this study.

The fluctuations observed in Meeting 2 suggest that even within an effective instructional framework, content complexity and delivery play a crucial role in student performance. While Discovery Learning supports active engagement, the success of such an approach depends on how well instructional materials are scaffolded and contextualized. Topics that are conceptually dense may require additional visual aids, interactive activities, or real-life examples to maintain student motivation and comprehension.

From a practical perspective, integrating Discovery Learning into interactive LKPD offers several advantages. First, it enhances student engagement by providing structured yet flexible phases that allow learners to take ownership of their learning. Second, it bridges theory and practice by incorporating field observations, creative projects such as ecosystem dioramas, and real-world case studies. Third, it develops 21st-century skills, including critical thinking, collaboration, creativity, and problem-solving, through inquiry-based group tasks. Finally, the adaptability of the LKPD design allows it to be applied to other science topics beyond ecosystems, broadening its utility in the curriculum.

In conclusion, this study confirms that combining Discovery Learning with interactive LKPD design can effectively improve biology learning outcomes, particularly in environmental and ecosystem topics. The approach not only enhances cognitive achievement but also cultivates environmental awareness, equipping students with the knowledge, skills, and attitudes needed to address ecological challenges in the 21st century.

4. CONCLUSION

This study demonstrates that integrating Discovery Learning into an Interactive Student Worksheet (LKPD) can significantly enhance students' cognitive learning outcomes in ecosystem topics. The analysis revealed that while performance fluctuated across meetings, most notably declining in the second meeting due to topic complexity and delivery factors, student achievement recovered in the third meeting, indicating the adaptability and effectiveness of the approach. The experimental group achieved a higher gain score (0.71, high category) compared to the control group (0.39, medium category), with a statistically significant difference in posttest results. These findings align with prior research

highlighting the benefits of active, inquiry-based learning in fostering deeper conceptual understanding, critical thinking, and engagement.

The structured six-phase Discovery Learning model embedded within the LKPD not only improved mastery of ecosystem concepts but also bridged theoretical knowledge with practical, real-world contexts. This approach proved adaptable, engaging, and capable of cultivating 21st-century skills, making it a valuable model for science education. Future research should explore its application in other subjects and integrate more diverse interactive elements to further enhance learning outcomes.

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