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Development of Student Worksheets (LKPD) Based on Scientific Literacy for the Ecosystem Learning Materials

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A B S T R A C T

Scientific literacy is a crucial skill in modern education. However, the limited availability of effective learning media remains one of the main factors contributing to the low level of scientific literacy among students in Indonesia. This study aims to develop a scientific literacy-based Student Worksheet (LKPD) as a learning medium. The research employed a Research and Development (R&D) approach using the 3D model, which consists of Define, Design, and Develop stages. Data were collected and analyzed through interviews, validation sheets completed by material experts and media experts, readability assessments conducted by a biology teacher and students, and response questionnaires administered to fifteen 10th-grade students at MAN 1 Bandung. The data were interpreted using a Likert scale. The results indicated that the LKPD received a validation score of 72% (valid) from the material expert and 92% (highly valid) from the media expert. The readability test produced scores of 81.2% (easy to understand) from the teacher and 87.3% of students. Student responses were also highly positive, with an average score of 86.6%. Based on these findings, the developed LKPD is feasible for classroom use and engage students in practicing scientific literacy skills.

1. Introduction

Scientific literacy is one of the essential prerequisites for students to master 21st-century skills effectively (Sovani, 2024). According to the Program for International Student Assessment (PISA), scientific literacy is an individual's ability to understand and use scientific knowledge to identify questions, acquire new insights, explain scientific phenomena, and draw conclusions related to scientific issues (OECD, 2019). However, Indonesia's average scientific literacy score in the 2022 PISA assessment was 383, far below the global average of 485, indicating a very low level of proficiency (OECD, 2023). Similarly, the Indonesian Madrasah Competency Assessment (AKMI) released by the Ministry of Religious

Affairs of the Republic of Indonesia showed that 51% of madrasah students were at the “basic” level of scientific literacy (Ditjen Pendis, 2023).

Several factors contribute to this low level of scientific literacy among Indonesian students, including teacher-centered learning approaches and a lack of student interest in specific material, process, and contextual competencies (Hidayah et al., 2023). Furthermore, the selection of inappropriate learning resources, misconceptions, non-contextual learning, and low reading comprehension contribute to the low levels of science literacy. Learning resources directly relate to students’ scientific literacy capabilities (Suparya et al., 2022).

Based on a preliminary study conducted through interviews with a biology teacher at MAN 1 Bandung, a school that has implemented the AKMI program, it was observed that students' science literacy needs improvement. Many students have not yet acquired these essential skills. One of the primary reasons for this issue at school is the lack of innovative learning resources, such as Student Worksheets (LKPD), designed to enhance scientific literacy skills, particularly for the abstract material of Ecosystems. This situation presents a problem that requires an immediate solution.

An effective solution is to design and develop a scientific literacy-based Student Worksheet (LKPD) specifically for the ecosystem material. According to Asnaini (2017), Student Worksheets are an effective learning alternative. LKPD allows students to access information about concepts LKPD has studied through structured learning activities. Moreover, the material of Ecosystems demands strong scientific literacy skills due to its broad and complex scope. German researcher Ernst Haeckel defined ecosystems as an extensive scientific field studying the interaction between organisms and their environment, further underscoring the need for appropriate instructional materials (Sholehuddin, 2021).

Previous studies have supported the effectiveness of literacy-based LKPDs research by Widianingrum & Ducha (2023) showed that a developed scientific literacy-based E-LKPD demonstrated high validity, indicating that E-LKPD was a suitable learning resource. Additionally, a study by Dewi et al. (2022) demonstrated that using an inquiry-based LKPD for the ecosystem topic yielded positive results in improving scientific literacy. This finding further supports the validity of LKPDs. Nufus et al. (2024) also observed positive outcomes from using LKPDs in ecology materials lessons.

This research possesses novelty compared to previous studies; the science literacy-based LKPD being developed will have a more specific focus on the Ecosystems topic through the analysis of plankton diversity, a study which has not been previously conducted at MAN 1 Kota Bandung. Therefore, this research aims to address the problem at the school by integrating a local context into the design and development of the scientific literacy-based LKPD. This approach seeks to enhance the relevance of the material to students’ real-life experiences while simultaneously emphasizing the development of conceptual understanding and scientific literacy. The developed LKPD is expected to support the learning process and engage

students in practicing scientific literacy, enabling students not only to understand the material textually but also to grasp its meaning more contextually.

2. Methodology

This study uses the Research and Development (R&D) method. By using the R&D method, this research produces a learning media product in the form of a science literacy-based Student Worksheet (LKPD) on the Ecosystem material. This product uses a development procedure with the 3D model, namely Define, Design, and Develop (Thiagarajan et al., 1974; Sugiyono, 2019). The research was conducted in Bandung City from December 2024 to May 2025.

Data collection was obtained from an interview with a biology teacher at MAN 1 Kota Bandung to get information about the problems and needs of students. The Design stage was carried out through a literature review by adjusting to student needs, collecting reading sources, and selecting a design format. In the Develop stage, data were obtained through validation sheets addressed to a material and media expert lecturer, readability sheets addressed to one Biology teacher and fifteen students, and response questionnaires distributed to fifteen 10^{th}-grade students at MAN 1 Bandung.

The interview results were analyzed descriptively to identify students' needs as a foundation for development. Ecosystem-related literature, scientific literacy, and LKPD Design stages were analyzed to guide the worksheet's structure. In the Develop stage, validation, readability, and response test results were analyzed using a Likert scale with five rating categories, Very Good (score 5), Good (score 4), Fair (score 3), Poor (score 2), and Very Poor (score 1) (Riduwan & Sunarto, 2019).

The percentage score for each test was calculated by dividing the total obtained score by the maximum possible score, then multiplying by 100%. The interpretation of average percentages followed score interval criteria. A score of ≥81% was categorized as "highly valid" for validation tests and "highly positive" for student responses. A score of ≥61% was considered "easy to understand" in readability tests. Scores between 61% and 100% were classified as "valid" for validation and "positive" for response evaluations (Riduwan & Sunarto, 2019).

3. Results and Discussion

The product developed in this study was designed to help students improve their scientific literacy skills by creating and developing a Student Worksheet (LKPD) that incorporates scientific literacy indicators and competencies, particularly in the context of ecosystem material. The following outlines the results of each stage of development based on the Research and Development (R&D) method using the 3D model (Define, Design, and Develop).

Define Stage

This initial stage focused on identifying learning issues to support the development of a scientific literacy-based Student Worksheet (LKPD). The analysis aimed to explore challenges in the learning process, particularly regarding curriculum, material, student needs and characteristics, and conceptual understanding. An interview with a biology teacher at MAN 1 Bandung revealed that the school applies the Merdeka Curriculum. This curriculum requires that each subject align with each phase's learning outcomes and objectives, and for 10^{th}-grade, these are in Phase E.

The material analysis revealed that students struggle to understand the topic of ecosystems due to its complexity and abstract nature. Moreover, the interview indicated that many students demonstrated low levels of scientific literacy during the learning process. This was evident in their inability to explain scientific phenomena or offer scientifically grounded solutions to problems. Therefore, a learning medium that facilitates understanding ecosystem concepts is necessary. One potential solution is developing an LKPD that incorporates indicators of scientific literacy.

Design Stage

The LKPD was structured based on scientific literacy principles in this second stage. The worksheet includes indicators such as the ability to explain phenomena scientifically, design and evaluate scientific investigations, critically interpret data and scientific evidence, and apply scientific information to decision-making and actions. The LKPD was designed to align with the learning objectives for the ecosystem topic in 10^{th}-grade, as stipulated by the curriculum. The achievement indicators were also matched with relevant scientific literacy competencies. A literature review was conducted to identify practical features of instructional media and inform the worksheet's design.

The developed LKPD included supportive activities such as concept reinforcement, simple laboratory exercises, and case study problem-solving tasks, all grounded in scientific literacy approaches. This stage is aimed at developing the initial product design. The design process required an outline of the media material and a detailed plan for the LKPD layout. According to Yunus & Heldy (2018), an LKPD should include several components such as the title, usage instructions, learning objectives, sources of information, student activities, and evaluation tasks. The LKPD in this study was designed using the *Canva Pro* application, with additional design features, and finalized in Portable Document Format (PDF). An example of the design output for the scientific literacy-based LKPD on the ecosystem topic is presented in Figure 1.

Develop Stage

The final stage of this study served as a continuation of the previous phases and functioned as an evaluation process for the developed product. The aim was to

gather feedback to ensure that the Student Worksheet (LKPD) could be effectively utilized in the learning process. This evaluation was done through three primary assessments: validation, readability, and student response tests.

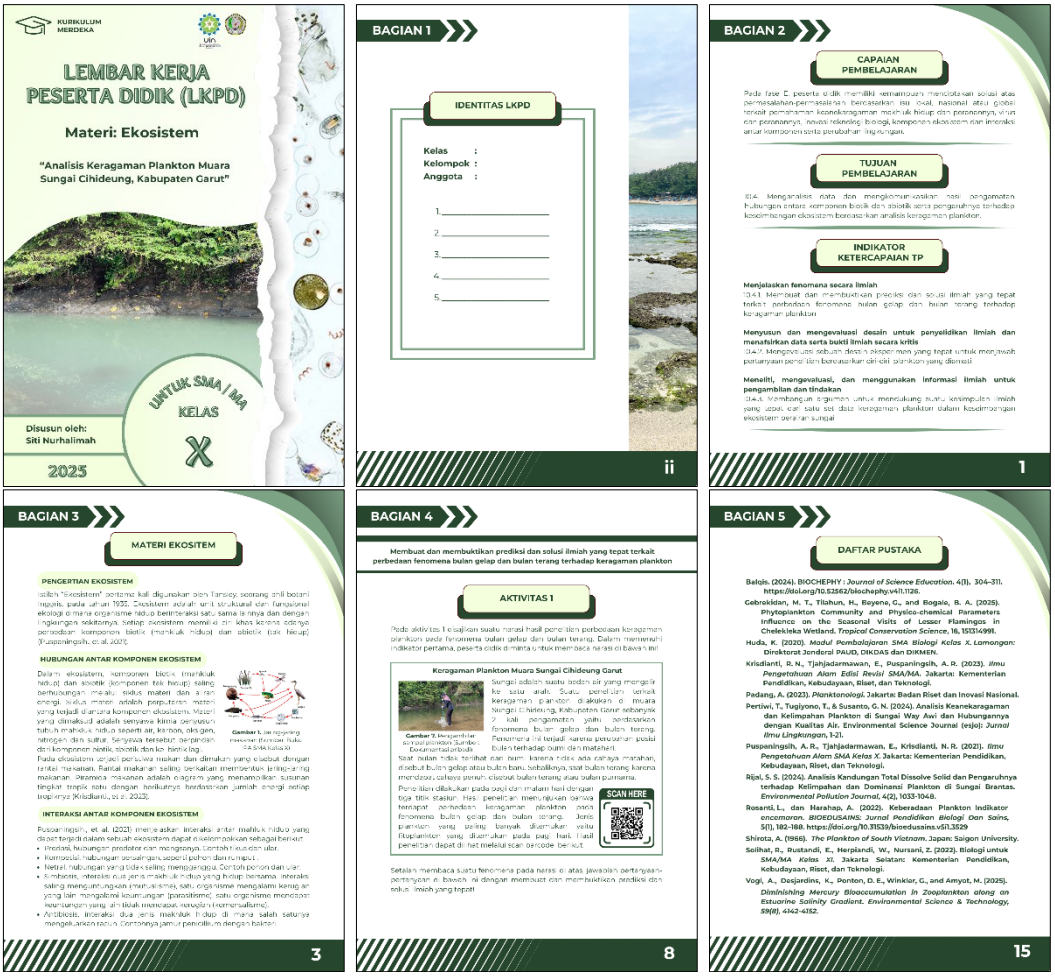

Figure 1. Several examples of LKPD designs based on scientific literacy

a. Validasi Test

The validation process involved two experts: one university lecturer specializing in ecosystem material and another specializing in instructional media. These validators evaluated, provided feedback, and suggested revisions to improve the LKPD. The validation assessment results from the material and media experts were calculated and analyzed. Table 1 presents the validation results from the material expert.

Table 1. Material Expert Validation Results

Aspect	Percentage	Criteria
Material quality	68%	Valid
Accuracy of material and questions	75%	Valid
Currency of material and questions	73%	Valid
Average	**72%**	**Valid**

The validation by the material expert assessed three key aspects: the quality of the material, the accuracy of the material and questions, and the currency or relevance of the material. According to Khairunnisa & Mayrita (2019), material quality refers to the correctness of the learning material, alignment of the test items with indicators, and clarity of the concepts presented. In this study, the material quality aspect received the lowest score, indicating a need for further refinement. Conversely, the accuracy of the material and questions received the highest percentage, reflecting that the material aligns well with established concepts and scientific theories, which supports the students' knowledge acquisition (Lutfianti, 2021). Consistent with Andaresta & Rachmadiarti (2021), who found that accurate and presented LKPD material can reduce misconceptions and enhance understanding.

The currency of material and questions was also rated as valid, though it requires improvement to ensure the LKPD remains relevant to current environmental issues. Kinanti & Sudirman (2017) state that high-quality learning materials must reflect updated and contemporary information to maintain relevance. Overall, the LKPD achieved an average validation score of 72%, which meets the criteria for validity and indicates that it is suitable for classroom implementation. Scientific literacy-based learning is successful when students understand concepts and apply their knowledge in real-life situations (Yuliati, 2017).

During the material validation process, the validator made several suggestions for improvement, including:

1) Incorporating reflection activities related to current local environmental issues, such as river pollution and conservation strategies, as shown in Figure 2.
2) Increasing the variety of questions, especially those based on Higher Order Thinking Skills (HOTS) and scientific literacy, as shown in Figure 3a and Figure 3b.
3) Strengthening project-based learning or case studies to create more meaningful and applicable learning experiences, as shown in Figure 4a and Figure 4b.
4) A glossary should be added to support students' understanding of key scientific terms, as shown in Figure 5.

Figure 2. Addition of material

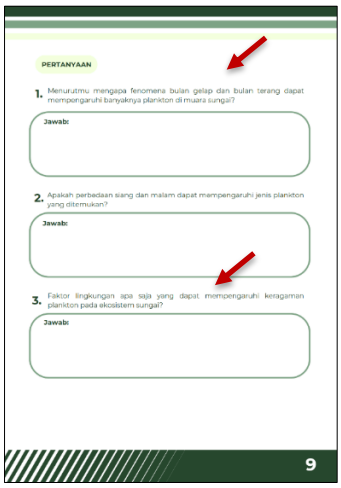

Figure 3a. Before revision

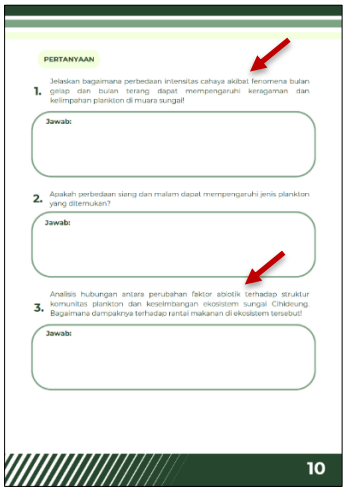

Figure 3b. After revision

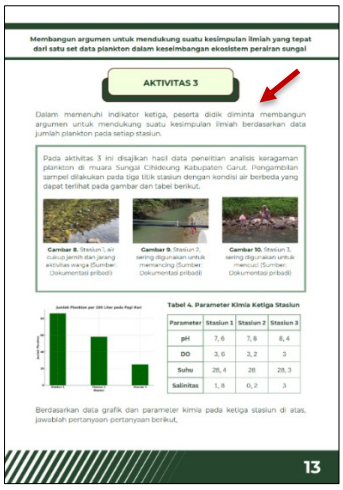

Figure 4a. Before revision

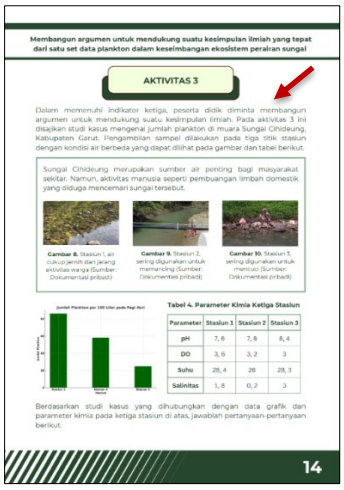

Figure 4b. After revision

Figure 5. Addition of glossary

Incorporating the revisions suggested by the material expert aimed to ensure the feasibility of the LKPD as a practical learning resource ready for classroom implementation. The validator recommended that the material be linked to current local environmental issues and that case-based learning be integrated to encourage student reflection and create more meaningful learning experiences. These suggestions were aligned with the currency aspect of the material and questions. This is consistent with the core objectives of biology education, which include fostering an understanding of the relevance of scientific knowledge to present and future societal contexts. Students are expected not only to comprehend material at a textual level but also to interpret it contextually (Rahmayani, 2019).

Additionally, the validator advised increasing the variety of questions using Higher Order Thinking Skills (HOTS) and scientific literacy-based formats to strengthen students' reasoning abilities. Training students in scientific literacy through classroom activities involving real-world and environmental contexts helps them apply scientific knowledge to solve everyday problems (Hidayati & Indana, 2025). Furthermore, the validator suggested including a glossary to assist students in understanding scientific terms within the LKPD. A glossary can enhance comprehension by clarifying terminology, enabling students to grasp scientific concepts more effectively (Andhani et al., 2021).

Following the material expert's validation, a similar validation process was conducted by a media expert. The expert media validation results are presented in Table 2.

Table 2. Media Expert Validation Results

Aspect	Percentage	Criteria
Visual and material design	90%	Highly Valid
Language use	90%	Highly Valid
Graphics	88%	Highly Valid
Media characteristics	100%	Highly Valid
Average	**92%**	**Highly Valid**

The scientific literacy-based Student Worksheet (LKPD) was rated as "Very Valid", with an overall average score of 92% from the media expert. No revisions were recommended, indicating that the LKPD was highly suitable for instructional settings. This result confirms that the product successfully met the media evaluation criteria. According to Purnamasari et al. (2018), a learning material is viable when it fulfills all core assessment components.

Among the evaluated aspects, media characteristics, visual and material design, and language use received the highest scores, followed closely by graphics. The LKPD design paid careful attention to visual elements such as layout, structure, and material organization to ensure visual appeal. An engaging worksheet design can create a positive impression on students and improve their learning motivation (Ningsih & Utami, 2022). Shangguan et al. (2020) noted that an attractive cover draws student attention, enhances aesthetics, and shapes positive perceptions of learning materials, improving learning performance.

b. Readability Test

Before the LKPD was implemented in the classroom, a readability test was conducted to evaluate its clarity and comprehensibility for use during the learning process. This test involved a biology teacher who completed a readability questionnaire covering seven assessment aspects. Additionally, a student readability questionnaire was administered to fifteen 10^{th}-grade students at MAN 1 Bandung, focusing on three criteria: visual appearance, material presentation, and usefulness. The percentage scores for each aspect were calculated and averaged. Table 3 presents the readability test results from the biology teacher.

Table 3. Biology Teacher Readability Test Results

Aspect	Percentage	Criteria
Material quality	84%	Easy to understand
Accuracy of material and questions	80%	Easy to understand
Currency of material and questions	80%	Easy to understand
Visual and material design	80%	Easy to understand
Language use	85%	Easy to understand
Graphics	80%	Easy to understand
Media and characteristics	80%	Easy to understand
Average	**81,2%**	**Easy to understand**

Based on the biology teacher's evaluation across all seven aspects, the scientific literacy-based Student Worksheet (LKPD) on the ecosystem material was rated "Easy to understand" with an average percentage score of 81.2%. This result indicates that the LKPD meets the established criteria for readability. Among all aspects, language use received the highest score, emphasizing its critical role in supporting student comprehension. Proper language structure helps learners understand the material more easily and reduces the risk of misinterpretation (Septiana et al., 2021).

According to Guswita (2021), the primary purpose of using simple language in instructional materials is to encourage active student participation and promote deep understanding of the subject matter. Ineffective or poorly structured language can lead to misunderstandings of the concepts presented in the LKPD (Septiana et al., 2021). In line with the views of Pradita & Lubis (2018), the language used in student worksheets must be informative, clear, and concise to facilitate understanding and minimize misinterpretation, especially for students.

During the readability test, the biology teacher also provided constructive feedback, including:

1) In Activity 1, it was recommended to add a question regarding scientific solutions that had not yet been addressed, as shown in Figure 6a and Figure 6b.
2) The assessment table provided in the LKPD appendix suggested adding a row for recording the total score, as shown in Figure 7a and Figure 7b.

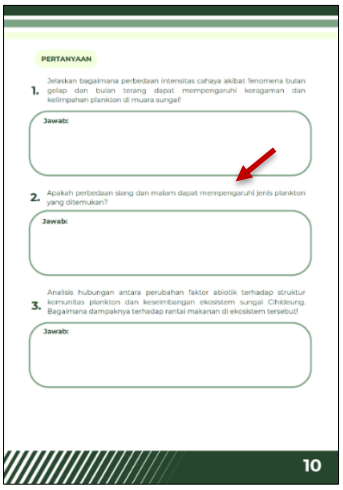

Figure 6a. Before revision

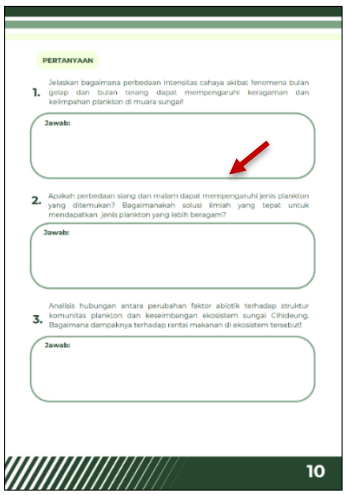

Figure 6b. After revision

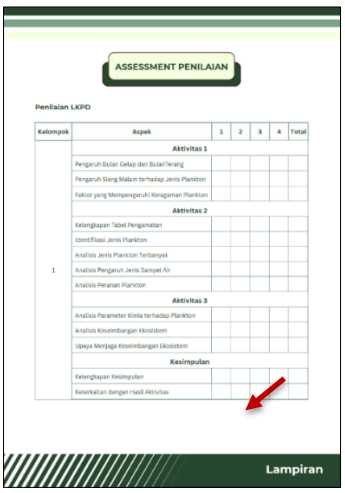

Figure 7a. Before revision

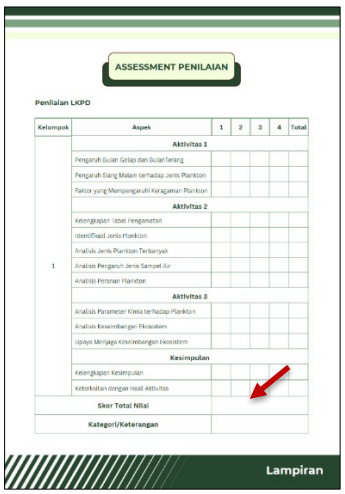

Figure 7b. After revision

In addition to the biology teacher's feedback, a specific suggestion was provided to improve a question in Activity 1, aligning it more closely with the learning objective indicator: "formulate and test appropriate scientific predictions and solutions." The question should be framed using a scientific literacy approach to train students' analytical and problem-solving skills. In identifying phenomena, students must apply their scientific knowledge to explain specific scientific events (Saraswati et al., 2021). According to Khasanah & Setiawan (2022), students with high scientific literacy are expected to understand information related to scientific processes and real-world facts and apply that knowledge to solve everyday problems.

In addition to the teacher's assessment, students also conducted a readability test. The results from fifteen 10th-grade students at MAN 1 Bandung are shown in Table 4.

Table 4. Students' Readability Test Results

Aspect	Percentage	Criteria
Visual appearance	90%	Easy to understand
Material presentation	87%	Easy to understand
Usefulness	85%	Easy to understand
Average	**87,3%**	**Easy to understand**

The scientific literacy-based LKPD received an average readability score of 87.3% from students, placing it in the "easy to understand" category. This result indicates that all evaluated aspects meet the established assessment criteria. Among the 15 student respondents, the highest individual score was 100%, while the lowest was 65.7%, accompanied by a comment that some sentences in the LKPD were challenging to understand. This highlights the importance of aligning sentence structure and complexity with students' education.

According to Minakh & Susantini (2023), the development of an LKPD must consider its readability level to ensure students can fully comprehend the material. This is consistent with findings by Machsun & Indana (2023) who emphasized that readability directly influences student learning success. Fransiska et al. (2021) also noted that the sentence structure in instructional materials must be tailored to the learners' grade level to help them better understand the learning objectives and overall meaning. Moreover, using LKPDs contributes to fostering scientific attitudes among students, such as curiosity, critical thinking, objectivity, and responsibility in completing tasks (Utariadi et al., 2021).

c. Response Test

Before the student response test, a limited LKPD trial was conducted with three groups of 10^{th}-grade students at MAN 1 Bandung to evaluate their achievement of scientific literacy indicators integrated within the worksheet. The results from this limited trial, which focused on ecosystem-related scientific literacy, are presented in Table 5.

Table 5. Limited Trial Results

Group	Score
Group 1	83,3
Group 2	80
Group 3	86,6

The scores achieved by the three groups in the table indicate that the developed LKPD meets the criteria for learning feasibility based on this limited implementation. The students' ability to complete the questions in each activity demonstrates that the LKPD successfully addressed the expected learning outcomes. Students could analyze data and communicate their observations regarding the relationships between biotic and abiotic components and their impact on balance in aquatic ecosystems.

The LKPD was designed to align with the learning objectives for class X students and integrated scientific literacy competencies throughout its activities. In each section, students successfully answered questions that involved formulating and testing scientific predictions, evaluating experimental designs, and constructing arguments to support scientific conclusions. These achievements demonstrate students' ability to predict phenomena arising from real-world problems. This finding aligns with Rini et al. (2021), who noted that the ability to make scientific predictions involves understanding, identifying, and analyzing information to anticipate possible outcomes based on scientific evidence and logical reasoning.

Following the limited trial, a student response test was administered to assess students' perceptions of the LKPD. Fifteen class X students completed a response questionnaire based on three evaluation criteria: visual and material appeal, material comprehension, and student motivation. The results of the student response questionnaire assessment are shown in Table 6.

Table 6. Student Response Test Results

Aspect	Percentage	Criteria
Visual and material appeal	90%	Highly positive
Material comprehension	86%	Highly positive
Student motivation	88%	Highly positive
Average	**86,6%**	**Highly positive**

Based on the response questionnaire completed by fifteen 10^{th}-grade students, the scientific literacy-based Student Worksheet (LKPD) developed in this study received an overall "Highly Positive" rating, with an average score of 86.6% across all aspects. Among individual respondents, the highest score was 100%, and the lowest was 62%. Nonetheless, the data show consistently strong positive responses across all three evaluated dimensions during the trial. These findings indicate that students' responses to scientific literacy-based LKPDs align with the targeted assessment indicators.

These findings indicate that students responded positively to using the LKPD in the ecosystem learning unit. The worksheet captured students' interest and provided motivational support throughout the learning process. According to Ayulistiana & Yuliani (2020), well-designed LKPD can engage students effectively as learning media, making the learning experience more enjoyable. Additionally, the LKPD was tailored to accommodate students' needs, thereby contributing to improved instructional quality in the classroom. Through a combination of relevant material, active learning activities, and verified instructional validity, the scientific literacy-based LKPD has proven to be an effective educational tool for delivering meaningful and engaging learning experiences (Hanum & Amini, 2023).

4. Conclusion

Based on the findings of this study, the scientific literacy-based Student Worksheet (LKPD) on the topic of ecosystems, developed using the Research and

Development (R&D) method with the 3D model (*Define, Design, Develop*), received positive evaluations in terms of validity, readability, and student response. The validation results categorized the LKPD as valid according to the material expert and highly valid according to the media expert. In addition, the readability tests were conducted by a biology teacher, and the students rated the LKPD as easy to understand. The response questionnaire completed by fifteen 10^{th}-grade students also indicated a highly positive response. Therefore, the study concludes that the developed scientific literacy-based LKPD is practical and effective for classroom use so teachers can easily implement it, enhance students' understanding of ecosystem concepts, engage students in practicing scientific literacy skills, and support the overall effectiveness of the learning process.

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