REFLECTION JOURNAL
https://journal-center.litpam.com/index.php/RJ
reflectionjournal21@gmail.com

Desember, 2023 Vol. 3, No. 2
e-ISSN: 2808-1501
pp. 64-73

Implementation of Worksheets Based on Experiments on The Subject of Biotechnology to Develop Students' Scientific Literacy

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Diterima: November 2023; Revisi: Desember 2023; Diterbitkan: Desember 2023

Abstract: This study aimed at bolstering students' scientific literacy in biotechnology through the implementation of Experiment-Based Learning and Creativity Worksheets (LKPD). Utilizing a classroom action research framework, the investigation was conducted over two cycles, incorporating planning, action, observation, evaluation, and reflection phases. It involved 30 students and used observational sheets for monitoring teacher and student activities, along with multiple-choice and essay questions to assess students' scientific literacy. The findings revealed a notable enhancement in both teaching methods and student learning outcomes, facilitated by the LKPD usage. Specifically, teacher performance improved from achieving 80% of the set criteria in the first cycle to 90% in the second, upgrading their rating from 'Good' to 'Very Good'. This improvement was paralleled by a rise in students' average scores from 85.33 to 90.58, indicating a heightened engagement with and comprehension of biotechnological principles. The employment of LKPDs proved critical not just for expanding knowledge but for the practical application of scientific concepts, as demonstrated by an average literacy score of 88. Furthermore, an uplift in the average scientific literacy score from 76.59 in the first cycle to 84.89 in the second emphasizes the significance of LKPDs in enhancing students' grasp of scientific theories. Overall, the interventions across the cycles successfully elevated the caliber of teaching, enriched the student learning experience, and significantly improved science literacy, thus contributing to an enhancement in educational quality.

Keywords: LKPD, experiments, Scientific Literacy

How to Cite: Ngaji, I. U., Mirawati, B., Ratnasari, D., Arifin, A. A., & Fajri, S. (2023). Implementation of Worksheets Based on Experiments on The Subject of Biotechnology to Develop Students' Scientific Literacy. *Reflection Journal*, *3*(2), 64–73. https://doi.org/10.36312/rj.v3i2.1733

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INTRODUCTION

Scientific literacy embodies a comprehensive skill set, encompassing both the knowledge and procedural know-how required for the scientific explanation of phenomena, the interpretation of data, and the application of evidence in decision-making or problem-solving contexts pertinent to science and technology. As delineated by the (OECD, 2004), scientific literacy extends beyond mere knowledge acquisition, demanding the ability to engage scientifically in explaining phenomena, to critically evaluate and design scientific investigations, and to adeptly interpret scientific data and evidence. This capacity is crucial for addressing questions, challenges, and conceptualizations related to the scientific and technological domains.

Fundamentally, scientific literacy is a multifaceted process that hinges on facts, concepts, principles, and theories, as well as the methodologies for acquiring and evolving knowledge (Firdaus et al., 2023; Suryati et al., 2021). This encompasses practical approaches, cognitive strategies, problem-solving techniques, and behavioral norms, all systematically structured with a strong emphasis on observational and experimental evidence (Mahyuny et al., 2022). Within frameworks such as the Program of International Student Assessment (PISA), scientific literacy is perceived as the amalgamation of individual scientific knowledge with the application of this knowledge in identifying questions, acquiring new insights, elucidating scientific phenomena, and formulating evidenced conclusions. Thus, mastering scientific literacy is pivotal for students, enabling them to comprehend their surroundings and phenomena through a lens grounded in scientific evidence, which is increasingly crucial given the rapid advancements in technology and science.

In the educational context, LKPD (Student Worksheets) serve as crucial pedagogical tools for educators to disseminate natural science topics, blending instructional content with exercises or assignments for student engagement. The adoption of experiment-based science learning methodologies, as suggested by (Lestari, 2018) is instrumental in enriching students' knowledge through hands-on LKPD activities. These activities encourage simple experimental undertakings, thereby nurturing students' innate abilities to observe, inquire, experiment, rationalize, and communicate effectively (Harahap, 2020; Hiebert, 2007; Slekiene & Lamanauskas, 2020). Despite these advancements, observations at SMP Negeri 5 Gerung, West Lombok, reveal a significant portion of students lacking in scientific literacy, with deficiencies in science skills, conceptual understanding, and engagement levels, which notably impacts their ability to correlate learned scientific knowledge with everyday phenomena, especially in areas like biotechnology.

This observed discrepancy accentuates the pivotal role of LKPD, particularly those designed with a focus on scientific literacy, in augmenting students' comprehension and practical application of scientific concepts. Customized instructional resources, such as LKPD that are meticulously crafted to bolster scientific literacy, have demonstrated their effectiveness in not only elevating students' higher-order thinking skills but also in deepening their understanding of scientific methodologies. According to (Yulia et al., 2022), the deployment of such specialized teaching materials, including the implementation of PQ4R (Preview, Question, Read, Reflect, Recite, and Review) strategies within electronic LKPDs (E-LKPD), has been shown to significantly enrich the learning experience, rendering it more dynamic and interactive, thereby promoting students' engagement and cognitive development (Nirmala et al., 2021)

Moreover, the ambit of scientific literacy transcends the confines of pure science to permeate diverse disciplines, including mathematics and social sciences, highlighting its interdisciplinary significance. The practicality and validity testing of LKPD through methodologies such as field trials and questionnaires have been instrumental in assessing its efficacy in bolstering students' comprehension, analytical capabilities, and problem-solving prowess (Suriani & Devita, 2020). Furthermore, the integration of LKPD based on Socio-Scientific Issues (SSI) has proven to be both valid and pragmatic, significantly enhancing the caliber of science education in junior high schools by fostering a more contextual and application-oriented learning environment (Putriana, 2020). This holistic approach to education, underpinned by tailored LKPD, is essential for cultivating a nuanced understanding of scientific literacy, thereby preparing students to navigate and contribute meaningfully to an increasingly complex and technologically driven world. Furthermore, the integration of critical thinking within LKPD through investigative approaches enriches the learning experience by offering a structured pathway for students to explore, understand, and apply learning materials. This strategy not only makes learning more enjoyable and interactive but also fosters student motivation, self-confidence, and critical problem-solving capabilities (Hulyadi, 2022; Kurniah et al., 2023; Puspita & Dewi, 2021; Yuzan & Jahro, 2022).

Recent studies underscore the importance of integrating advanced methodologies in LKPD design to foster scientific literacy, especially in burgeoning fields like biotechnology. (Nirmala et al., 2021; Wulan et al., 2023) emphasized the need for electronic student worksheets incorporating scientific approaches to enhance critical thinking in biotechnology, while (Arifah et al., 2022) showcased the benefits of ethnoscience and STEM-based worksheets in boosting literacy and character development. Moreover, delineations by (Dewantara et al., 2019; M. Nasir et al., 2021, 2021) on the construction of scientific literacy-based worksheets, focusing on problem identification, exploration, application, and bibliographic components, further attest to the crucial role these materials play in deepening students' scientific understanding. (Chasanah et al., 2022; Fives et al., 2014; Setiawan, 2020) reinforce the significance of designing and evaluating scientific literacy worksheets grounded in scientific approaches and the assessment of students' perceptions of scientific knowledge, respectively.

In light of these considerations, the research endeavors to elucidate the impact of LKPD on the cultivation of scientific literacy among students, highlighting the potential of experiment-based learning resources in facilitating a comprehensive and immersive educational experience tailored to foster not only knowledge acquisition but also critical analytical skills within the scientific realm.

METHOD

The methodology underlying the study conducted at SMPN 5 Gerung in West Lombok Regency between May 17 and May 30, 2023, employs Classroom Action Research (CAR) with a focus on enhancing instructional quality and teaching efficiency. This research included a diverse group of 30 students, with a gender composition of 17 males and 13 females, aiming to assess and improve teaching strategies through empirical observation and testing. Observational methods were central to this study, utilizing customized observation sheets for both students and teachers to systematically gather data on student engagement and instructional effectiveness throughout the educational process. This approach was complemented by the deployment of Student Worksheets (LKPD), which were instrumental in evaluating the implementation fidelity of lesson plans and in promoting active learning among students.

Moreover, the research methodology emphasized collaboration with local biology educators to ensure the observation tools and educational materials were contextually relevant and aimed at achieving the learning objectives effectively. Testing played a pivotal role as well, designed to measure students' scientific literacy through descriptive evaluative questions crafted by the researcher. This dual approach of observation and testing was geared towards not only understanding the current state of instructional execution and student participation but also identifying avenues for improvement in teaching practices and learning outcomes. By focusing on scientific literacy as a measure of student achievement, the research underscores the importance of developing critical thinking and comprehensive understanding within the educational framework. Overall, this CAR study seeks to contribute valuable insights into effective teaching methodologies and the enhancement of instructional quality, with a keen focus on fostering an engaging and productive learning environment.

The Classroom Action Research (CAR) implementation steps begin with planning, followed by action and observation, and culminating in reflection. The details of these steps are as follows:

First Cycle Stages

1. Planning Stage: At this stage, the researcher determines the focus of special attention events to be observed, then creates an observation instrument to identify the facts occurring during the action. Activities at this stage include developing Lesson Plans (RPP), creating Student Worksheets (LKPD), drafting observation sheets, and designing evaluation tools and planning test outcomes.
2. Action Implementation Stage: Here, the designed or strategized learning applications are implemented. The action is carried out over two cycles, with one Lesson Plan (RPP) implemented in each cycle.
3. Observation (Observation and Evaluation): The researcher conducts observations and records all necessary events and occurrences during the action by monitoring student activities. Data collection is performed using observation formats or assessments that have been prepared, including careful observation of the learning process and student outcomes. Collected data may include quantitative data (test results) reflecting student activity, enthusiasm, and the quality of discussions conducted.
4. Reflection: This stage is intended for a comprehensive review of the conducted actions based on collected data, followed by an evaluation to perfect subsequent actions. Reflection in CAR encompasses the analysis and assessment of the observed outcomes of the implemented actions. If issues arise from the reflection process, a reassessment is conducted through the next cycle, which includes re-planning, re-action, and re-observation to resolve the issues.

Second Cycle Stages

The procedure in the second cycle is fundamentally similar to the first, except that the second cycle involves correcting deficiencies identified from the student learning outcomes analyzed in the first cycle. Cycle II is conducted if Cycle I does not achieve classical completeness and so forth, ensuring continuous improvement.

RESULTS AND DISCUSSION

This study was conducted from May 17 to May 30, 2023, at SMPN 5 Gerung, West Lombok District, involving 30 students, with 17 male and 13 female students. The research aimed to examine the implementation of the Student Worksheet (LKPD) on the development of students' scientific literacy.

The first data set was derived from observation sheets that captured teacher and student activities, utilized to understand teacher activity during the teaching process. The second data set focused on the improvement of student learning outcomes obtained through the distribution of the Student Worksheet (LKPD), used to evaluate the enhancement of student learning regarding the materials taught. The third set of data consisted of student learning evaluation results in the form of grades, with the data collection instrument being a written test. This data was employed to ascertain the students' comprehension of the taught material.

Before the entire research process commenced, the initial step taken by the researcher was to conduct preliminary observations and prepare general learning tools, including the Lesson Plan (RPP), research necessities such as the observation sheets for teacher and student activities, the Student Worksheet (LKPD), and the test sheets for assessing student learning outcomes at the end of each lesson. The following will detail the research findings for each cycle according to the conducted learning process.

Analysis of Cycle I and II Teacher Activities

The results of teacher observations carried out by filling in the teacher activity observation sheet in cycles I and II can be seen in the following table

Table 1. Observation results of cycle I and II teacher activities

Aspects observed	Cycle I	Cycle II
Many activities	8	9
Total score	8	9
Maximum Score	10	10
Percentage	80%	90%
Criteria	Good	Very good

The data from the table reveals that the teacher's activities in both Cycles I and II were evaluated against 10 criteria. In Cycle I, the teacher met 7 of these criteria but did not meet 2. This resulted in a completion rate of 80%, with the remaining 20% not fulfilled, thus the performance was rated as 'Good'. In Cycle II, there was an observable enhancement in classroom management, with the teacher meeting 9 out of the 10 criteria. The percentage completion rose to 90%, with only 10% of the indicators unmet, leading to a classification of 'Very good'. This indicates an improvement in the teacher's activities from the first to the second cycle.

Analysis of Student Learning Activities

The observation outcomes were derived by distributing activity sheets to the students. The subsequent results from observation and analysis for both cycles I and II were then systematically compiled into tabular form after the data collection was completed. This table format facilitated a clearer comparison and assessment of the observed activities across the two cycles.

Table 2 Observations of Student Learning Responses in Cycle I and Cycle II

Aspects observed	Cycle I	Cycle II
The number of students	30	30
Total value	2560	2718
Average	85,33	90,58
Category	Baik	Sangat baik

From the information provided, it is understood that the learning response of students in Cycle I consisted of 30 attending students, accumulating a total score of 2560 and an average score of 85.33. In Cycle II, the same number of students attended, but the collective score increased to 2718, resulting in a higher average score of 90.58. This indicates that there has been an improvement in the students' learning response during the educational process.

Analysis of the results of practicum activities with Experiment-Based LKPD

Subsequently, the researcher distributed the student worksheets that contained questions related to the biotechnology project. The teacher elucidated the tasks within the worksheet and invited the students to complete the distributed worksheets. Prior to this, the researcher organized the students into five groups, with each group consisting of six members.

Upon the distribution of the worksheets, students were guided to engage in discussions with their group members. Meanwhile, the researcher monitored and ensured that every group actively collaborated in completing the worksheets, also providing guidance to students who encountered difficulties with the questions presented. Despite some students being less active within their groups, attributed to a lack of motivation in completing the worksheets, those who were actively engaged in the task demonstrated a willingness to inquire about unclear aspects, thereby receiving targeted guidance from the researcher.

The process of evaluating the worksheets was jointly undertaken by the researcher and the Science teacher, who methodically inspected the worksheets being filled out by the students in each group. The researcher noted that a particular group was struggling, a situation attributed to the students' limited focus during the explanation of the biotechnology project's methodology.

Table 3. Analysis of practicum results with experimental-based LKPD

Number of Values	2627
Average	88
The highest score	100
Lowest Value	67
Complete	25
Not Completed	5
Completion percentage	83,33%

The data presented in the uploaded image provides a detailed analysis of students' scientific literacy concerning an experimental Learning and Creativity Worksheet (LKPD) focused on biotechnology. A significant dataset was used in this analysis, comprising 2627 individual scores, reflecting a comprehensive assessment of student performance. The average score obtained by the students was a notable 88 out of a possible 100, suggesting a high level of understanding overall.

In terms of performance range, the highest score achieved by a student was a perfect 100, indicating that the top performers fully grasped the biotechnology material covered by the LKPD. On the other end of the spectrum, the lowest score recorded was 67, which suggests that while some students may have struggled, even the minimum level of understanding was relatively high. Of all participants, 25 students successfully completed the assessment, meeting the set proficiency benchmark. However, there were 5 students who did not meet the required standard, resulting in an overall completion percentage of 83.33%. This figure serves as a quantitative testament to the effectiveness of the LKPD in enhancing students' scientific literacy in biotechnology.

Results of analysis of students' scientific literacy

The bar chart presents an evaluation of the progression in students' scientific literacy, comparing two different periods of assessment, Cycle I and Cycle II. It illustrates an overall improvement from the first to the second cycle.

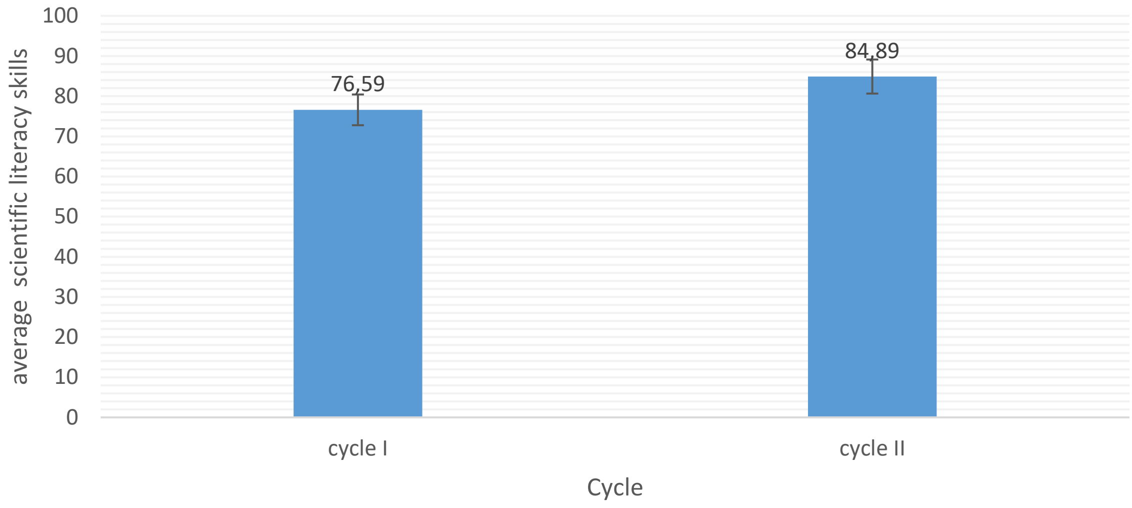

Figure 1. Results of analysis of students' scientific literacy in cycle 1 and cycle II

The bar chart depicts a comparative analysis of students' average scientific literacy skills over two evaluation periods, labeled as Cycle I and Cycle II. In Cycle I, the students achieved an average score of 76.59, which establishes a benchmark for their scientific literacy at the beginning of this assessment period. This foundational score is crucial as it sets a reference point for any subsequent improvement or changes in the students' performance.

Moving on to Cycle II, the data reveals a substantial advancement, with the average scientific literacy score climbing to 84.89. This elevation represents an increase of 8.3 points from the first cycle, signaling a significant boost in the students' understanding and application of scientific concepts. The observed improvement can be attributed to the successful application of experimental-based Learning and Creativity Worksheets (LKPD) in the curriculum. The enhancement of scientific literacy, as evidenced by these results, is paramount, as it underscores the students' ability to not only grasp scientific principles but also to apply them thoughtfully in both academic contexts and in the broader spectrum of their daily lives.

Scientific literacy encompasses knowledge and comprehension of scientific concepts and processes essential for identifying questions, acquiring new knowledge, understanding scientific phenomena, and making conclusions based on existing evidence. This literacy is crucial in the 21st century, enabling society to address daily life challenges. However, the development of scientific literacy in Indonesia has not yet reached its full potential, hindered by various factors that keep it low.

Scientific literacy is a multifaceted concept that includes key skills for understanding and engaging with scientific information. (Norman & Skinner, 2006; Suryati et al., 2022) describe it as a core skill within eHealth literacy, alongside traditional literacy, health literacy, information literacy, media literacy, and computer literacy. (Laugksch, 2000) provides a deep conceptual overview of scientific literacy, emphasizing its importance beyond the professional science education community. This review synthesizes diverse works on scientific literacy to offer a comprehensive understanding of the concept.

Competencies involved in scientific literacy include identifying scientific issues, explaining phenomena scientifically, and using scientific findings to solve problems (Budiarti & Tanta, 2021). It also involves the ability to critically read and understand scientific papers, identifying their key content (Geithner & Pollastro, 2016), and extends to evaluating and designing scientific investigations, interpreting data and evidence scientifically, and explaining scientific phenomena (Sholikah et al., 2020). Furthermore, the development of scientific literacy is linked to broader educational goals. (Otto et al., 2022) suggest that undergraduate training in peer review can enhance scientific literacy, scientific identity, and a sense of belonging to science. This approach not only fosters disciplinary literacy but also contributes to students' overall scientific understanding.

In conclusion, scientific literacy is a fundamental skill that empowers individuals to critically navigate and engage with scientific information. Incorporating scientific literacy into educational frameworks and assessments enables individuals to develop the competencies necessary to understand, evaluate, and effectively contribute to scientific knowledge.

The factors contributing to low scientific literacy in Indonesia include ineffective and unengaging learning resources, incorrect and rushed delivery of scientific concepts leading to misconceptions, and a less conducive learning environment. To improve scientific literacy, it is essential to understand, critique, and seek information related to science in daily life. Experimentation activities suitable for SMP 5 Negeri Gerung have been implemented to captivate students' interest.

Negeri Gerung enhances students' scientific literacy skills. These Experiment-Based Student Worksheets (LKPD) support scientific learning and involve science teachers at SMP Negeri 5 Gerung, West Lombok. Such teaching materials are crucial for achieving competency. LKPD plays a significant role in developing meaningful learning activities and creativity both in and out of the classroom. The use of Learning Tools (LKPD) has been shown to be beneficial in education. LKPD, when developed interactively with multimedia innovations (Andriana et al., 2022), can engage students in learning activities, helping them discover and develop concepts. During challenging times like the Covid-19 pandemic, LKPD has been instrumental in fostering independent learning (Halimatusadiah, 2022). Additionally, interactive LKPD based on guided discovery has proven effective in enhancing science learning outcomes (Suniasih & Sujana, 2023) These findings underscore the importance of well-designed and interactive LKPD in making learning more engaging, active, and enjoyable for students.

Aligned with efforts to enhance students' scientific literacy, scientific literacy can connect scientific (scientific) concepts with social issues in the community. This aspect of scientific literacy is crucial in education, especially in science subjects like biotechnology, significantly impacting the environment ((Arlis et al., 2020)

The development of scientific literacy prepares students for higher education competencies. Educators must understand basic student information in class and diagnose individual students to develop them into effectively literate in science. Assessments are involved to provide learning information related to students' knowledge and skill achievements or misunderstandings about concepts or content taught by teachers. This information can then be used by teachers to improve their teaching and enhance students' scientific literacy (Mun et al., 2015)

CONCLUSION

Conclusions drawn from the analysis of teacher activities, student learning activities, and the impact of Experiment-Based Learning and Creativity Worksheets (LKPD) on students' scientific literacy highlight significant progress in learning outcomes during the two intervention cycles. The increase in teacher activity from a rating of 'Good' in Cycle I to 'Very Good' in Cycle II, with an increase in criteria met from 80% to 90%, indicates the positive impact of targeted intervention strategies aimed at improving teacher performance. teaching methods and classroom management. This increase in teacher activity is reflected in an increase in students' scientific literacy, where the average score increased from 85.33 in Cycle I to 90.58 in Cycle II, which reflects the high level of student learning response. The application of LKPD based on experiments on the subject of biotechnology in practical activities has proven to be an important factor in improving learning, which significantly increases students' scientific literacy. With an average student science literacy score of 88. LKPD not only facilitates a deeper understanding of biotechnology but also equips students with the skills needed to apply scientific concepts effectively. Furthermore, the increase in the average student scientific literacy score from 76.59 in Cycle I to 84.89 in Cycle II shows the great impact of using experimental LKPD into learning, thereby fostering a richer and more comprehensive understanding of scientific principles among students. student. Collectively, these findings attest to the effectiveness of the intervention implemented in two cycles, resulting in marked improvements in teacher performance, student learning outcomes, and scientific literacy, thereby improving the overall educational experience.

RECOMMENDATION

To elevate the effectiveness and impact of educational interventions on both teacher performance and student outcomes, it is recommended to implement a multifaceted approach. Firstly, enhancing support for teachers through continuous professional development and training in innovative teaching methodologies is crucial for improving pedagogical effectiveness across all evaluation criteria. Secondly, the sustained implementation and refinement of Experiment-Based Learning and Creativity Worksheets (LKPD) should be encouraged, especially in scientific subjects, to deepen students' practical understanding and application of theoretical concepts. Additionally, targeted interventions must be developed for lower-performing students to ensure equitable educational benefits and address disparities in learning outcomes. Expanding the assessment framework to cover a broader range of scientific literacy metrics will provide a more comprehensive evaluation of students' abilities to apply scientific principles. Finally, conducting longitudinal studies to assess the long-term effects of these strategies on teacher and student performance will support ongoing improvements and adaptation of educational practices. These recommendations aim to foster an inclusive, effective, and continuously evolving educational environment.

ACKNOWLEDGMENT

The completion of this research was due to support from the Biology education study program at the Mandalika Education University and collaborating universities

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