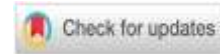




The implementation of discovery learning to improve scientific literacy in biology learning of protists



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ABSTRACT

This study highlights the importance of developing 21st-century competencies, particularly students' abilities to explain scientific phenomena, design investigations, and interpret data and evidence. The topic of Protists was chosen due to its high diversity and complexity, which often makes it difficult for students to understand, requiring a learning strategy that emphasizes active exploration and concept discovery. The study aimed to examine the effect of the Discovery Learning model on students' scientific literacy in biology. A quasi-experimental pretest–posttest control group design was employed with two purposively selected tenth-grade classes in a senior high school. The experimental class ($n = 20$) used the Discovery Learning model, while the control class ($n = 20$) received conventional instruction. A scientific literacy test based on PISA indicators was used as the instrument. Results showed the experimental class's mean score increased from 36.33 to 83.33, with an N-Gain of 0.70 (high category). Normality ($p > 0.05$) and homogeneity ($p > 0.05$) assumptions were met, and One-Way ANOVA ($p < 0.05$) indicated a significant difference, suggesting that Discovery Learning effectively improves students' scientific literacy through active exploration, data analysis, and concept discovery.

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INTRODUCTION

One of the essential competencies that must be developed in the 21st century is scientific literacy. Scientific literacy refers to the ability to use scientific knowledge, understand concepts, and apply scientific processes to make appropriate decisions in everyday life (Hasasiyah, 2020). It also encompasses the capacity to explain scientific phenomena, evaluate evidence-based information, and connect knowledge to real-world contexts (Huryah et al., 2017). Students with good scientific literacy are better prepared to think critically, solve problems, and participate responsibly in society.



However, research findings indicate that students' scientific literacy in Indonesia remains relatively low. Several studies, such as those by Fauziah and Fathiah (2020), show that students often struggle to apply scientific concepts in real-life contexts and to interpret scientific data correctly. This condition is influenced by multiple factors, including the education system, curriculum, teaching methods, and learning resources that have not fully supported the development of scientific literacy.

One of the biological concepts that particularly reveals students' weak scientific literacy skills is the topic of Protists. Protists have a wide diversity and complex characteristics that require analytical and conceptual understanding. Many students experience difficulty connecting the diversity of Protists with their ecological roles, which results in low performance in explaining biological phenomena, generating hypotheses, and designing investigations (Qomariyah, 2019).

These challenges indicate that conventional teaching strategies are less effective in promoting higher-order thinking and scientific literacy. To address this issue, an instructional model that actively engages students in the process of inquiry and concept discovery is required. One such model is Discovery Learning, a method that allows students to construct knowledge through exploration, observation, analysis, and verification (Sulfemi & Yuliana, 2019). According to Mustofa (2019), Discovery Learning consists of five stages: observation, manipulation, generalization, verification, and application. Through these steps, students are guided to formulate questions, test ideas, and apply the resulting concepts in new situations, thereby improving their scientific reasoning and literacy skills. In the context of the 2013 Curriculum, Discovery Learning is one of the recommended learning models as stated in the Regulation of the Minister of Education and Culture (Permendikbud) No. 103 of 2014. This model supports the development of curiosity, independence, and scientific thinking while promoting a student-centered learning environment (Khasinah, 2021).

Based on preliminary classroom observations, students' low scientific literacy—particularly in learning Protists—reflects the absence of systematic stages that train students to connect knowledge with scientific problems (Fauziah & Fathiah, 2020). Therefore, the application of the Discovery Learning model is expected to become an effective solution to enhance students' scientific literacy by engaging them in active exploration and concept discovery.

This study contributes novelty by implementing the Discovery Learning model specifically in biology learning on the topic of Protists—an area rarely investigated in previous research. The study also examines the extent to which Discovery Learning can improve students' abilities to explain scientific phenomena, analyze data, and design scientific investigations as indicators of scientific literacy. Thus, the purpose of this research is to analyze the effect of the Discovery Learning model on improving students' scientific literacy in biology learning on the Protist topic.

RESEARCH METHODS

Research Design

This study employed a quasi-experimental method with a nonequivalent pretest–posttest control group design. This design was chosen because the research subjects were drawn from pre-existing classes, making it impossible for the researcher to apply full randomization. According to Sugiyono (2019) and Creswell & Creswell (2018), quasi-experimental designs are appropriate when random assignment is not feasible, allowing researchers to examine causal relationships in natural classroom settings while maintaining control over extraneous variables.

Population and Samples

The study was conducted during the odd semester at a senior high school. The research population consisted of 60 tenth-grade students, from which two classes, totaling 40 students, were selected purposively. One class, consisting of 20 students, served as the experimental group and was

taught using the Discovery Learning model, while the other class, also consisting of 20 students, served as the control group and received conventional instruction.

Instruments

The research instrument was a multiple-choice test consisting of five items designed to measure students' scientific literacy in the Protist topic. The indicators assessed included: (1) explaining scientific phenomena, (2) analyzing data, and (3) designing scientific investigations. An example for the *analyzing data* indicator is: "Data show that the population of *Paramecium* grows faster in neutral water than in acidic water, indicating that (A) Acidity accelerates growth, (B) Neutral water supports growth better, (C) Acidic water increases population, (D) pH has no effect." Before being administered, the instrument was validated by three experts in biology education to ensure its content validity, clarity, and relevance to the assessed indicators. The results of the validation showed that the instrument was feasible and appropriate for measuring students' scientific literacy skills.

Procedures

Data were collected through a pretest (administered before instruction) and a posttest (administered after instruction) in both the experimental and control classes. The study was conducted over four meetings, each lasting 90 minutes, and consisted of three main stages: preparation, implementation, and data analysis.

In the preparation stage, the researchers developed lesson plans (RPP), designed research instruments in the form of pretest and posttest items, and conducted expert validation involving three biology education specialists to ensure content validity, clarity, and alignment with the assessed indicators. The instruments were then revised according to expert feedback before being administered to students.

During the implementation stage, two different learning approaches were applied. The experimental class was taught using the Discovery Learning model, which consists of six phases: (1) stimulation, (2) problem statement, (3) data collection, (4) data processing, (5) verification, and (6) generalization. In this process, students actively engaged in exploration, data analysis, and independent knowledge construction related to the Protist topic. Meanwhile, the control class received conventional instruction using lecture and question–answer methods, where learning was more teacher-centered and less focused on inquiry and discovery.

In the data collection phase, both groups were administered a pretest before the learning intervention to assess their initial scientific literacy levels. After the completion of the instructional sessions, a posttest with the same indicators was given to measure students' improvement in scientific literacy.

Data Analysis

The collected data were analyzed using both descriptive and inferential statistical techniques. Descriptive analysis was used to describe students' performance by calculating the mean scores of the pretest and posttest in both the experimental and control groups. Additionally, the N-Gain analysis was applied to determine the level of improvement in students' scientific literacy using the formula proposed by Fauziah and Fathiah (2020):

$$N - Gain = \frac{\text{posttest} - \text{pretest}}{100 - \text{pretest}}$$

Inferential analysis was conducted to examine the statistical significance of differences between the experimental and control groups. Before conducting the inferential test, assumption

tests were performed, including a). normality test, using the Kolmogorov–Smirnov or Shapiro–Wilk test to ensure that the data were normally distributed, b). Homogeneity test, using Levene’s test to confirm that the data variances between groups were homogeneous. After both assumptions were met, a One-Way ANOVA test was carried out to determine whether there were significant differences in students’ scientific literacy improvement between the two groups. If the ANOVA results showed a significant difference, it indicated that the Discovery Learning model had a statistically significant effect on improving students’ scientific literacy in the Protist topic. The combination of descriptive analysis (N-Gain) and inferential analysis (ANOVA) was used to provide a comprehensive understanding of both the magnitude of improvement and the statistical significance of the differences observed, in accordance with the characteristics of an experimental research design.

RESULTS

The analysis of students’ scientific literacy skills through the implementation of the Discovery Learning model in grade X revealed a significant improvement. The comparison of the mean pretest and posttest scores is presented in Table I.

Table I. The comparison of the mean pretest and posttest scores

| Description | Lowest Score | Lowest Score | Mean |
|-------------|--------------|--------------|-------|
| Pretest | 45 | 25 | 36,33 |
| Posttest | 95 | 75 | 83,33 |

Based on Table I, it can be seen that the mean pretest score was 36.33, while the mean posttest score reached 83.33. This result indicates a substantial improvement in students’ scientific literacy after the implementation of the Discovery Learning model. The higher posttest scores compared to the pretest suggest that the use of this model was effective in enhancing students’ understanding and scientific literacy skills.

Furthermore, to determine the effectiveness of the improvement, an N-Gain analysis was conducted, as presented in Table 2. Based on Table 2, the average N-Gain score was 0.70, which falls into the high category (Hake, 1999). Thus, the implementation of the Discovery Learning model proved to be effective in enhancing students’ scientific literacy skills on the Protist topic.

Table 2. The effectiveness of the improvement of an N-Gain analysis

| Class | Pretest | Posttest | N-Gain | Category |
|-----------|---------|----------|--------|----------|
| Experimen | 36,33 | 83,33 | 0,70 | high |

DISCUSSION

The results of the study indicate that the implementation of the Discovery Learning model had a significant effect on improving students’ scientific literacy in the Protist topic. This is evidenced by the difference between the mean pretest score of 36.33 and the posttest score of 83.33, with an N-Gain value of 0.70, which falls into the high category. These results demonstrate that Discovery Learning is effective in enhancing students’ abilities to explain scientific phenomena, analyze data, and design scientific investigations.

Before conducting the inferential statistical test, normality and homogeneity tests were performed as prerequisites. The normality test using the Shapiro–Wilk test showed that both the pretest and posttest data were normally distributed ($p > 0.05$). The Levene’s test for homogeneity also indicated that the data from both groups had homogeneous variances ($p > 0.05$). After meeting these assumptions, an ANOVA test was conducted to determine whether there was a

significant difference in students' scientific literacy improvement between the experimental and control groups. The ANOVA results revealed a significant difference ($p < 0.05$), confirming that the use of the Discovery Learning model had a statistically significant effect on students' scientific literacy compared to conventional instruction

This improvement occurred because the Discovery Learning model provides students with the opportunity to actively discover and construct knowledge through exploration and problem-solving activities. The learning process involves several stages, namely stimulation, problem formulation, data collection, data processing, verification, and generalization (Bruner, 1961; Hosnan, 2014). Through these stages, students are trained to think critically, analyze information, and connect their findings with relevant scientific concepts. Thus, students do not merely receive material passively but also engage in the use of scientific thinking skills such as analyzing data, explaining phenomena, and drawing conclusions, in line with the goals of scientific literacy emphasized by the OECD (2019).

The findings of this study are supported by several previous studies. Jamallika, Handziko, and Krisnawati (2024) demonstrated that the use of evolution videos as a supporting medium in Discovery Learning had a positive effect on high school students' concept mastery and scientific literacy. This result is consistent with the study by Agustini et al. (2025), which emphasized the effectiveness of outdoor-based Discovery Learning in improving biology concept mastery and scientific literacy. In addition, Hernawati et al. (2019) highlighted that the competencies of evaluating and designing scientific investigations contribute the most to enhancing scientific literacy, while Afnan (2023) emphasized the importance of using scientific literacy instruments to measure students' scientific problem-solving abilities.

In line with these findings, Sutrisna and Anhar (2020) reported that the abilities to explain phenomena, evaluate, and design scientific investigations are key indicators of scientific literacy that can be developed through active learning approaches such as Discovery Learning. Furthermore, Mulbar, Adnan, and Sugiarti et al. (2021) found that junior high school students' scientific literacy skills, particularly in biology, remain relatively low in terms of interpreting and organizing scientific data. Therefore, discovery-based learning strategies are needed to strengthen these skills.

In the context of Protist learning, Hardianto et al. (2024) introduced the concept of *protist literacy*, which refers to students' ability to analyze, understand, and apply knowledge about Protists in solving real-world problems. This finding demonstrates the relevance of Discovery Learning in enhancing students' analytical and contextual understanding of abstract and complex biological concepts. In addition, Fausan et al. (2021) emphasized the importance of scientific literacy-based biology learning to help students understand scientific concepts more deeply and contextually.

In general, various previous studies reinforce the finding that Discovery Learning is an effective approach for developing scientific literacy by emphasizing exploration, concept discovery, and the application of science in everyday life. Mustofa (2019) and Zulfa, Setiadi, Merta, and Sukarso (2022) also stated that Discovery Learning can enhance students' scientific literacy skills through learning activities based on discovery and scientific problem solving.

The findings of this study are also consistent with those of Dewi, Nurmilawati, and Budiretnani (2017), who found a significant improvement in scientific literacy skills from cycle I to cycle II following the implementation of Discovery Learning among seventh-grade students, particularly in the indicators of identifying scientific opinions, creating data graphs, and solving quantitative problems. Similarly, Aulia and Hardinata (2024) reported an improvement in students' scientific literacy from a low to a moderate category through the application of Discovery Learning in ecology topics at the junior high school level, demonstrating the effectiveness of this model in developing scientific reasoning and contextual thinking skills.

Furthermore, Rosdiana, Tanah Boleng, and Susilo (2017) reported that the development of Discovery Learning integrated with scientific literacy produced an N-Gain value of 0.74, indicating high effectiveness in enhancing scientific thinking skills and understanding of complex biological concepts. Overall, the findings of this study strengthen the evidence that Discovery Learning plays an important role in enhancing students' scientific literacy through a constructivist approach. By promoting active inquiry, critical thinking, and hands-on exploration, this model enables students to build meaningful scientific understanding and apply it in various real-life situations.

CONCLUSION

Thus, the implementation of Discovery Learning can serve as an effective alternative learning model to improve the quality of biology education, particularly in fostering students' scientific literacy. This is evident from the increase in the average pretest to posttest scores as well as the N-Gain value, which falls into the high category.

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