UNIVERSITAS SEBELAS MARET
BIOEDUKASI: JURNAL PENDIDIKAN BIOLOGI
https://jurnal.uns.ac.id/bioedukasi
1693-265X (Print) | 2549-0605 (Online)

Impact of Discovery Learning with Reflective Learning Journals on Students' Critical Thinking in Environmental Change Topic

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Submission	: 12/08/2024
Revision	: 05/02/2025
Accepted	: 10/02/2025

ABSTRACT

One of the issues in biology education is the low level of students' critical thinking skills. This is primarily due to conventional, teacher-centered learning approaches that do not allow students to develop their thinking. Therefore, innovative teaching strategies are needed to enhance students' critical thinking abilities, like the discovery learning model integrated with reflective learning journals. This study aims to investigate the impact of the discovery learning model integrated with reflective learning journals in improving students' critical thinking skills, including an analysis based on high and low academic abilities. This quasi-experimental study employs a pretest-posttest control group design. The sample was selected using cluster random sampling at SMA Negeri 2 Karanganyar, with class X-E8 as the control group and class X-E6 as the experimental group. Primary data was collected with observation sheets, tests, and documentation. Hypothesis testing was conducted using ANCOVA and N-Gain tests. The findings indicate significant differences in students' critical thinking skills on environmental changes when taught using the discovery learning model alone compared to the discovery learning model combined with reflective learning journals. Moreover, differences were observed based on students' high and low academic abilities. Combining the discovery learning model with reflective learning journals enables students to identify and formulate problems based on observed phenomena, determine learning objectives, gather data, draw conclusions, and articulate their thoughts through reflective journal writing. This instructional approach is used for broader implementation and further investigation to assess its impact on other learning outcomes.

Keywords: Discovery learning, Reflective learning journal, Critical thinking, Environmental change topic

Introduction

The rapid development of technology and information in the 21st century has led to significant changes in various aspects of human life, including education (Mardhiyah et al., 2021). Developing a 21st-century education concept is crucial due to the increasing competition in the job market, where cognitive skills only are insufficient for students (Ariyanto et al., 2020). One of the essential competencies in 21st-century education is critical thinking (Halim, 2022).

Critical thinking involves analyzing and evaluating information. It is a self-directed, self-disciplined, self-monitored, and self-corrective way of thinking (Paul & Elder, 2006). According to Facione (2015), the core of critical thinking includes interpretation, analysis, evaluation, inference, explanation, and self-regulation. Halim (2022) asserts that critical thinking underpins various other competencies and can be integrated with creative thinking, problem-solving, and innovation skills.

Previous research indicates that students' critical thinking skills in several research areas are relatively low. Susilowati et al. (2017) found that students' critical thinking skills were generally low, with an average score of 51.60%. The percentage of each critical thinking aspect revealed low scores: interpretation (54.87%), analysis (46.56%), evaluation (54.58%), inference (49.24%), explanation (43.83%), and self-regulation (60.44%). Similarly, research by Suharyani et al. (2023) at SMA Negeri 2 Mranggen on the environmental change topic showed that students' critical thinking skills remained low. This issue may be attributed to teaching strategies that do not focus on empowering critical thinking and often emphasize conceptual understanding.

Biology education involves scientific aspects encompassing facts and principles derived from scientific processes requiring critical thinking for problem-solving (Agnafia, 2019). Interviews with biology teachers at a high school revealed that innovative teaching methods are rarely employed, and students' critical thinking skills are still low, as evidenced by their lack of active participation in asking questions, answering questions, and expressing opinions in biology classes. Hamdani et al. (2019) concur that the low critical thinking skills are due to conventional, teacher-centered learning methods that focus on rote learning, providing students with few opportunities to develop their thinking.

Moreover, low critical thinking skills may result from teachers not considering differences in academic ability in the classroom. Students with higher academic abilities tend to have better critical thinking skills than those with lower academic abilities (Setiawati & Corebima, 2017). Current teaching strategies often fail to address the diverse academic abilities of students, leading to a significant gap between high and low-achieving students in problem-solving and critical-thinking skills (Karmana et al., 2020). Therefore, innovative teaching methods are needed in biology education to effectively enhance students' critical thinking skills.

One approach to improving students' critical thinking skills is implementing the discovery learning model (Dari & Ahmad, 2020). This student-centered model involves students in observation, reasoning, and communication activities to develop their critical thinking skills. Discovery learning requires students to investigate, think critically, and independently find answers to problems (Melati et al., 2022). Ellizar et al. (2019) found that discovery learning effectively enhances students' critical thinking skills across different academic abilities. The discovery learning model assumes that students can independently discover knowledge, but this model can be challenging for students with learning problems. According to Westwood (2008), students with learning problems often struggle to form opinions, make predictions, or draw conclusions from this discovery learning. Therefore, an additional method is needed to overcome the weaknesses of this model. One is combining the discovery learning model with reflective learning journals.

Reflective learning journals can stimulate students' critical thinking skills. Writing reflective journals expresses critical ideas and self-reflection (Sudirman et al., 2021). Reflective journal writing is linked to critical thinking because it involves students reflecting on their learning activities and directly engaging their thought processes (Munawaroh et al., 2015).

The discovery learning model combined with reflective learning journals is suitable for teaching environmental change, which involves critical thinking and problem-solving skills due to its relevance to everyday life (Sado et al., 2020). The characteristics of environmental change are marked by contextual problems, where students face biological issues occurring in their surroundings. Students are expected to find appropriate solutions or strategies based on scientific evidence and apply them daily (Hidayah & Kuntjoro, 2022).

Given these challenges, combining discovery learning with reflective journals is anticipated to make learning activities more effective and enhance students' critical thinking skills. This study examines the differences in students' critical thinking skills when using the discovery learning model compared to the discovery learning model combined with reflective learning journals, including an analysis based on high and low academic abilities. This combination is expected to facilitate critical thinking skills across all levels of students' academic abilities.

Methods

Research Design

This study uses a quasi-experimental design with a pretest-posttest control group design. Two groups were randomly selected. The control group (X1) received the discovery learning model as the control treatment. The experimental group (X2) received the discovery learning model combined with reflective learning journals as the experimental treatment. The research design is shown in Table 1.

Table 1. Research design

Group	*Pretest*	Treatment	*Posttest*
Control	O_1	X_1	Q_2
Experimental	O_1	X_2	Q_2

Population and Sample

The population for this study includes students from classes X-E1, X-E2, X-E3, X-E4, X-E5, X-E6, X-E7, and X-E8 at SMA Negeri 2 Karanganyar. The population was tested for homogeneity before the sample was selected. The sample consists of two randomly selected classes: class X-E8, which has 30 students as the control group, and class X-E6, which has 30 students as the experimental group.

Data Collection Techniques

Data collection for this study involved using observation sheets to assess the implementation of the discovery learning model, pretest and posttest to measure critical thinking skills, reflective learning journals (only for the experimental group), and documentation (semester scores to determine the sample class). The critical thinking test has a validity value > 0.55 and a reliability score of 0.707, indicating that the questions are valid and reliable. The observation instruments and reflective learning journals were validated by two experts and deemed suitable for use.

Data Analysis

Student semester scores were analyzed to determine the research sample. Following the collection of semester score data, normality and homogeneity tests were conducted to ensure the data met the necessary statistical assumptions. Two classes, X-E8 and X-E6, were randomly selected as the research sample from a population of eight classes confirmed to be normally distributed and homogeneous.

Observation sheets were utilized to evaluate the implementation of the discovery learning model's syntax. Training observers conducted observations using a four-point Likert scale ranging from 1 (lowest) to 4 (highest). Once the observation data were collected, the scores were calculated to quantify the level of success in implementing the model. These scores provided a comprehensive assessment of the implementation quality, where higher scores

indicated effective application of the discovery learning syntax, and lower scores highlighted areas requiring improvement. A subsequent analysis was performed to determine the overall effectiveness and identify specific aspects needing refinement.

Data analysis involves testing for normality, homogeneity, linearity, and independence. Hypothesis testing is conducted using ANCOVA and N-Gain tests. The decision rule for ANCOVA is: if the p-value > 0.05, then H0 is accepted and Ha is rejected; if the p-value < 0.05, then H0 is rejected and Ha is accepted.

The N-Gain test measures the difference between a subject's pretest and posttest results (Widyastuti et al., 2024). It is calculated using Hake's (1998) formula and categorized according to Table 2.

$$< g > = \frac{< Spost > - < Spre >}{100 - < Spre >}$$

Note:

<g> : Normalized gain average
<Spost> : Average score of the posttest
<Spre> : Average score of the pretest

Table 2. N-gain categories (Eviyanti, 2018)

N-Gain	Categories
g ≥ 0.7	High
0,3 ≤ X < 0,7	Medium
G < 0,3	Low

Results and Discussion

Results of the Normality and Homogeneity Test of the Research Population

A normality test using the Shapiro-Wilk test was conducted for all samples. The results are presented in Table 3.

Table 3. Results of the normality test of the research population

Source	Class	Significance	Condition	Conclusion
Students' academic ability	X-E1	0,146	Sig. > 0,05	H_0 accepted
	X-E2	0,300	Sig. > 0,05	H_0 accepted
	X-E3	0,188	Sig. > 0,05	H_0 accepted
	X-E4	0,140	Sig. > 0,05	H_0 accepted
	X-E5	0,110	Sig. > 0,05	H_0 accepted
	X-E6	0,161	Sig. > 0,05	H_0 accepted
	X-E7	0,101	Sig. > 0,05	H_0 accepted
	X-E8	0,053	Sig. > 0,05	H_0 accepted

Table 3 shows that all classes have a significance value of more than 0.05. This means that H0 is accepted or the data is normally distributed. After the normality test is conducted, the next step is the homogeneity test, which is carried out using the Levene test. The results of the homogeneity test are presented in Table 4.

Table 4. Results of the homogeneity test of the research population

Source	Significance	Condition	Conclusion
Students' academic ability	0,977	Sig. > 0,05	H_0 accepted

Table 4 shows that the significance value of students' academic abilities is more than 0.05. It means that H0 is accepted or the data is homogeneous.

Observation Results on the Implementation of Discovery Learning Syntax

Both groups observed the implementation of discovery learning syntax at every meeting. The observation results are presented in Table 5.

Table 5. Observation results on the implementation of discovery learning syntax

Syntax	Scores			
	Control Group		Experimental Group	
	Meeting 1	Meeting 2	Meeting 1	Meeting 2
Apperception and Motivation				
- Opening the lesson	4	4	4	4
- Giving apperception	4	4	4	4
- Giving motivation	4	4	4	4
Orientation	4	4	3	3
Hypothesis Generation	3	4	3	4
Hypothesis Testing	4	4	4	4
Conclusion	4	4	4	4
Regulation	3	3	3	4
Evaluation	4	4	4	4
Reflection	3	4	3	3
Closing	4	4	4	4
Total	**41**	**43**	**40**	**42**
Percentage	**93.18%**	**97.72%**	**90.9%**	**95.45%**

Table 5 shows the percentage of implementation syntax in the control and experimental groups. In every meeting, both the control and experimental groups had percentage values above 90.

Description of Pretest and Posttest Critical Thinking Skills Data

Pretests and posttests were administered to the experimental and control groups to assess students' critical thinking skills. Table 6 presents statistical data for the pretest and posttest results.

Table 6. Comparison of pretest and posttest results for critical thinking skills in the control and experimental groups

Statistical Analysis	Control Group		Experimental Group	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Mean	61.24	69.16	64.73	76.81
Median	62.5	70.8	66.7	79.2
Std. Deviation	7.98	6.71	7.72	7.15
Variance	63.63	45.05	59.58	51.15
Minimum	45.8	58.3	45.8	58.3
Maximum	75	87.5	79.2	91.7

Table 6 shows an increase in the average scores for both the control and experimental groups. The control group experienced an increase of 7.92, whereas the experimental group experienced an increase of 12.08. This data indicates that both groups showed improvement following the intervention.

ANCOVA Results for Students' Critical Thinking Skills

The critical thinking skills test results were further analyzed using ANCOVA, with students' academic ability as the covariate. The data for students' critical thinking skills and academic ability were normal, homogeneous, linear, and independent, thus meeting the requirements for performing ANCOVA. The outcomes of the first hypothesis test are presented in Table 7.

Table 7. ANCOVA Results for Students' Critical Thinking Skills

Data	Sum of Squares	df	Mean Square	F	*Sig.*	Condition	Conclusion
Learning Model	193,8	1	193,8	4,173	0,046	Sig.<0.05	H_0 rejected

Table 7 shows a significance value of less than 0.05, leading to the rejection of H0. This indicates a difference in students' critical thinking skills on environmental change topics between those using the discovery learning model and those using the discovery learning model combined with reflective learning journals. The average score for essential thinking skills of students in the experimental group was higher than that of the control group. Therefore, the discovery learning model combined with reflective learning journals positively impacts the critical thinking skills of X-grade students at SMA Negeri 2 Karanganyar.

Critical Thinking Skills of High and Low Academic Ability

The difference between pretest and posttest scores was further analyzed using the N-Gain test for both high and low-academic-ability students in each group. Table 8 presents a comparison of N-Gain for different academic abilities.

Table 8. Comparison of N-gain across different academic abilities

Group	Academic Ability	Average		*N-Gain*	Category
		Pretest	*Posttest*		
Control	High	62,9	70,8	0,213	Low
	Low	60,4	67,1	0,169	Low
Experiment	High	63,8	76,2	0,344	Medium
	Low	66,7	80,4	0,402	Medium

Table 8 shows that the N-Gain for critical thinking skills in the control group is higher for students with high academic ability than for those with low academic ability. Conversely, in the experimental group, the N-Gain is higher for students with low academic ability than for those with high. This indicates improved critical thinking skills for both high and low-academic-ability students.

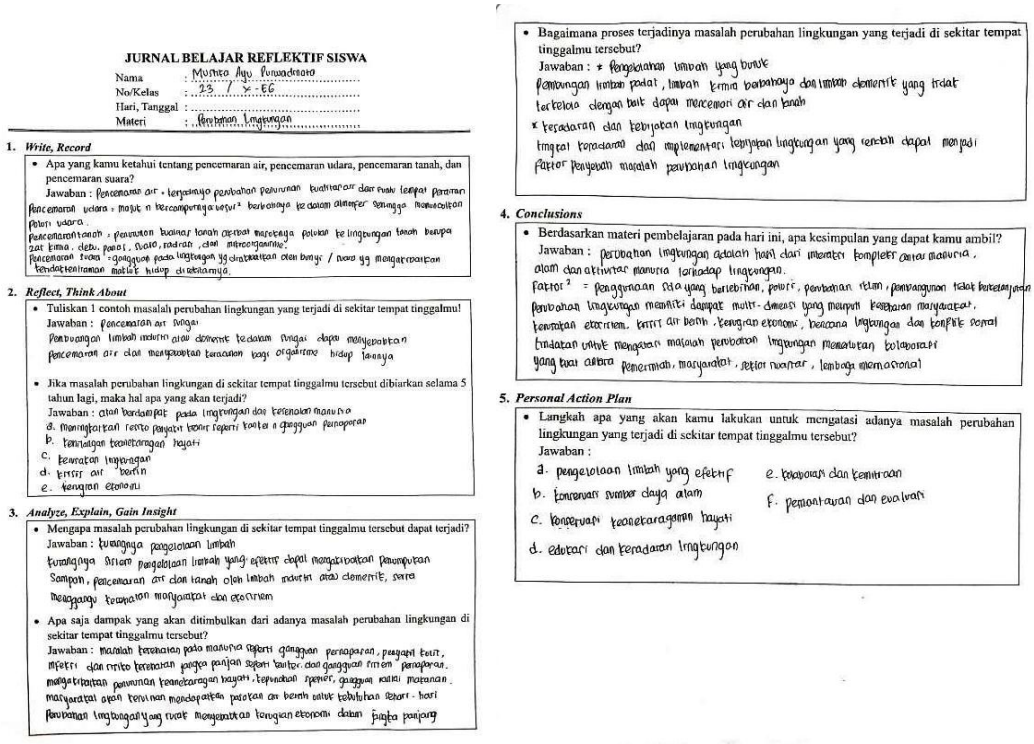
Comparison of Critical Thinking Skills Between Control and Experimental Groups

A hypothesis test using ANCOVA demonstrated a significant difference in students' critical thinking skills on the topic of environmental change when using the discovery learning model compared to the discovery learning model combined with reflective learning journals. Although both groups showed improvement, the average increase in the experimental group was higher than in the control group. Applying the discovery learning model and reflective learning journals in the experimental group was a key factor in enhancing students' critical thinking skills.

Observations revealed that students in both the control and experimental groups exhibited similar levels of active participation during the learning process. Students demonstrated engagement by asking questions, expressing opinions, and contributing actively to group discussions. For instance, during group presentations, students from non-presenting groups enthusiastically posed questions to the presenting group, fostering a dynamic and interactive learning environment. This high level of participation promoted collaboration and critical thinking, ensuring that the classroom atmosphere remained vibrant and far from passive. According to Marisya & Sukma (2020), the discovery learning model emphasizes active student participation in the learning process and allows students to discover and investigate concepts independently, leading to more durable learning outcomes. Previous research by Melati et al. (2022) supports this finding, showing that students in the experimental group using the discovery learning model had higher critical thinking skills, with an average score of 78.62, compared to students in the control group using direct instruction, who had an average score of 52.91.

In addition to the learning model, the experimental group also engaged in reflective learning journal writing. This approach allowed students to connect theory and practice, integrating intrapersonal, interpersonal, cognitive, emotional, and professional aspects of their selves (Bruno & Dell'Aversana, 2017). Reflective learning journals also aid students in self-reflection, recalling material, enhancing understanding, and increasing knowledge (Arter et al., 2016; Sudirman et al., 2021; Susilo et al., 2022). Writing reflective journals allows students to develop self-awareness and prepare for future learning by helping them understand what will be learned and how to approach it. The journal supports students in maintaining reflective notes based on their own experiences and observations, studying and understanding them better, and making informed decisions on addressing challenges. Consequently, reflective journal writing can assist students in developing meaningful, critical, and constructive learning skills (Yadav, 2022). Although reflective journaling requires additional time, the critical thinking and analysis level achieved is well worth the effort (Arter et al., 2016).

The reflective learning journal utilized in this study is a modified version of the reflective writing model from Northern Illinois University. This model includes the following components: "write, record,"; "reflect, think about, "; "analyze, explain, gain insight,"; "conclusions," and "personal action plan" (Nga, 2016). The journal assignment was integrated into the evaluation phase of the regulation stage of the discovery learning model. An example of a student's reflective learning journal entry is shown in Figure 1.



JURNAL BELAJAR REFLEKTIF SISWA

Nama : Mutiara Ayu Purnadewara
No/Kelas : 23 / X - EC
Hari, Tanggal :
Materi : Pencemaran Lingkungan

1. *Write, Record*
   - Apa yang kamu ketahui tentang pencemaran air, pencemaran udara, pencemaran tanah, dan pencemaran suara?
   Jawaban : Pencemaran air = terjadinya perubahan penurunan kualitas air dari suatu tempat perairan
   Pencemaran udara = mulut n berkembangnya vektor² berbahaya ke dalam atmosfer sehingga menyebabkan polusi udara.
   Pencemaran tanah = perubahan bahkan tanah akibat masuknya polutan ke lingkungan tanah berupa zat kimia, deterjen, plastik, radikal, dan mikroorganisme.
   Pencemaran suara = gangguan pada lingkungan yg disebabkan oleh bunyi / suara yg mengganggu kenyamanan manusia hidup di sekitarnya.

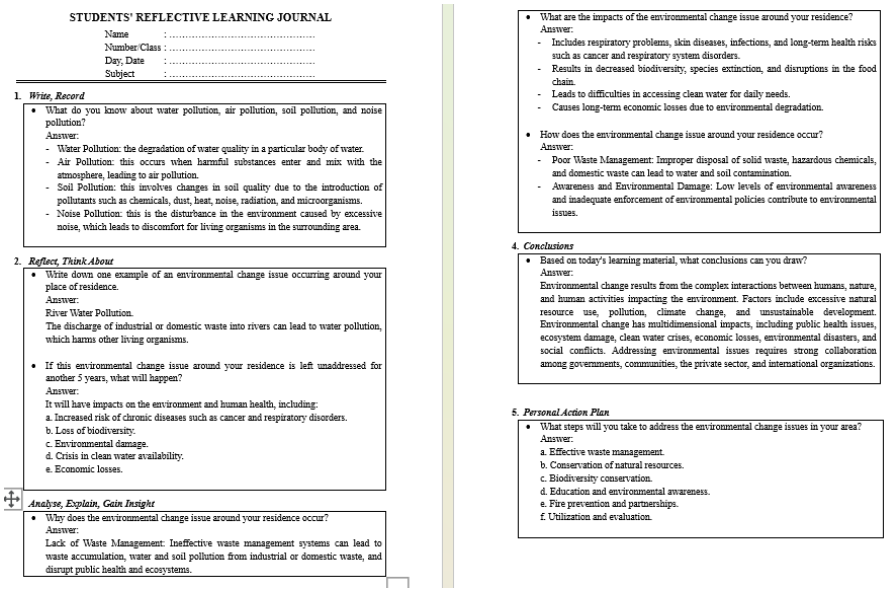
2. *Reflect, Think About*
   - Tuliskan 1 contoh masalah perubahan lingkungan yang terjadi di sekitar tempat tinggalmu!
   Jawaban : Pencemaran air sungai
   Pembuangan limbah industri atau domestik ke dalam sungai dapat menyebabkan pencemaran air dan mengancam kehidupan bagi organisme hidup lainnya
   - Jika masalah perubahan lingkungan di sekitar tempat tinggalmu tersebut dibiarkan selama 5 tahun lagi, maka hal apa yang akan terjadi?
   Jawaban : akan berdampak pada lingkungan dan kesehatan manusia
   a. meningkatnya resiko penyakit kronis seperti kanker dan gangguan pernapasan
   b. kematian tanaman dan hewan
   c. kematian tanaman
   d. krisis air bersih
   e. kerugian ekonomi

3. *Analyze, Explain, Gain Insight*
   - Mengapa masalah perubahan lingkungan di sekitar tempat tinggalmu tersebut dapat terjadi?
   Jawaban : kurangnya pengelolaan limbah
   kurangnya sistem pengelolaan limbah yang efektif dapat mengakibatkan penumpukan sampah, pencemaran air dan tanah oleh limbah industri atau domestik, serta menganggu kesehatan masyarakat dan ekosistem
   - Apa saja dampak yang akan ditimbulkan dari adanya masalah perubahan lingkungan di sekitar tempat tinggalmu tersebut?
   Jawaban : masalah kesehatan pada manusia seperti gangguan pernapasan, penyakit kulit, infeksi dan risiko kesehatan jangka panjang seperti kanker, dan gangguan sistem pernapasan. mengakibatkan punahnya keanekaragaman hayati, kepunahan spesies, gangguan rantai makanan. masyarakat akan kesulitan mendapatkan pasokan air bersih untuk kebutuhan sehari-hari. perubahan lingkungan yang rusak menyebabkan kerugian ekonomi dalam jangka panjang

- Bagaimana proses terjadinya masalah perubahan lingkungan yang terjadi di sekitar tempat tinggalmu tersebut?
  Jawaban : * pengelolaan limbah yang buruk
  pembuangan limbah padat, limbah kimia berbahaya dan limbah elektronik yang tidak terkelola dengan baik dapat mencemari air dan tanah
  * kesadaran dan kebiasaan lingkungan
  tingkat kesadaran dan implementasi kebiasaan lingkungan yang rendah dapat menjadi faktor penyebab masalah perubahan lingkungan

4. *Conclusions*
   - Berdasarkan materi pembelajaran pada hari ini, apa kesimpulan yang dapat kamu ambil?
   Jawaban : perubahan lingkungan adalah hasil dari interaksi kompleks antara manusia, alam dan aktivitas manusia terhadap lingkungan.
   faktor² = penggunaan sda yang berlebihan, polusi, pembangunan, perkembangan teknologi pembuangan lingkungan memiliki dampak multi-dimensi yang meliputi kesehatan masyarakat, kerusakan ekosistem, krisis air bersih, kerugian ekonomi, bencana lingkungan dan konflik sosial tindakan untuk mengatasi masalah perubahan lingkungan memerlukan kolaborasi yang baik antara pemerintah, masyarakat, sektor swasta, lembaga internasional

5. *Personal Action Plan*
   - Langkah apa yang akan kamu lakukan untuk mengatasi adanya masalah perubahan lingkungan yang terjadi di sekitar tempat tinggalmu tersebut?
   Jawaban :
   a. pengelolaan limbah yang efektif
   b. konservasi sumber daya alam
   c. konservasi keanekaragaman hayati
   d. edukasi dan kesadaran lingkungan
   e. kolaborasi dan kemitraan
   f. pemantauan dan evaluasi



STUDENTS' REFLECTIVE LEARNING JOURNAL

Name : .....
Number/Class : .....
Day, Date : .....
Subject : .....

1. *Write, Record*

- What do you know about water pollution, air pollution, soil pollution, and noise pollution?

Answer:
- Water Pollution: the degradation of water quality in a particular body of water.
- Air Pollution: this occurs when harmful substances enter and mix with the atmosphere, leading to air pollution.
- Soil Pollution: this involves changes in soil quality due to the introduction of pollutants such as chemicals, dust, heat, noise, radiation, and microorganisms.
- Noise Pollution: this is the disturbance in the environment caused by excessive noise, which leads to discomfort for living organisms in the surrounding area.

2. *Reflect, Think About*

- Write down one example of an environmental change issue occurring around your place of residence.

Answer:
River Water Pollution.
The discharge of industrial or domestic waste into rivers can lead to water pollution, which harms other living organisms.

- If this environmental change issue around your residence is left unaddressed for another 5 years, what will happen?

Answer:
It will have impacts on the environment and human health, including:
a. Increased risk of chronic diseases such as cancer and respiratory disorders.
b. Loss of biodiversity.
c. Environmental damage.
d. Crisis in clean water availability.
e. Economic losses.

Analyse, Explain, Gain Insight

- Why does the environmental change issue around your residence occur?

Answer:
Lack of Waste Management: Ineffective waste management systems can lead to waste accumulation, water and soil pollution from industrial or domestic waste, and disrupt public health and ecosystems.

- What are the impacts of the environmental change issue around your residence?

Answer:
- Includes respiratory problems, skin diseases, infections, and long-term health risks such as cancer and respiratory system disorders.
- Results in decreased biodiversity, species extinction, and disruptions in the food chain.
- Leads to difficulties in accessing clean water for daily needs.
- Causes long-term economic losses due to environmental degradation.

- How does the environmental change issue around your residence occur?

Answer:
- Poor Waste Management: Improper disposal of solid waste, hazardous chemicals, and domestic waste can lead to water and soil contamination.
- Awareness and Environmental Damage: Low levels of environmental awareness and inadequate enforcement of environmental policies contribute to environmental issues.

4. *Conclusions*

- Based on today's learning material, what conclusions can you draw?

Answer:
Environmental change results from the complex interactions between humans, nature, and human activities impacting the environment. Factors include excessive natural resource use, pollution, climate change, and unsustainable development. Environmental change has multidimensional impacts, including public health issues, ecosystem damage, clean water crises, economic losses, environmental disasters, and social conflicts. Addressing environmental issues requires strong collaboration among governments, communities, the private sector, and international organizations.

5. *Personal Action Plan*

- What steps will you take to address the environmental change issues in your area?

Answer:
a. Effective waste management.
b. Conservation of natural resources.
c. Biodiversity conservation.
d. Education and environmental awareness.
e. Fire prevention and partnerships.
f. Utilization and evaluation.

Figure 1. Results of student reflective learning journal work (Indonesian-upper and English-bottom)

Writing reflective learning journals at the end of each meeting indirectly encourages students to take more responsibility for their learning process (Munawaroh et al., 2015). Reflective learning journals serve as a means to connect existing knowledge with new knowledge, forming significant concepts and responsible responses. Implementing reflective learning journals is crucial as they can be a tool for teachers to create a thinking environment that goes beyond the learning material, fostering deeper understanding and appropriate responses from students (Kainde & Tahya, 2020). Writing these journals helps students develop critical thinking skills and intellectual abilities. In this context, writing reflective learning journals benefits students by promoting critical reflection and self-discovery responses to the topic (Sudirman et al., 2021). The combination of discovery learning and reflective learning journals enhances students' critical thinking skills by allowing them to identify and formulate problems based on phenomena, set learning goals, collect data, draw conclusions, and express their thoughts through journal writing.

Critical Thinking Skills in High and Low Academic Abilities

The N-Gain test determines whether students' scores increase or decrease after receiving treatment. The gain score is the value obtained from the difference between scores after and before the treatment (posttest-pretest) with the maximum score achieved (Hake, 1998). Both the control and experimental groups experienced an increase in critical thinking skills; however, the rate of improvement in the control group was relatively lower compared to the experimental group.

The N-Gain results for the control group show that students with higher academic abilities have a higher N-Gain than students with lower academic abilities. This finding aligns with Danil's (2021) opinion that students with higher academic abilities can better respond to and understand lessons, process information, organize and explore knowledge, and draw conclusions based on available information, leading to significantly higher critical thinking skills.

The N-Gain in the experimental group showed higher results than the control group for both high and low academic abilities. Interestingly, students with lower academic abilities had a higher N-Gain than those with higher academic abilities. This finding suggests that students with lower academic abilities were able to improve their critical thinking skills more significantly than those with higher academic abilities. This is consistent with the study by Cahyani et al. (2018), which found that the achievement of critical thinking skills in students with lower academic abilities was higher than in those with higher academic abilities. The improvement in critical thinking skills among students with lower academic abilities may be

attributed to the discussion activities between students of different academic abilities during the learning process. Higher-ability students often provide guidance or peer tutoring to those with lower academic abilities during these activities.

During the evaluation phase of the discovery learning model, students were assigned the additional task of writing reflective learning journals. This task engages students in critical thinking as they must re-evaluate and reconstruct their arguments. According to Nisak et al. (2017), students with lower academic abilities require more time to master skills than their higher-achieving peers. However, with sufficient time, these students can achieve similar targets. Writing reflective journals offers extra time for lower-ability students to reflect on their learning, enhancing their critical thinking skills.

Students' effort in writing reflective learning journals is a key factor that can affect their learning outcomes. Students with higher academic abilities usually have strong analytical skills but might not put as much effort into writing journals because they feel confident in their understanding of the topic. As a result, their reflections may be less thorough. In contrast, students with lower academic abilities tend to put more effort into writing reflective journals. They work diligently to grasp the topic and reflect on their learning process, even if their initial understanding is limited. This extra effort can lead to higher N-Gain, as the reflective process helps them improve their understanding.

Conclusion

Based on the research findings, there are differences in students' critical thinking skills regarding environmental change topics when using the discovery learning model and the discovery learning model combined with reflective learning journals. Students' critical thinking skills in the discovery learning model, combined with reflective learning journals, were higher compared to the discovery learning model alone. Additionally, there are differences in critical thinking skills based on students' academic abilities (high and low) when using the two learning models. Critical thinking skills were higher in the discovery learning model combined with reflective learning journals for high and low-academic-ability students. Reflective learning journals contributed to the increase in N-Gain as the reflective process helped students improve their understanding.

The research findings indicate that implementing discovery learning integrated with reflective learning journals significantly enhances students' critical thinking skills, particularly in terms of environmental change. The reflective process facilitated by the journals prompts students to analyze, evaluate, and synthesize the concepts learned, strengthening their critical thinking abilities. Furthermore, reflective learning journals indirectly promote environmental awareness by encouraging students to examine their attitudes and behaviors toward environmental issues. Through reflective engagement, students are prompted to consider the real-world implications of environmental changes and their responsibility in fostering sustainable environmental practices. Future implementations and research should explore the impact of combining discovery learning with reflective learning journals on other learning outcomes.

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