

Implementation of Contextual Discovery Learning Model to Improve Scientific Literacy

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Abstract: Scientific literacy is an essential 21st-century competency that enables students to explain scientific phenomena, design investigations, and interpret evidence-based data. This study aims to analyze the improvement of students' scientific literacy through the application of the Discovery Learning model with a contextual approach to human respiration material. The learning context is developed through a comparative analysis of air pollution data from urban and rural areas, enabling students to examine the relationship between air quality and respiratory system disorders in a real and relevant manner. This study used a quantitative method with a one-group pretest-posttest design. The subjects were 31 eighth-grade students of SMP Negeri 1 Selorejo. The instruments used included a scientific literacy test (pretest and posttest), an observation sheet for learning implementation, and a student response questionnaire. Data analysis was carried out in stages, beginning with a normality test to determine data distribution. Because the data were not normally distributed, hypothesis testing was continued using the non-parametric Wilcoxon test. The magnitude of the increase was calculated through the N-Gain value. The results showed a significant increase in scientific literacy, as indicated by the Wilcoxon test, with an N-Gain of 0.70, which falls within the moderate category. These findings demonstrate that integrating Discovery Learning with a contextual approach grounded in urban and rural air pollution data effectively facilitates students' connections between respiratory system concepts and real-world environmental issues. Thus, this learning model contributes to strengthening scientific literacy competencies in a more meaningful and contextual way.

Keywords: Air Pollution; Contextual; Discovery Learning; Respiratory System; Science Literacy.

Introduction

Education in the 21st century, or the era of the Industrial Revolution 4.0, takes place amidst scientific and technological advances. The strategic direction of education in the 21st century focuses on mastering critical thinking skills, complex problem resolution, and advanced scientific literacy [1]. A crucial competency that needs to be improved in the 21st century is scientific literacy, an individual's capacity to apply scientific knowledge to identify problems, formulate conclusions based on empirical evidence, and make decisions informed by a responsible scientific understanding of global issues. It refers to an individual's ability to utilize scientific knowledge in discussion cycles, including explaining problems, explaining scientific events, and drawing conclusions based on evidence relevant to the issues being studied [2]. In line with the framework developed by the Organisation for Economic Co-operation and Development, scientific literacy encompasses three core competencies: explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting scientific data and evidence [3].

Data from the 2022 Program for International Student Assessment (PISA) shows that Indonesian students' average scientific literacy score ranks 67th out of 81 countries. Indonesia's PISA 2022 scientific literacy score was 383, a significant decrease compared to the previous year. In 2018, the scientific literacy score was 396. This score is still far

below the international average of 485 [3]. As a result, Indonesia lags 102 points behind the global standard [3].

The problem of low scientific literacy was then strengthened by the results of pre-research in one of the schools in Blitar city by testing 3 indicators of scientific literacy, namely 1) explaining scientific phenomena with a correct score of 41.11, 2) evaluating and designing scientific investigations with a correct score of 31.11 and 3) interpreting scientific data and evidence with a correct score of 25. These findings suggest insufficient development of higher-order scientific competencies. Classroom observations indicate that science learning remains dominated by factual memorization rather than conceptual construction, limiting students' opportunities to engage actively with authentic scientific phenomena and apply knowledge to real-life situations.

Recent empirical studies have reported the effectiveness of Discovery Learning in improving higher-order thinking and scientific literacy. For instance, discovery learning enhanced analytical skills in respiratory system topics [4]. Significant improvements in students' scientific literacy on temperature and heat concepts using this model [5]. Positive effects of Discovery Learning on elementary students' scientific literacy. While these studies confirm the general effectiveness of Discovery Learning, they predominantly focus on cognitive outcomes without systematically integrating contextual environmental data as authentic learning resources [6].

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Furthermore, the effectiveness of Discovery Learning and Contextual Teaching and Learning (CTL) separately in improving higher-order thinking skills. However, the integration of Discovery Learning with a contextual approach grounded in real environmental data, particularly on the human respiratory system, remains underexplored. Most previous research does not explicitly connect urban–rural environmental differences, such as air quality data, to the development of scientific literacy competencies aligned with the OECD framework [7].

Therefore, this study addresses two critical research gaps simultaneously. First, a methodological gap: the limited integration of Discovery Learning with a structured, context-specific approach applied to respiratory system material at the junior high school level. Second, a contextual gap: the underutilization of authentic environmental data (urban versus rural air quality) as inquiry-based learning stimuli. By incorporating real environmental data into classroom investigations, this study moves beyond abstract concept learning and situates scientific reasoning within students’ lived experiences [8].

Theoretically, this study is grounded in constructivist learning principles. According to Jean Piaget, knowledge is constructed actively through processes of assimilation and accommodation when learners interact with meaningful experiences [9]. Lev Vygotsky emphasizes the importance of social interaction and scaffolding within the Zone of Proximal Development to support higher-order thinking [10]. Moreover, Jerome Bruner argues that Discovery Learning enables students to construct concepts through structured stages: stimulation, problem identification, data collection, data processing, verification, and generalization [11].

Each stage of Discovery Learning aligns conceptually with the three scientific literacy indicators. The stimulation and problem identification stages encourage students to explain scientific phenomena by recognizing contextual respiratory issues. Data collection and processing stages train students to evaluate and design scientific investigations using environmental data. Verification and generalization stages develop students’ ability to interpret scientific data and evidence to draw justified conclusions. By explicitly mapping learning syntax to literacy indicators, this study provides a clearer theoretical linkage between pedagogical design and competency development aspect not been sufficiently elaborated in prior research [12].

Thus, this research extends previous studies in three ways. Conceptually, it integrates Discovery Learning with contextual environmental data to strengthen all three scientific literacy competencies. Methodologically, it analyzes improvements across each literacy indicator rather than merely reporting overall gain scores. Contextually, it utilizes authentic urban and rural air quality data related to respiratory health, making learning socially relevant and evidence-based [13].

Based on these considerations, the purpose of this study is to analyze the implementation of Discovery Learning with a contextual approach in improving junior high school students’ scientific literacy on the topic of the human respiratory system. This research is expected to contribute both theoretically—by clarifying the linkage between instructional syntax and literacy competencies—and practically—by providing an evidence-based model for

contextual science instruction aligned with 21st-century demands.

Research Methods

This research employed a quantitative, pre-experimental, one-group pretest–posttest design. This design was chosen to identify the effect of implementing the Discovery Learning model with a contextual approach on students’ scientific literacy, comparing pre-treatment (pretest) and post-treatment (posttest) results. This research design involved one group of subjects who were given a pre-test (O_1), then given treatment (X), and then given a post-test (O_2). The difference in O_1 and O_2 scores was used to determine whether there had been an increase in scientific literacy [14].

Table 1. One Group Pretest-Posttest Research Design

Pre-test	Treatment	Post-test
O_1	X	O_2

The research was conducted at SMP Negeri 1 Selorejo, Blitar Regency, East Java, in the even semester of the 2026/2027 academic year. The study population was all eighth-grade students. The sampling technique used was total sampling, with all 31 students in grade VIII-E being selected as the research sample.

The independent variable in this study was the implementation of the Discovery Learning model with a contextual approach. Operationally, this model is implemented through six main syntaxes: (1) stimulation, (2) problem identification, (3) data collection, (4) data processing, (5) verification, and (6) generalization, all of which are integrated with a real-world context in the form of analysis of air pollution data in urban and rural environments related to human respiratory system disorders. The dependent variable is students’ scientific literacy, operationalized based on three competency indicators: (1) the ability to explain scientific phenomena, measured by students’ ability to relate respiratory system concepts to pollution-related disorders; (2) the ability to evaluate and design scientific investigations, measured by identifying variables, formulating hypotheses, and determining simple investigative procedures; and (3) the ability to interpret scientific data and evidence, measured by the ability to read graphs/tables of air quality data and draw evidence-based conclusions.

Research data was collected through three instruments: a scientific literacy test, an observation sheet on learning implementation, and a student response questionnaire. The scientific literacy test consisted of 10 multiple-choice questions structured around scientific literacy indicators and cognitive levels, based on the PISA framework. The test instrument was first validated by a science lecturer and a science teacher.

Observation sheets were used to assess the implementation of the learning syntax. Observations were conducted by two observers using a Guttman scale (yes/no) for the implementation of the stages and a Likert scale (1–4) to assess the quality of implementation. Meanwhile, the student response questionnaire used a four-level Likert scale to measure students’ perceptions of the meaningfulness,

engagement, and relevance of the implemented contextual learning.

Data analysis was conducted in stages. First, a normality test was conducted using the Shapiro–Wilk test because the sample size was less than 50 students. The test results indicated that the pretest and posttest data were not normally distributed ($p < 0.05$). Therefore, the nonparametric Wilcoxon Signed-Rank Test was used to determine whether the pretest and posttest scores differed significantly. The Wilcoxon test was chosen because the paired data did not meet the assumption of normality, making it more appropriate than the paired t-test.

In addition to the significance test, the increase in scientific literacy was analyzed using normalized gain (N-Gain) calculations to determine the level of treatment effectiveness. N-Gain values were categorized into three criteria: high ($g > 0.7$), medium ($0.3 \leq g \leq 0.7$), and low ($g < 0.3$). This analysis provided a quantitative overview of the magnitude of the increase in scientific literacy skills following the application of the learning model.

Data analysis

Analyzing the improvement of students' scientific literacy after the application of the Discovery Learning model with a contextual approach to human respiration material, analyzed using the Shapiro-Wilk test, paired t-test and N-Gain percentage. Analyzing the implementation of the Discovery Learning model with a contextual approach to human respiration material, analyzed using the Guttman scale and Likert scale. Analyzing students' responses after the application of the Discovery Learning model with a contextual approach to human respiration material, analyzed using a Likert scale with a range of 1-4.

Results and Discussion

This analysis covers three main aspects: students' scientific literacy skills, the level of learning implementation, and students' responses to learning. These three data sets were analyzed regularly to answer the research objectives: to describe improvements in scientific literacy skills, the effectiveness of learning implementation, and students' responses. The following is a complete description of the research results and their discussion.

Science Literacy Skills

Students' scientific literacy skills were measured by comparing pretest and posttest scores. The instrument used in this study was a multiple-choice test consisting of 10 questions. Students' scores were then classified according to their respective scientific literacy indicators.

The average pretest score for the indicator explaining scientific phenomena was 65.59 in the 'good' category and increased to 94.62 in the 'very good' category in the posttest. For the indicator evaluating and designing scientific investigations, the average pretest score was 59.13 in the 'sufficient' category, and the posttest score increased to 81.72 in the 'very good' category. Meanwhile, the indicator interpreting scientific data and evidence had an average pretest score of 61.29 in the 'good' category, which then increased to 88.70 in the 'very good' category in the posttest.

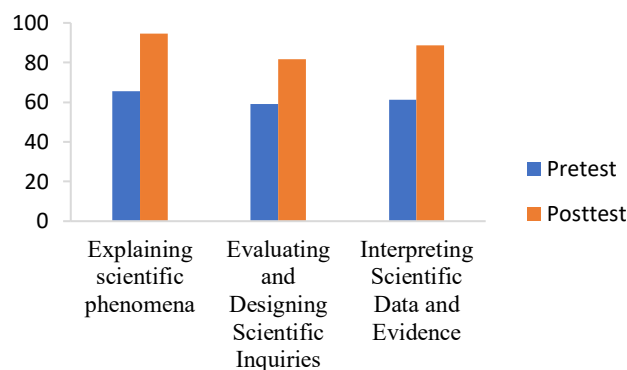


Figure 1. Bar Chart of Average Pretest and Posttest Scores for Each Indicator

Normality test

In the data analysis stage, the first step is to test the assumption of normality using the Shapiro-Wilk test. The results of this test, presented in Table 2, indicate that the data are not normal.

Table 2. Normality Test Analysis Results

No	Test	Significance	Information
1.	Pretest	0.030	Abnormal
2.	posttest	0.001	Abnormal

Based on Table 2, the pre-test and post-test scores were not normally distributed, with significance values of 0.030 and 0.001, respectively. To assess whether there was a statistically significant difference and improvement in learning between pre- and post-test scores, a paired-samples t-test was conducted.

Hypothesis testing

This study tested the hypothesis using non-parametric tests, specifically the Wilcoxon test, because the collected data were not normally distributed. Two hypotheses were formulated: the null hypothesis (H0), which states there is no significant difference in scientific literacy skills, and the alternative hypothesis (H1), which states there is a significant difference. The average pretest and posttest data comparing the two conditions are presented in Table 3.

Table 3. Average Scores of Pretest and Posttest

Test	Amount	Mean	Category
Pretest	31	62.00	Good
posttest	31	88.35	Very good

The data in Table 3 shows an increase in learning outcomes from the pretest to the posttest. This is evident from the average pretest score of 62.00 (good category), which increased to 88.35 (very good category) in the posttest. Hypothesis testing using the Wilcoxon test was conducted with the stipulation that H0 is accepted if the significance value is > 0.05 and H0 is rejected if the significance value is < 0.05 . The complete results of the Wilcoxon test are shown in Table 4.

Table 2. Wilcoxon Test Results

	Post-test – pretest
Asymp.Sig. (2-tailed)	<0.001

Based on Table 4, the significance value of Asymp. Sig. (2-tailed) < 0.001, so it is smaller than 0.05. Based on the decision-making criteria, if the significance value < 0.05, then H₀ is rejected and H₁ is accepted.

N-Gain

N-Gain analysis was used to measure the effectiveness of the Discovery Learning model with a Contextual Approach in improving students' scientific literacy. Data analysis was conducted by referring to the scientific literacy skill indicators that were the focus of this study, including the ability to explain scientific phenomena, design and evaluate scientific investigations, and interpret scientific data and evidence.

Table 3. Data from the Results of the N-Gain Analysis for Each Indicator

Science Literacy Indicators	N-Gain score	Category
Explaining Scientific Phenomena	0.84	Tall
Evaluating and Designing Scientific Inquiries	0.55	Currently
Interpreting Scientific Data and Evidence	0.70	Tall

Implementation of Learning

This research was conducted in two class VIII-E meetings at SMP Negeri 1 Selorejo, each lasting 2 x 40 minutes. The first meeting's activities included a pre-test, LKPD, and a simple respiratory system observation practicum. The second meeting focused on presenting observation results, administering the post-test, and completing student response questionnaires. Data on learning implementation were collected through observation sheets completed by two student observers. The results from each observer are ordinal data analyzed in Table 6 (Guttman Scale).

Table 6. Analysis Results Using the Guttman Scale

Activity	O1		O2	
	Yes	No	Yes	No
	Meeting 1			
Introduction	5	-	5	-
Core activities	4	-	4	-
Closing	3	-	3	-
	Meeting 2			
Introduction	5	-	5	-
Core activities	2	-	2	-
Closing	3	-	3	-
Total	22	-	22	-
% Implementation	100%			

The implementation of the Discovery Learning model with a Contextual Approach to improve scientific literacy in the human respiratory system was very successful, as

indicated by the observation data shown in Tables 7. The first meeting included introductory activities, the core activities of phase 1 stimulation, phase 2 problem statement, phase 3 data collection, phase 4 data processing, and the closing. The complete learning syntax was carried out well. Phase 5 verification, phase 6 generalization, and closing were the main activities of the second meeting, which began with an introduction. The Guttman and Likert scales were used to examine both meetings. The Guttman Scale analysis yielded a 100% implementation rate. Meanwhile, the Likert-scale analysis yielded a total score of 158, corresponding to 89.79% achievement, which is classified as very good.

Table 7. Analysis Results Using the Likert Scale

Meeting	Percentage (%)	Category
Meeting 1	87.50	Very good
Meeting 2	92.04	Very good
Overall average	89.77	Very good

Response Learners

Data on students' responses to the implementation of the Discovery Learning model with a Contextual Approach were collected through a 10-item questionnaire. Aspects measured included the level of student interest, the level of meaningfulness in the learning process, and the level of satisfaction with its implementation. The results of a detailed analysis regarding the responses of class VIII-E students at SMP Negeri 1 Selorejo are presented in Table 8.

Table 8. Student Response Analysis Results

Indicator	Average value	Category
Satisfaction Participant	82.52	Very good
Meaningfulness Learning	83.60	Very good
Student Interests	79.83	Very good
Explain Phenomenon Scientific	86.29	Very good
Designing and Evaluating Investigation Scientific	80.64	Very good
Interpreting Scientific Data and Evidence	83.06	Very good
Overall Average	82.65	Very good

The data in Table 8 indicate that the average score for the learning response of class VIII-E students at SMP Negeri 1 Selorejo to the application of the Discovery Learning model with a Contextual Approach to the respiratory system material is in the positive category.

In the initial stage (pretest), there was quite a striking variation in ability, with 3 students in the "Poor" category and 4 others in the "Sufficient" category. This condition is consistent with crucial factors such as differences in prior knowledge and individual cognitive capacity that influence academic achievement [15]. A more in-depth analysis showed that the indicator "explaining scientific phenomena" experienced the greatest improvement, with an average score of 65.59 (good category) in the pretest rising to 94.62 (very good category) in the posttest. Students' scientific literacy in the indicator explaining scientific phenomena increased the most among the other categories. This occurred because the

skills honed in this indicator were the ability to explain natural phenomena using scientific knowledge, recognize scientific descriptions, explanations, and predictions, and propose explanations for certain phenomena [16]. This aligns with research indicating that a process becomes more effective when the phenomenon is directly linked to real-life experiences in students' surroundings [17]. The results of the normality test on the pretest and posttest data for students indicated that the data were not normally distributed, so the analysis continued with a nonparametric test, the Wilcoxon Signed-Rank Test. Based on the Wilcoxon test results in the IBM SPSS Statistics program, presented in Table 4, the significance value was 0.001. This value is smaller than the 0.05 significance level, so the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted. This significant improvement is due to the model design, which ensures that each syntactic phase actively contributes to the development of scientific literacy skills. This aligns with the research by Fauzi and Irwandani [18], which strengthens the evidence that the Discovery Learning model can significantly improve conceptual understanding and scientific literacy skills. The indicator explaining scientific phenomena showed the most significant increase, for N-Gain of 0.84 (high category) confirming the improvement in learning outcomes, as seen from the increase in the average score from 62.00 in the pretest to 88.35 in the posttest. Learning with the Discovery Learning model in this indicator is to build students' abilities in utilizing scientific understanding as a foundation in explaining natural phenomena, recognizing scientific descriptions, explanations, and predictions, and proposing explanations of certain phenomena [19].

The indicator "evaluating and designing scientific investigations" had an N-Gain of 0.55, which is also in the moderate category but lower than the other indicators. This achievement can be interpreted as the skill of designing and evaluating scientific investigations, which is a higher-order thinking competency that requires procedural and epistemic abilities simultaneously. Based on the PISA scientific literacy framework developed by the Organization for Economic Co-operation and Development, this competency requires not only conceptual understanding but also the ability to identify variables, formulate hypotheses, determine procedures, and evaluate the validity of evidence [20]. In the context of this study, students are still in the transition stage from memorization-oriented learning to discovery-based learning, so investigative abilities have not yet developed optimally. This is in line with Jean Piaget's cognitive constructivism theory, which emphasizes that the development of formal thinking skills requires a gradual adaptation process through assimilation and accommodation [21]. Furthermore, according to Lev Vygotsky, complex skills such as designing investigations will develop more optimally if supported by intensive scaffolding in the zone of proximal development (ZPD) [22]. Thus, achieving the moderate category in this indicator indicates that the learning intervention has strengthened investigative skills but still requires more systematic guidance and habituation.

From a methodological perspective, this study employed a one-group pretest-posttest pre-experimental design without a control group. This design allows researchers to identify changes before and after treatment, but has limitations in controlling for external variables that

may influence the results. Without a comparison group, score improvements cannot be entirely attributed exclusively to the implementation of the Discovery Learning model with a contextual approach. Several potential biases may arise, including a testing effect, where students experience improved scores due to familiarity with the question format during the posttest, and the relatively small sample size (31 students), requiring caution in generalizing the study results. Furthermore, maturational factors and other learning experiences outside the treatment also have the potential to influence improvements in scientific literacy [23].

Nevertheless, the N-Gain value of 0.70 indicates substantial improvement. From a learning effect size perspective, the improvement from a low pretest to a higher posttest indicates that the intervention has practical significance, although strong causality cannot yet be claimed due to design limitations. This interpretation strengthens the argument that integrating Discovery Learning with a contextual approach can create more meaningful learning because students not only receive information but also construct understanding through analyzing air pollution data contextualized to their daily lives [24].

The findings of this study are also consistent with the results of previous experimental research. Research by Masna et al. (2024) showed that the Discovery Learning model had a significant effect on improving students' scientific literacy on the topic of temperature and heat [5]. Similarly, Maulana et al. (2024) reported a significant increase in scientific literacy following the implementation of Discovery Learning at the elementary school level. This similarity in findings strengthens the external validity of the research, which suggests that the discovery-based learning approach consistently makes a positive contribution to the development of scientific literacy competencies across various content contexts and educational levels [6].

This study provides empirical evidence that implementing Discovery Learning with a contextual approach on the human respiratory system can moderately to near-highly improve students' scientific literacy. However, to strengthen claims of effectiveness, further research is recommended using a quasi-experimental or a pure experimental design with a control group, a larger sample size, and a more comprehensive effect-size analysis. Thus, the scientific contribution of the research lies not only in improving scores but also in an in-depth understanding of the pedagogical mechanisms underlying the development of students' scientific literacy.

The Discovery Learning Model with a Contextual Approach has proven effective in its implementation, achieving 100% in both meetings. This assessment was conducted using an observation sheet with a Guttman scale, where each phase of the activity was scored 1 (Yes) for implementation and 0 (No) for non-implementation. In addition, to evaluate the quality of implementation, a Likert scale was used. During the learning, all phases were implemented, including the introduction, core activities divided into 6 syntaxes, and the closing. In the preliminary activities, the teacher began with prayer, class conditioning, apperception, motivation, and delivery of objectives, then measured the students' abilities by giving pre-test questions. The results of the implementation will be continued using a Likert scale to evaluate the quality of learning implementation. Based on the assessment results from two

observers, a total score of 158 was obtained, equivalent to 89.77%. This score places the overall quality of learning implementation in the 'very good' category.

Data on student responses were collected using a questionnaire designed to measure three dimensions: interest in learning models, meaningfulness of learning, and satisfaction with the learning process and indicators of scientific literacy. The questionnaire consists of 10 multiple-choice questions. This was completed by all samples, consisting of 31 respondents who are participants in Class VIII-E of SMP Negeri 1 Selorejo. An effective model can create an engaging learning environment, which ultimately facilitates meaningful understanding of the material. Therefore, student responses play an important role in supporting the smooth learning process [25]. Overall, the implementation of the Discovery Learning model, with a contextual approach to participants, educates class VIII of SMP Negeri 1 Selorejo and shows a very good response, with an average score of 82.55. Although it is necessary to study advanced methods for optimal improvement, learning, and participant education.

Conclusion

This study concluded that applying the Discovery Learning model with a contextual approach to the human respiratory system significantly improved the scientific literacy of eighth-grade students. This improvement was demonstrated by an N-Gain value of 0.70, which falls in the moderate to high range, and the Wilcoxon test showed a significant difference between pretest and posttest scores ($p < 0.001$). Furthermore, the learning implementation was in the very good category, and student responses to the learning demonstrated positive perceptions. These findings indicate that discovery-based learning grounded in real-world contexts can foster active student engagement in developing conceptual understanding and scientific literacy. Students responded very positively to the implementation of the Discovery Learning model with a contextual approach. This was evident in the average response score of 82.55, which falls into the very good category. These results indicate that this learning model was well-received and perceived as beneficial by students during the learning process. Overall, this study makes an empirical contribution to science learning practice by demonstrating that integrating structured, context-based discovery learning significantly improves scientific literacy. Further strengthening of the pedagogical implications and further development of the research design are expected to expand the contribution of these findings, both in educational practice and in future science education research.

Author's Contribution

I.T.N.H. Ullum: conceptualization, methodology, investigation, manuscript writing, data analysis, and revision; Martini: Manuscript review.

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