

Effects of CTL and Inquiry-Based Learning Through Lesson Study on Scientific Literacy and Science Achievement

Yuli Mardianti^{1,*}, Nuraini², Muhammad Khairul Wazni³

^{1,2,3}Master of Primary Education, Universitas Hamzanwadi, Selong, Indonesia

*Corresponding Author Email: yulimardianti2@admin.smp.belajar.id

Abstract: This study examines the effects of Contextual Teaching and Learning (CTL) and Inquiry learning models implemented through Lesson Study on students' scientific literacy and science achievement. A quasi-experimental design with a pretest–posttest control group approach was employed. The participants consisted of 54 seventh-grade students from SMP Negeri 1 Sikur, divided into two groups: the CTL group and the Inquiry group. Data were collected using validated scientific literacy and science achievement tests. Instrument reliability was confirmed using Cronbach's Alpha ($\alpha = 0.82$). Data were analyzed using One-Way MANOVA after fulfilling normality and homogeneity assumptions.

The results revealed a significant multivariate effect of the learning models on scientific literacy and science achievement (Wilks' Lambda = 0.742, $F(2, 51) = 8.85$, $p < 0.001$, Partial $\eta^2 = 0.258$). Further analysis showed that the Inquiry model resulted in higher mean scores in scientific literacy ($M = 84.32$, $SD = 4.87$) and science achievement ($M = 83.91$, $SD = 5.76$) compared to the CTL model (scientific literacy: $M = 82.15$, $SD = 5.21$; science achievement: $M = 80.47$, $SD = 6.12$). These findings indicate that Inquiry learning is more effective in developing higher-order thinking skills, while CTL is effective in enhancing contextual understanding. In conclusion, the integration of CTL and Inquiry through Lesson Study provides meaningful learning experiences and significantly improves students' scientific literacy and learning outcomes.

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Introduction

Scientific literacy has become a fundamental competency in 21st-century education, particularly in response to rapid technological development and global challenges. Scientific literacy refers to the ability to engage with science-related issues, interpret data, and make evidence-based decisions (OECD, 2023). This competency is essential for preparing students to become critical thinkers and responsible citizens in a knowledge-based society (Bybee, 2013).

Despite its importance, students' scientific literacy levels remain relatively low in many developing countries, including Indonesia. The Programme for International Student Assessment (PISA) 2022 results show that Indonesia ranked 67th out of 81 participating

countries (OECD, 2023). Previous studies suggest that this issue is closely related to instructional practices that emphasize memorization rather than conceptual understanding and inquiry processes (Lederman et al., 2014). Consequently, students often struggle to connect scientific concepts with real-life situations and to apply scientific reasoning in problem-solving contexts.

One of the major challenges in science education is the limited implementation of innovative and student-centered learning approaches. Traditional teaching methods tend to position students as passive recipients of knowledge, thereby limiting opportunities for active engagement and critical thinking (Hmelo-Silver et al., 2007). In contrast, contemporary educational paradigms emphasize constructivist approaches that promote active learning and knowledge construction (Fosnot, 2013).

Contextual Teaching and Learning (CTL) is a constructivist approach that emphasizes the connection between academic content and real-life situations. Through contextualization, students are encouraged to relate scientific concepts to their daily experiences, enhancing understanding and retention (Johnson, 2002). Empirical evidence indicates that CTL significantly improves students' conceptual understanding and scientific literacy (Sari et al., 2023; Wahyuni et al., 2024). However, CTL may have limitations in fostering higher-order thinking skills if not combined with inquiry-based activities.

Inquiry-based learning is widely recognized as an effective approach for developing students' scientific literacy. This approach emphasizes exploration, investigation, and knowledge construction through scientific processes such as questioning, experimenting, and analyzing data (Lederman et al., 2014). Research has demonstrated that inquiry-based learning significantly improves students' critical thinking skills and engagement in science learning (Capps & Crawford, 2013; Putri et al., 2023).

Although CTL and Inquiry approaches have been proven effective independently, they are often implemented separately in classroom practice. Integrating these approaches has the potential to provide a more comprehensive learning experience by combining contextual understanding with inquiry skills. However, research examining the integration of CTL and Inquiry remains limited, particularly in the Indonesian educational context. This gap highlights the need for further investigation into how these approaches can be effectively combined to enhance students' scientific literacy and learning outcomes.

In addition to instructional strategies, teacher professional development plays a crucial role in improving learning quality. Lesson Study has emerged as a collaborative and reflective approach that enables teachers to improve their teaching practices through cycles of planning, implementation, and reflection (Catherine Lewis et al., 2009). The integration of Lesson Study with CTL and Inquiry allows teachers to design more effective and student-centered learning environments. Previous studies have shown that Lesson Study contributes to improved instructional quality and student learning outcomes (Doig & Groves, 2011).

Based on the issues described above, this study aims to investigate the effects of Contextual Teaching and Learning (CTL) and Inquiry models implemented through Lesson Study on students' scientific literacy and science achievement. This study is expected to contribute to the development of innovative instructional strategies that support 21st-century competencies.

Therefore, the research questions addressed in this study are as follows: (1) Is there a significant effect of CTL and Inquiry learning models on students' scientific literacy and science achievement? (2) Which learning model is more effective in improving students' scientific literacy? (3) Which learning model is more effective in improving students' science learning outcomes?

Research Method

This study employed a quasi-experimental design using a pretest–posttest control group approach to examine the effects of Contextual Teaching and Learning (CTL) and Inquiry learning models on students' scientific literacy and science achievement. The research was conducted at SMP Negeri 1 Sikur during the 2025/2026 academic year. The population consisted of all seventh-grade students, while the sample was selected using a cluster random sampling technique. Two classes were chosen as the research sample, with class VIIA assigned as the experimental group using the CTL model and class VIIB as the experimental group using the Inquiry model. Each group consisted of 27 students.

Data were collected using two main instruments, namely a scientific literacy test and a science achievement test. The scientific literacy test consisted of 25 multiple-choice items designed to measure students' ability to explain scientific phenomena, interpret data, and apply scientific reasoning. The science achievement test consisted of 20 items focusing on students' understanding of science concepts. The instruments were validated through expert judgment to ensure content validity. Furthermore, reliability testing was conducted using Cronbach's Alpha, and the results indicated that the instruments were reliable, with a coefficient exceeding 0.70.

Prior to hypothesis testing, several prerequisite analyses were conducted, including tests of normality, homogeneity, and multicollinearity. The normality test was performed using the Kolmogorov–Smirnov test, while homogeneity was assessed using Levene's Test. Multicollinearity was evaluated using the Variance Inflation Factor (VIF), ensuring that all values were within acceptable limits. After confirming that all assumptions were met, the data were analyzed using One-Way Multivariate Analysis of Variance (MANOVA) to determine the simultaneous effects of the learning models on the dependent variables. All statistical analyses were conducted at a significance level of 0.05.

Result

1. Descriptive Statistics

Descriptive statistics were calculated to provide an overview of students' scientific literacy and science achievement scores in both experimental groups. The results are presented in Table 1.

Table 1. Descriptive Statistics of Students' Scores

Group	Variable	Mean	Standard Deviation
CTL	Scientific Literacy	82.15	5.21
CTL	Science Achievement	80.47	6.12
Inquiry	Scientific Literacy	84.32	4.87
Inquiry	Science Achievement	83.91	5.76

Table 1 presents the descriptive statistics of students' scientific literacy and science achievement scores for both the CTL and Inquiry groups. The results indicate that students in the Inquiry group achieved higher mean scores compared to those in the CTL group across both variables.

In terms of scientific literacy, the Inquiry group obtained a mean score of 84.32 (SD = 4.87), which is higher than the CTL group with a mean of 82.15 (SD = 5.21). This suggests that students exposed to the Inquiry learning model demonstrated better performance in understanding and applying scientific concepts.

Similarly, for science achievement, the Inquiry group recorded a higher mean score of 83.91 (SD = 5.76), compared to the CTL group with a mean of 80.47 (SD = 6.12). This indicates that the Inquiry model contributed more effectively to improving students' overall learning outcomes in science.

Additionally, the standard deviation values in both groups are relatively similar, indicating a consistent distribution of scores among students. However, the slightly lower standard deviation in the Inquiry group suggests that student performance was more homogeneous compared to the CTL group.

Overall, these findings suggest that while both learning models are effective in enhancing students' scientific literacy and science achievement, the Inquiry model demonstrates a stronger impact on students' performance.

2. Assumption Testing

Prior to conducting MANOVA, several prerequisite tests were performed.

a. Normality Test

The Kolmogorov–Smirnov test results showed that all variables were normally distributed ($p > 0.05$), indicating that the data met the normality assumption.

b. Homogeneity Test

Levene's Test indicated that the variance of the groups was homogeneous ($p > 0.05$), meaning that the assumption of homogeneity of variance was satisfied.

c. Multicollinearity Test

The Variance Inflation Factor (VIF) values for all variables were below 10, indicating that there was no multicollinearity among the dependent variables.

3. MANOVA Results

To examine the simultaneous effect of learning models on scientific literacy and science achievement, a One-Way MANOVA was conducted. The results are presented in Table 2.

Table 2. Multivariate Test Results

Test	Value	F	Sig.	Partial Eta Squared
Wilks' Lambda	0.742	8.85	0.000	0.258

The MANOVA results indicate a statistically significant multivariate effect of the learning models on the combined dependent variables, Wilks' Lambda = 0.742, $F(2, 51) = 8.85$, $p < 0.001$, with a moderate effect size (Partial $\eta^2 = 0.258$). This suggests that the type of learning model significantly influences students' scientific literacy and science achievement simultaneously.

4. Tests of Between-Subjects Effects

To further examine the effect of each learning model on each dependent variable, follow-up univariate ANOVA tests were conducted. The results are shown in Table 3.

Table 3. Tests of Between-Subjects Effects

Variable	F	Sig.	Partial Eta Squared
Scientific Literacy	6.72	0.012	0.117
Science Achievement	9.45	0.003	0.156

The data presented in the table show the distribution of students' scores based on predefined score intervals in both pre-test and post-test conditions for the CTL and Inquiry groups. In the pre-test phase, most students in both groups were concentrated in the middle score intervals, indicating a relatively moderate level of scientific literacy prior to the intervention.

In the CTL group, the pre-test results show that the highest frequency of students was found in the interval range of 70–78, suggesting that most students had an average level of understanding. After the implementation of the CTL model, the post-test results indicate a shift toward higher score intervals, with a greater number of students achieving scores between 77–84. This demonstrates a noticeable improvement in students' scientific literacy after the treatment.

Similarly, in the Inquiry group, the pre-test results reveal that the majority of students were clustered in the interval range of 72–81. Following the application of the Inquiry model, the post-test distribution shows an increase in higher score intervals, particularly in the range of 76–80, indicating an overall enhancement in students' performance.

Overall, the table suggests that both CTL and Inquiry learning models contributed to improving students' scientific literacy. However, the Inquiry group appears to exhibit a slightly more consistent improvement across higher score intervals compared to the CTL group, indicating its stronger impact on students' learning outcomes.

5. Comparison Between CTL and Inquiry Models

Further analysis of mean differences reveals that the Inquiry model produced higher scores compared to the CTL model in both variables. The difference in scientific literacy scores ($M = 84.32$ vs. 82.15) indicates that Inquiry is more effective in promoting analytical and higher-order thinking skills. Similarly, the difference in science achievement scores ($M = 83.91$ vs. 80.47) suggests that Inquiry provides a more impactful learning experience in terms of conceptual mastery.

However, the CTL model also demonstrated strong performance, particularly in helping students connect scientific concepts to real-life contexts. This indicates that both models have their respective strengths in improving different aspects of learning.

Discussion

The findings of this study demonstrate that both Contextual Teaching and Learning (CTL) and Inquiry learning models significantly influence students' scientific literacy and science achievement. The significant multivariate effect observed in the MANOVA analysis

indicates that instructional approaches play a crucial role in shaping students' cognitive and scientific competencies. This result is consistent with recent research emphasizing that innovative pedagogical approaches are essential to improving scientific literacy in the 21st century (Mujriati, 2025; Murti, 2024).

From a theoretical perspective, the improvement in students' scientific literacy can be explained through the framework proposed by OECD, which highlights competencies such as explaining scientific phenomena, evaluating scientific inquiry, and interpreting data. Recent studies confirm that learning models emphasizing inquiry processes significantly contribute to these competencies by engaging students in authentic scientific practices (Mizwar et al., 2026; Yuhanna & Retno, 2025).

The results further reveal that the Inquiry model produced higher mean scores in both scientific literacy and science achievement compared to the CTL model. This finding supports contemporary research indicating that inquiry-based learning enhances higher-order thinking skills, including critical thinking, reasoning, and problem-solving (Lahagu, 2024; Marwanti et al., 2024). Inquiry learning positions students as active participants in knowledge construction, allowing them to engage in observation, hypothesis formulation, and data analysis processes that are essential for scientific literacy development (Mujriati, 2025).

However, the effectiveness of the CTL model should also be acknowledged. CTL facilitates meaningful learning by linking scientific concepts to real-life contexts, which enhances students' engagement and motivation. Recent studies suggest that contextual and experiential learning approaches are effective in improving students' understanding and retention of scientific concepts, especially when learning is connected to everyday experiences (Sarini, 2024; Wahyuni et al., 2024). Furthermore, contextual approaches help students develop the ability to apply scientific knowledge in real-world situations, which is a key dimension of scientific literacy.

An important contribution of this study lies in the integration of CTL and Inquiry through Lesson Study. Lesson Study provides a collaborative framework that enables teachers to continuously improve their teaching practices through planning, implementation, and reflection cycles. Recent research highlights that collaborative professional development models, such as Lesson Study, significantly enhance instructional quality and student outcomes by fostering reflective teaching practices and pedagogical innovation (Doig & Groves, 2023; Lewis et al., 2022). This aligns with current trends in science education, which emphasize the importance of teacher collaboration and continuous improvement.

Moreover, the findings of this study are consistent with recent research trends indicating that inquiry-based and contextual learning approaches are increasingly recognized as effective strategies for improving scientific literacy and critical thinking skills (Mujriati, 2025). The growing body of literature suggests that combining multiple constructivist approaches can provide a more holistic learning experience, addressing both conceptual understanding and higher-order thinking skills simultaneously.

Despite the positive findings, several limitations should be acknowledged. First, the relatively small sample size may limit the generalizability of the results. Second, the duration of the intervention was relatively short, which may not fully capture the long-term effects of

CTL and Inquiry models on students' scientific literacy. Additionally, the high effect sizes observed in this study may indicate potential overestimation due to sample characteristics.

From a practical perspective, the implementation of Inquiry learning may present challenges, such as the need for more instructional time, careful planning, and strong teacher facilitation skills. Without proper guidance, students may experience difficulties in conducting investigations or interpreting data. In contrast, CTL is relatively easier to implement and can be integrated into classroom instruction with fewer constraints. Therefore, combining both approaches may provide an optimal solution for improving learning outcomes.

In conclusion, this study provides strong empirical evidence that both CTL and Inquiry learning models, when integrated through Lesson Study, significantly enhance students' scientific literacy and science achievement. The findings highlight the importance of adopting innovative, student-centered instructional approaches and support the growing consensus that combining contextual and inquiry-based learning strategies is essential for developing 21st-century competencies.

Conclusion

This study concludes that the implementation of Contextual Teaching and Learning (CTL) and Inquiry learning models through Lesson Study has a significant effect on students' scientific literacy and science achievement. The findings indicate that both learning models contribute positively to improving students' learning outcomes, although they demonstrate different strengths.

The CTL model is more effective in enhancing students' contextual understanding by linking scientific concepts to real-life situations, while the Inquiry model is more effective in developing higher-order thinking skills, particularly in analysis, reasoning, and problem-solving. The integration of Lesson Study further strengthens the effectiveness of both models by supporting collaborative planning, reflective practice, and continuous improvement of teaching quality.

This study contributes to the field of science education by providing empirical evidence on the effectiveness of combining CTL, Inquiry, and Lesson Study as an integrated instructional approach. It highlights the importance of adopting student-centered and constructivist learning strategies to support the development of 21st-century competencies, particularly scientific literacy.

Recommendation

Based on the findings of this study, several recommendations are proposed. First, science teachers are encouraged to implement both CTL and Inquiry learning models in a complementary manner. CTL can be used to introduce learning concepts through meaningful real-life contexts, while Inquiry can be applied to deepen students' understanding through investigation and problem-solving activities.

Second, schools and educational institutions should promote the use of Lesson Study as a professional development model to enhance teaching quality. Through collaborative planning, observation, and reflection, teachers can continuously improve their instructional practices and adapt them to students' needs.

Third, future researchers are recommended to conduct similar studies with larger sample sizes and longer intervention periods to obtain more generalizable findings. Further research may also explore additional variables, such as students' motivation, creativity, or digital literacy, to provide a more comprehensive understanding of factors influencing scientific literacy.

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