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The Effectiveness of Guided Discovery Learning Model in Improving Junior High School Students' Scientific Literacy on Thermal Expansion

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Abstract

The purpose of this study is to evaluate how well junior high school students' scientific literacy on the subject of thermal expansion is enhanced by the guided discovery learning paradigm. Prior research has demonstrated that guided discovery learning improves students' cognitive performance and scientific literacy; nevertheless, its use in junior high school, especially with regard to thermal expansion content, is still restricted. This study used a nonequivalent pretest–posttest control group design using a quantitative, quasi-experimental technique. The sample consisted of 64 seventh-grade students from SMP Negeri 2 Nanga Pinoh, divided into experimental and control groups. The study instrument was an essay-based scientific literacy test developed using the PISA 2025 Science Framework and validated by reliability and empirical validity testing. Descriptive quantitative analysis was used to assess the data, and Cohen's d was used to calculate the effect size. According to the findings, the experimental group's average posttest score was higher than the control group's, with a modest Cohen's d value of 0.368. These results show that students' scientific literacy about thermal expansion material is enhanced by the guided discovery learning technique..

Keywords: Guided discovery learning; Scientific literacy; Thermal expansion; Effect size.

INTRODUCTION

21st-century students are expected to possess scientific literacy that goes beyond simply understanding concepts; they must also be able to apply them in daily life and make evidence-based decisions. According to the PISA 2025 framework, science literacy is the capacity to critically

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interpret scientific data and evidence, design and assess scientific investigations, research, evaluate, and apply scientific information to make decisions and take action, and explain phenomena in a scientific manner (OECD, 2025: 9). However, Indonesian students' science literacy scores were only 396 in the 2018 PISA results, which is still far lower than the OECD average of 489 (OECD, 2019: 18). This situation highlights the need for educational innovations that prioritize concept memory while also fostering scientific, introspective, and contextual thinking skills.

A class of thirty-two pupils had an average score of 42.25 on the preliminary science literacy exam, suggesting that the students' science literacy abilities still require improvement. This finding is reinforced by the results of interviews with science teachers at SMP Negeri 2 Nanga Pinoh, who indicated that students' science literacy skills are somewhat lacking due to their low interest in reading. Various efforts by the school, such as providing a reading corner and utilizing the library, have been made, but these have not yet proven to be very effective. Teachers have also utilized learning technologies, employed contextual problems, and guided discussions to gather and explore information; however, the results have not yet demonstrated effectiveness in improving science literacy.

Based on interviews with science teachers, it is evident that the need to improve students' science literacy is also influenced by classroom learning factors. The implementation of group discussion, demonstration, and inquiry-based, collaborative, and problem-based learning methods has not been fully effective because student participation is still dominated by certain students, while others tend to be passive and hesitant to ask questions. Additionally, differences in learning styles, a lack of motivation for independent learning, and insufficient review of the material at home—particularly regarding expansion and heat—contribute to students' limited understanding. These conditions highlight the need for more structured instruction focused on actively engaging all students in independently discovering concepts, thereby enabling science literacy to develop optimally.

One suitable model is guided discovery learning (GDL), developed by Bruner. In this model, teachers continue to provide guidance, but students are encouraged to seek out, investigate, and discover knowledge gradually and independently, making learning more meaningful.

In order to enhance science literacy abilities, the guided discovery learning (GDL) paradigm essentially emphasizes student participation and active learning (Amaditha, Fitri, & Ekanara, 2024: 21). Six learning steps are used to achieve GDL: issue definition, stimulation, data collection, data processing, verification, and generalization. This model positions students as discoverers of concepts through an inquiry process guided by the teacher, making learning more meaningful as

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students are actively involved in observing, asking questions, processing information, verifying findings, and drawing conclusions (Bruner, 1961 in Iswati & Purwati, 2022: 702).

Previous research has shown that guided discovery learning consistently contributes to improvements in cognitive abilities, science literacy, and scientific process skills across various educational levels, where the implementation of virtual-laboratory-based guided discovery learning has proven effective, with improvements in student scores predominantly falling into the moderate category (Eveline et al., 2022: 263), and the guided discovery method has been shown to be effective in influencing student achievement in chemistry across all levels of science literacy (Nbina, 2013: 5–6). Additionally, when teaching Newton's laws at the secondary education level, guided inquiry learning has demonstrated a strong correlation with students' communication and science skills regarding the sub-concept of environmental pollution (Amaditha et al., 2024: 30). Additionally, the guided exploration learning model has been demonstrated to improve scientific process skills, especially among students with high science literacy when compared to the expository model. (Aslamia et al., 2025: 161).

According to earlier studies, the link between the guided discovery learning (GDL) approach and students' science literacy with regard to the theme of expansion at the junior high school level has not been explicitly investigated. A research connecting the GDL model to students' science literacy is thus required since science literacy is essential for assisting students in comprehending scientific facts in a contextual way. Students' science literacy may be enhanced and a deeper comprehension of the subject of expansion may be facilitated by the GDL phases, which place an emphasis on inquiry, data collecting and processing, and autonomous conclusion-drawing.

Thus, the purpose of this study is to ascertain how well the guided discovery learning (GDL) approach improves the science literacy of SMP Negeri 2 Nanga Pinoh students with respect to the subject of expansion. This study is essential because it can offer theoretical advantages by bolstering empirical research on the use of GDL in junior high school science education, as well as practical advantages as an alternative learning model that can boost students' active engagement, training, and support the development of students' science literacy more effectively, especially with regard to the topic of expansion.

LITERATURE REVIEW

According to earlier studies, the guided discovery learning approach regularly enhances cognitive capacities, science literacy, and scientific process skills at different educational levels.

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According to Eveline et al. (2022: 263), student learning outcomes improved somewhat when virtual laboratory-based guided discovery learning was included. Thus, the guided discovery strategy enhances students' learning achievement in chemistry at all levels of science literacy, according to Nbina (2013: 5–6). Amaditha et al. (2024: 30) discovered a substantial correlation between students' scientific and communication skills and discovery-based learning at the secondary education level when it comes to the sub-concept of environmental pollution. Additionally, compared to the expository approach while teaching Newton's laws, Aslamia et al. (2025: 161) claim that the guided exploratory learning model can enhance students' scientific process abilities, especially among those with high levels of science literacy.

While the results of numerous studies show that guided discovery learning is effective in improving a variety of student abilities, such as overall learning outcomes, scientific process skills, or science literacy, current research is still restricted to particular topics, such as environmental pollution and Newton's laws, and has not thoroughly examined its application in improving science literacy, the topic of expansion at the junior high school level. This suggests that there is little empirical data to support the guided discovery learning model's efficacy in raising students' science literacy, particularly when it comes to the expansion issue.

Thus, by investigating how well guided discovery learning enhances students' science literacy, particularly with regard to the subject of expansion at the junior high school level, this study seeks to close this gap..

RESEARCH METHOD

To ascertain the impact of the guided discovery learning (GDL) model on students' science literacy, this study used a quantitative approach with a quasi-experimental design (Creswell, 2014: 224). This study employed quantitative data from student scientific literacy assessments. A nonequivalent (pretest and posttest) control group design was employed in the study. (Creswell, 2014: 231).

Tabel 1. Research Design

Group	*Pretest*	Treatment	*Posttest*
Exsperiment	Q1	GDL	Q2
Control	Q1	-	Q2

Two groups were used in this study: an experimental group and a control group, as indicated in Table 1. Pretest Q1 and posttest Q2 were administered to both groups; however, only

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the experimental group was instructed using the guided discovery learning (GDL) approach, whilst the control group received standard teaching.

During the odd semester of the 2025–2026 school year, students at SMP Negeri 2 Nanga Pinoh, Melawi Regency, West Kalimantan Province, participated in this study. Purposive sampling was used to choose two groups that made up the population. This approach was used since the science teachers' data indicated that the aptitudes of these two courses were similar. The study sample consisted of sixty-four students. The experimental group consisted of thirty-two pupils, whereas the control group consisted of thirty-two students. Creswell (2014), p. 211.

Essay-style questions based on the PISA 2025 science framework indicators comprised the science literacy test instrument, which was evaluated for reliability using Cronbach's Alpha coefficient (r_{11}) and empirical validity using Pearson's product-moment correlation (Creswell, 2014: 218). The instrument's empirical validity and reliability testing were carried out using pretest data from classes VIII C and VIII D..

Tabel 2. Validation Results for the Science Literacy Test Instrument

Question Number	$r_{calculated}$	r_{tabel} $(a = 0,05)$	Criteria
1.	0,256	0,246	valid
2.	0,569	0,246	valid
3.	0,633	0,246	valid
4.	0,635	0,246	valid
5.	0,588	0,246	valid
6.	0,452	0,246	valid

Table 2 makes it clear that six test items have r_calculated values higher than the r_tabel value of 0.246 at a significance level of 0.05. All test items are considered legitimate since the r_calculated values fall between 0.256 and 0.635. This shows that the exam was able to evaluate students' science literacy abilities properly in line with the predetermined markers. (Slamet and Wahyuningsih, 2022: 52).

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Tabel 3. Reliability Results for the Science Literacy Test Instrument

Number of questions	Cronbach's alpha	Category
6	0,488	Quite reliable

Based on **Table 3** the Cronbach's alpha coefficient was found to be 0.488 for a total of 6 items, which falls within the "moderately reliable" category. This demonstrates that the science literacy test instrument exhibits sufficient internal consistency in measuring students' science literacy (Rosario and Bertalya, 2023: 282).

There were three primary phases to this study process: planning, execution, and data analysis. Preliminary research activities to determine the initial conditions of science learning in the classroom, the creation of instructional materials in the form of teaching modules and student worksheets (LKPD), and expert validation of these materials and science literacy test instruments were all part of the preparation stage. The experimental class utilized the guided discovery learning model, the control class used traditional learning, and both groups took a pretest during the implementation stage. A posttest was administered once the treatment was finished. Pretests and posttests were therefore employed to gather data for this study. Data analysis was the final stage. The guided discovery learning paradigm and the PISA-based theoretical framework of science literacy serve as the foundation for this investigation..

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$$d_s = \frac{\bar{x} - \bar{x}}{\sqrt{\frac{(n_1 -)SD^2 + (n_2 - 1)\,SD^{\frac{2}{2}}}{n_1 + n_2 - 2}} - 4ac2}$$

The Cohen's d results were categorized to determine the effectiveness of the learning model on students' science literacy. The Cohen's d categories are based on the classification developed by Cohen (1988) as cited in Suwarto and Karunia Eka Lestari (2025: 888), namely:

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Tabel 4. Cohen's d Alpha Coefficients and Categories

Criteria	Category
0,00 < d < 0,20	Low
0,20< d < 0,50	Currently
d > 0,80	High

Cohen's d effect sizes are divided into three groups according to Table 4: low, moderate, and high. The efficacy of the instructional paradigm in raising students' science literacy is evaluated using this categorization..

RESULT

The experimental group consisted of a class that received instruction using the guided discovery learning (GDL) model, while the control group followed instruction using the conventional teaching model typically used by teachers in the classroom.

Tabel 5. Results of Classical Descriptive Analysis

Group	Test	N	Minimum	Maximum	Mean	Std. Deviation
Exsperiment	Pre Test	32	12,50	54,17	35,29	7,99
	Post Test	32	33,33	83,33	63,02	11,09
Control	Pre Test	32	16,67	50,00	31,77	9,57
	Post Test	32	20,83	62,50	40,10	11,19

The average pretest score for the experimental group was 35.29, compared to 31.77 for the control group, according to Table 5's descriptive analysis results. This suggests that prior to the administration of the medication, the two groups' starting talents were comparatively similar. Following the intervention, the experimental group's average posttest score rose to 63.02, whereas the control group's climbed to 40.10. Additionally, the experimental group's growth (27.73 points) was greater than the control group's (8.3 points). These findings show that the experimental group's pupils' science literacy improved more than the control group's.

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Tabel 6. Results of Descriptive Analysis for Each PISA 2025 Competency

PISA 2025 Indicators	Group	Test	N	Minimum	Maximum	Mean	Std. Deviation
(1) Explaining Phenomena Scientifically	Exsperiment	Pre Test	2	25,0	62,5	39,84	7,40
		Post Test	2	25,0	87,5	62,11	14,01
	Control	Pre Test	2	0	62,5	37,11	11,22
		Post Test	2	25,0	62,5	37,89	12,49
(2) Developing and evaluating designs for scientific investigations, and interpreting scientific data and evidence	Exsperiment	Pre Test	2	0	62,5	30,47	14,53
		Post Test	2	0	87,5	59,77	16,11
	Control	Pre Test	2	0	62,5	17,97	16,17
		Post Test	2	0	62,5	33,98	18,30
(3) Researching, evaluating, and using scientific information to make decisions and take action	Exsperiment	Pre Test	2	0	62,5	35,55	14,24
		Post Test	2	37,5	87,5	67,19	12,99
	Control	Pre Test	2	12,5	62,5	40,23	15,79
		Post Test	2	12,5	75	48, 44	14,81

According to Table 6, the experimental group's scores on all science literacy abilities increased from the pretest to the posttest. The average score for the pupils' ability to describe things scientifically rose from 39.84 to 62.11. The average score rose from 30.47 to 59.77 in the ability of planning and assessing a study and interpreting scientific findings. In the meanwhile, the average score rose from 35.55 to 67.19 for the ability to investigate, assess, and use scientific data

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to make judgments.. Conversely, the control group also showed an increase, but the improvement was modest or not as significant as that in the experimental group.

Tabel 7. Results of the Classical Cohen's d Test

Group	N	Mean	Std. Deviation	Std. Pooled	Cohen's d	Category
Exsperiment	32	63,02	11,09	62,25	0,37	Currently
Control	32	40,10	11,19			

Table 7 yielded a Cohen's d value of 0.368, which is classified as moderate. This figure was obtained by comparing the experimental class's and the control class's mean posttest scores after the learning procedure. The experimental class's average posttest score was 63.02, greater than the control group's 40.10. The pooled standard deviation was then used to standardize this average difference, yielding a Cohen's d value of 0.368..

Tabel 8. Cohen's d scores for each PISA 2025 competency

PISA 2025 Indicators	Mean group Exsperiment	Mean group Control	Std. Deviation group Exsperiment	Std. Deviation group Control	Std. Pooled	Cohen's d	Category
Explaining Phenomena Scientifically	62,11	37,89	14,01	12,49	73,92	0,33	Currently
Developing and evaluating designs for scientific investigations, and interpreting scientific data and evidence	59,77	33,98	16,11	18,30	95,99	0,27	Low

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Researching, evaluating, and using scientific information to make decisions and take action	67,19	48,44	12,99	14,81	77,56	0,24\	Low

The mean posttest scores for each science literacy indicator were compared between the experimental group and the control group in order to perform an effect size analysis based on Table 8. Cohen's d value of 0.33 is in the middle range for the ability to explain occurrences scientifically. Cohen's d value of 0.27 is in the low range for the ability to create and assess plans for scientific investigations as well as to analyze scientific data and findings. Cohen's d value of 0.24 is in the low range for the ability to investigate, assess, and use scientific data to make judgments and take action..

DISCUSSION

According to Table 5's Classical Descriptive Analysis results, the experimental and control groups' very identical average pretest scores show that both groups' starting abilities were comparable prior to the intervention. This implies that the learning intervention was the main factor influencing the variations in posttest results. This result is in line with the pretest–posttest study design with a control group, which use the pretest to account for students' starting skills so that variations in posttest results may be linked to the therapy that was used. (Dugard & Todman, 1995: 189–191).

According to Table 6's descriptive analysis of each PISA 2025 skill, every science literacy competency in the experimental group increased from the pretest to the posttest, although the control group's rise was comparatively less. This suggests that, in comparison to traditional instruction, guided exploration learning is successful in raising students' science literacy levels. This conclusion is consistent with the findings of a research conducted by Mustikawati and Nurita, which demonstrated that the use of guided discovery learning may greatly enhance students' science literacy by getting them actively involved in the idea discovery process. (Mustikawati & Nurita, 2021: 115).

According to (Cohen, 1988) as cited in (Suwarto and Karunia Eka Lestari, 2025: 888), the

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Cohen's d value of 0.368, which falls into the moderate category based on the results in Table 7, suggests that using the guided discovery learning model has a statistically significant impact on raising students' science literacy. Its effectiveness is demonstrated by the difference in science literacy achievement between the experimental and control groups after the learning process. This result is consistent with the findings of Anggriani et al. (2020, pp. 456–460), who reported that students' science literacy competencies improved after guided discovery learning was implemented. The magnitude of improvement fell into the moderate to high category, indicating that the model is successful in raising students' science literacy.

The mean posttest scores for each science literacy indicator were compared between the experimental and control groups in order to perform an effect size analysis based on Table 8. The Cohen's d value of 0.33 is in the middle range for the ability to explain things scientifically. These findings show that the guided discovery learning model's implementation is sufficiently successful. This is in line with research (Destrini, 2018: 19–20) that demonstrates how students' science process abilities may be enhanced by the guided discovery learning model through active learning. Students' observations of the phenomenon of expansion connected to the Dayak community's mandau-making techniques throughout the stimulation and issue statement stages, as well as their formulation of problems based on the findings of the observed phenomena, support this.

The Cohen's d value of 0.27 is in the low range for the ability to create and assess plans for scientific research and to understand scientific data and findings. These findings suggest that guided discovery learning's efficacy on this metric is still subpar. This is due to the fact that some students still have difficulty creating experimental protocols and doing methodical data analysis. This result is in line with studies (Nurlina, 2019: 137) that demonstrate the underdevelopment of students' science process abilities in experimental activities. However, during the phases of data collection and processing, students participated in a straightforward metal wire expansion experiment and processed the results of that experiment..

A Cohen's d score of 0.24 indicates a poor level of skill in gathering, analyzing, and using scientific data to make choices and take action. These findings show that pupils' proficiency with this metric is still restricted. This result is consistent with studies (Nurlina, 2019: 137) demonstrating that students still struggle to acquire higher-order science process abilities. However, the guided discovery learning model's verification and generalization phases teach students how to assess the dependability of data, evaluate the validity of hypotheses, and make inferences based on experiment-derived evidence. Although students still require practice for this skill to grow to its full potential, these exercises aid in the development of students' capacity to

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apply scientific knowledge in decision-making..

CONCLUSION

According to the study's findings, seventh-grade junior high school students' science literacy on the subject of expansion is improved when the guided discovery learning paradigm is used. The experimental group's Cohen's d effect size value, which is in the moderate range, illustrates its efficacy. As a result, the guided discovery learning model may be employed as a substitute teaching strategy to help students' science literacy.

This study has limitations related to the duration of the learning process. During the guided discovery learning phase, particularly in the verification and generalization stages, learning activities had to be expedited due to time constraints, resulting in these stages being shorter than originally planned. This limitation should be taken into account when interpreting the research results and planning future studies.

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