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The Impact of Science Storming on Students' Scientific Literacy in Elementary Education

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ABSTRACT
This study aims to analyze the effectiveness of the Science Storming learning model in improving science literacy among elementary school students. The study employed a quantitative approach with a quasi-experimental design (nonequivalent control group pretest-posttest). The research subjects consisted of fifth-grade students divided into an experimental group (n=22) and a control group (n=16). The instrument used was a science literacy test covering the ability to understand changes in the state of matter, the relationship between temperature and changes in state, and the interpretation of scientific phenomena. Data analysis utilized descriptive statistics, normality tests, paired-sample t-tests, and independent-sample t-tests. Results showed a pretest mean of 59.69 for the control group and 60.00 for the experimental group, while posttest scores increased to 67.64 (control) and 85.64 (experimental). The paired t-test for the experimental group showed a significant difference (mean difference = −25.636; $p < 0.05$). These findings indicate that Science Storming is effective in improving science literacy through the exploration of ideas and scientific discussions that foster a deeper and more contextual conceptual understanding.

INTRODUCTION

Science education in elementary schools is of fundamental importance because it serves as the foundation for building students' scientific literacy and scientific thinking skills (Putri et al. 2024). The results of the 2022 Program for International Student Assessment were recently announced on December 5, 2023, and Indonesia ranked 68th with scores of 379 in mathematics, 398 in science, and 371 in reading. This study evaluated the achievements of 15-year-old students in mathematics, reading, and science. Participation in the 2022 Program for International Student Assessment involved approximately 690,000 students from 81 countries, and this survey is conducted every three years. Since 2000, the Organisation for Economic Co-operation and Development has consistently conducted this assessment (Zulfa et al. 2024). Through science learning, students are not only required to master basic concepts but are also guided to develop scientific process skills such as observing, classifying, measuring, interpreting data, and drawing conclusions (Nurul Qolbi et al., 2025). The role of science storming is to improve the science literacy and experimental skills of elementary school students.

Science Storming is the application of brainstorming techniques integrated into inquiry-based science learning and practice to stimulate ideas, experiment planning, and reflection; quasi-experimental evidence shows an increase in student creativity, motivation, and cognitive achievement, but the definition and long-term evaluation are still limited (Nurlaela, 2023). Science education in elementary schools plays an important role in building the foundations of science literacy, but in reality, the level of science literacy among Indonesian students is still relatively low (Afkar et al. 2024). Low science literacy is caused by learning practices that are still predominantly teacher-centered, textual in nature, and do not provide opportunities for students to be actively involved in exploration and scientific inquiry (Rustandi, 2023). Students memorize information rather than developing conceptual understanding and critical thinking skills (Yulianti & Gunawan, 2019). Science storming is important for improving the science literacy of elementary school students in line with global demands.

Scientific literacy is one of the most important aspects of science learning in elementary schools (Purnawati & Yakin, 2025). Science literacy focuses not only on mastering concepts, but also on applying them in real life through experiments (Parisu et al. 2025). Science literacy encompasses not only factual knowledge, but also critical thinking, problem solving, evidence-based decision making, and fostering a scientific attitude towards natural phenomena (Hidayah & Wahidah, 2026). At the elementary school level, strengthening science literacy is an important foundation for the development of 21st-century competencies, as it helps students build meaningful conceptual understanding while practicing inquiry and scientific reflection skills (Sutiani et al., 2021). The integration of science literacy in the Natural Sciences Education learning process needs to be designed systematically and contextually in order to optimize the cognitive, affective, and psychomotor potential of students (Sudirman et al., 2025). The post-truth phenomenon requires people to possess strong information literacy and critical thinking skills so they can analyze and evaluate the truthfulness of information rationally and based on verifiable evidence (Aji Yoga Sekar & Marwan, 2025).

Similar studies on science storming in improving elementary school students' science literacy have been extensively researched (Afrijon & Safrudin, 2024; Hanani et al., 2025;

Mardiyah et al., 2026; Nugraha & Indihadi, 2019; Praminingsih et al., 2023; Sunandar & Effendi, 2018). All of the above studies report that the application of brainstorming techniques systematically integrated into the context of science learning; unlike brainstorming in general, science storming directs and facilitates the process of gathering ideas so that it is in line with scientific steps such as problem formulation, hypothesis proposal, experiment design, and data interpretation. By structuring the initial discussion into a series of inquiry activities, science storming not only encourages the generation of many ideas but also trains students to use evidence-based reasoning, construct scientific arguments, and relate scientific concepts to contextual phenomena. Thus, this method is relevant for improving science literacy and experimental skills in students.

Recent studies indicate that improving students' scientific literacy remains a major challenge in many education systems. For example, the results of the 2022 Programme for International Student Assessment show that Indonesian students' scientific literacy ranks relatively low compared to many other countries (Musa et al, 2023). In response to this challenge, several studies emphasize the importance of active and collaborative learning strategies that allow students to explore ideas, discuss concepts, and interpret scientific evidence. Discussion-based and inquiry-oriented approaches have been shown to improve students' ability to construct scientific explanations and apply scientific reasoning (Hsu, 2021; Sutiani et al., 2021). Similarly, brainstorming-based learning strategies encourage students to express ideas freely while connecting them to relevant scientific concepts (Priyatna et al,2019). Research also suggests that collaborative idea-generation activities can enhance creativity, motivation, and problem-solving abilities in science learning contexts Praminingsih et al., 2023; Hanani et al., 2025). Through processes such as idea exploration, group discussion, and collaborative analysis, students can develop critical thinking and the ability to interpret scientific information (Syolendra, 2024). Furthermore, integrating brainstorming strategies with contextual learning activities helps students relate scientific knowledge to everyday phenomena, leading to more meaningful conceptual understanding (Barokah, 2025). Collectively, these findings suggest that structured collaborative learning environments provide strong potential for strengthening scientific literacy. However, most existing research has examined brainstorming mainly as a general discussion technique rather than as a systematic instructional framework specifically designed to develop scientific literacy. Therefore, integrating brainstorming techniques within a more structured pedagogical approach—such as the Science Storming model—may offer a promising way to enhance elementary school students' scientific literacy through critical, reflective, and contextual learning processes.

Despite these contributions, most previous studies have demonstrated that brainstorming-based learning strategies can enhance students' creativity, motivation, and cognitive achievement in science learning (Afrijon & Safrudin, 2024; Hanani et al., 2025; Praminingsih et al., 2023). These studies highlight the potential of brainstorming techniques to encourage students to generate ideas, discuss scientific concepts, and engage in collaborative learning activities. However, most previous research has focused mainly on brainstorming as a general discussion strategy and has rarely examined its structured integration with science literacy development in elementary science education. In particular, limited research has explored how the Science Storming approach can systematically support the development of key dimensions of scientific literacy, such as explaining scientific

phenomena, interpreting evidence, and connecting scientific concepts to everyday contexts. Therefore, this study aims to address this research gap by examining the effectiveness of the Science Storming learning model in improving elementary school students' scientific literacy through a quasi-experimental approach. By integrating brainstorming techniques with contextual science learning activities, this research seeks to provide empirical evidence of how structured idea exploration and scientific discussion can enhance students' scientific literacy in elementary education.

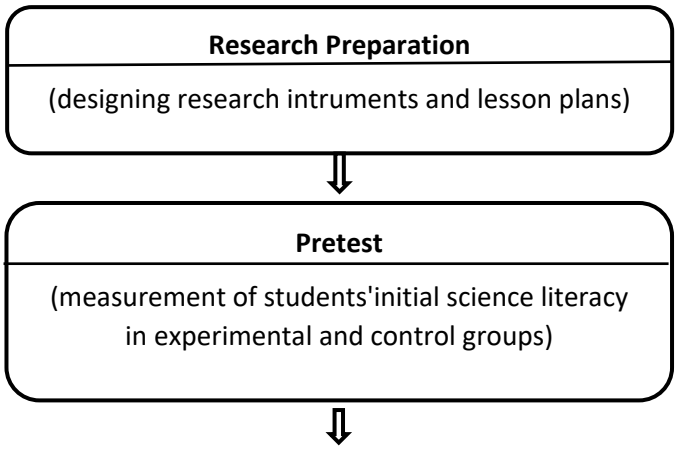
Although various studies have shown that brainstorming techniques and their variations in science education can enhance student engagement, critical thinking skills, and learning outcomes, most of these studies still focus on general brainstorming activities and have not been systematically integrated into a science literacy framework. Previous research tends to position brainstorming as an initial strategy for generating ideas without explicitly linking it to dimensions of science literacy, such as the ability to explain scientific phenomena, use evidence rationally, and make science-based decisions in real-life contexts. Furthermore, empirical studies specifically examining the effectiveness of the Science Storming model an integrative form of brainstorming in enhancing science literacy at the elementary school level remain relatively limited, both nationally and internationally. Therefore, this study aims to address this gap by developing and testing the application of Science Storming as a learning model that not only emphasizes collaborative idea exploration but also guides students' thinking processes toward the construction of scientific understanding that is systematic, contextual, and evidence-based, thereby contributing both theoretically and empirically to the development of science education in elementary schools.

METHOD

This study employed a quantitative approach using a quasi-experimental method conducted in a real classroom setting, where full control of external variables was not possible. The research design used was a nonequivalent control group pretest–posttest design, involving two groups: an experimental group that received learning using the Science Storming model and a control group that received conventional instruction.

The population of this study consisted of all fifth-grade elementary school students. The sample was selected using purposive sampling based on students' initial academic ability and learning environment conditions. The final sample included 38 students, consisting of 22 students in the experimental class and 16 students in the control class.

The research procedure was carried out through several stages. Figure 1 illustrates the overall stages of the research process used in this study.



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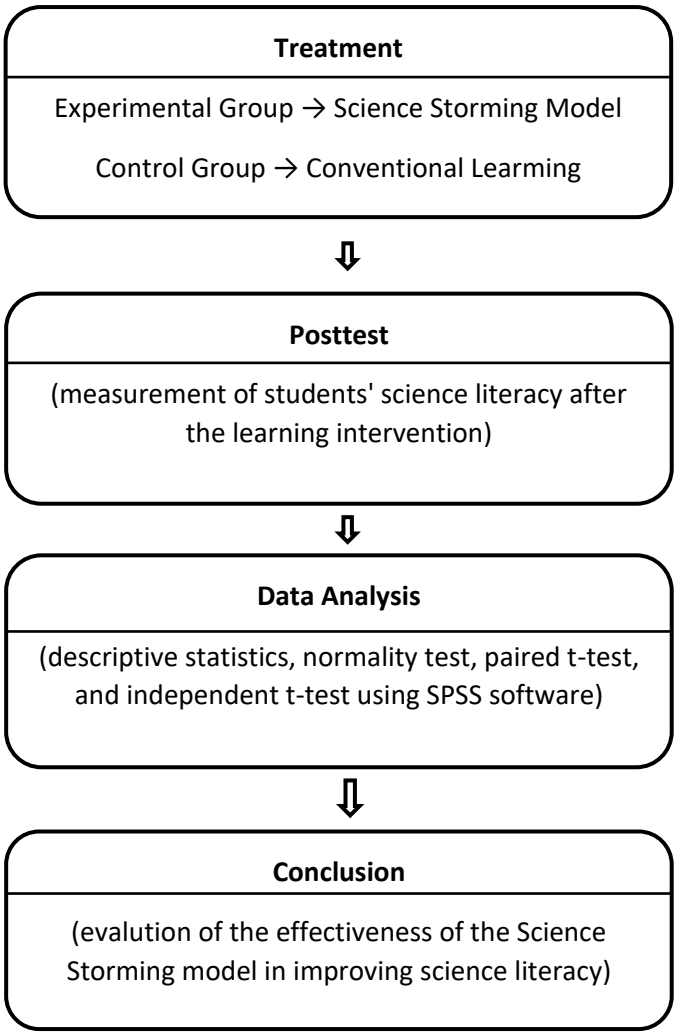

Figure 1. Research Procedure of the Study

Preparation Stage - The researchers prepared the research design, learning materials based on the Science Storming model, research instruments, and data collection procedures.

Pretest Stage - Both the experimental and control groups were given a pretest to measure students' initial science literacy abilities before the learning intervention.

Treatment Stage - The experimental group received learning using the Science Storming model, while the control group received conventional science instruction. The learning activities were conducted during three classroom meetings.

Posttest Stage - After the treatment, both groups were given a posttest to measure the improvement in students' science literacy.

Data Analysis Stage - The collected data were analyzed using descriptive statistics to determine the average improvement in learning outcomes. Inferential statistical analysis was conducted using a normality test, paired sample t-test, and independent sample t-test with the help of SPSS.

Research Instrument - The instrument used to measure students' science literacy was a test consisting of three indicators: (1) identifying various types of changes in the form of objects in everyday life, (2) explaining the relationship between temperature and changes in

the form of objects, and (3) interpreting natural events involving changes in the form of objects.

RESULT AND DISCUSSION

The results of this study indicate that the Science Storming learning model significantly improves students' scientific literacy compared with conventional instruction. One effective learning innovation to achieve these goals is the application of the Science Storming method, a collaborative approach that combines creative discussion (brainstorming) with simple scientific experiments relevant to students' daily lives. Through Science Storming, students are encouraged to express ideas and propose hypotheses. It is hoped that this method will significantly improve students' scientific literacy and practical skills. To support this analysis, the results of a statistical description of the effectiveness of the application of Science Storming are presented in Table 1.

Table 1. Descriptive Statistics of Students' Science Literacy Scores

	N	Mean	Minimum	Maximum	Std. Deviation	Description
Class Control	16	59.69	55	65	3.005	Pretest
Class Experiment	22	60.00	55	65	2.582	
Class control	16	67.25	60	72	3.624	Posttest
Class Experiment	22	85.64	78	91	3.388	

Table 1 shows descriptive statistics of science literacy in the control class and experimental class before and after treatment. At the pretest stage, the average score for the control class was 59.69 and for the experimental class was 60.00, with a relatively similar minimum and maximum score range (55–65) and low standard deviation, indicating that the initial abilities of both groups were at an equivalent and homogeneous level. After the treatment, there was an increase in both groups, but the increase in the experimental class was more prominent. The average posttest score of the control class increased to 67.25 with a standard deviation of 3.624, while the experimental class experienced a much higher increase to 85.64 with a standard deviation of 3.388. The higher score range in the experimental class (78–91) shows that Science Storming learning has a stronger positive impact on science literacy development than conventional methods. A comparison of the pretest and posttest scores shows that the learning intervention provided to the experimental class was able to improve student learning outcomes more significantly and consistently. The normality test calculations for the pretest and posttest results of science literacy skills can be seen in Table 2.

Table 2. Results of the Science Literacy Normality Test

Class	Test	Test Statistics	p-Value	Description
Control	Pretest	0.970	0.83	Normal

	Posttest	0.920	0.16	Normal
Experiment	Pretest	0.960	0.66	Normal
	Posttest	0.965	0.75	Normal

Table 3 shows the results of the science literacy normality test, which confirms that all data in both the control class and the experimental class are normally distributed. The p-values for the control class pretest and posttest were 0.83 and 0.16, respectively, while those for the experimental class were 0.66 and 0.75; all were greater than 0.05. This condition indicates that the data did not violate the normality assumption and were therefore suitable for analysis using parametric tests such as the paired samples t-test and independent samples t-test. These findings also indicate that the variation in initial and post-treatment abilities is within a reasonable distribution pattern, so that comparisons of results between groups and between measurement times can be carried out validly and reliably. The sample t-test calculations for the science literacy data are shown in Table 3.

Table 3. Paired Sample T-Test Results

	Class	Mean Difference	Sig. (p)	Uji-t
Literasi Sains	Experiment	-25.636	0.00	-110.007
	Control	-7.563	0.00	-27.662

Table 3 presents the results of the paired sample t-test, which confirms a significant increase in science literacy, especially in the experimental class that applied the Science Storming learning model. For the variable of science literacy, the experimental class showed a mean difference of -25.636 with a significance value of 0.00 ($p < 0.05$) and a t-value of -110.007, which confirms that there was a very significant increase between the pretest and posttest scores. These findings confirm that Science Storming is more effective in improving science literacy than conventional methods because it facilitates scientific thinking and idea exploration. The independent t-test calculations for the science literacy results are shown in Table 4.

Table 4. Independent T-Test Results

Variabel	Group	N	Mean	Std. Deviation	Std. Eror Mean
Science literacy	Control	16	67.64	3.624	0.906
	Experiment	22	85.64	3.388	0.722

Table 4 shows the results of the independent t-test, which indicates a very significant difference between the experimental class and the control class in science literacy. The average score for the experimental class was 85.64, which was much higher than that of the control class at 67.64. This striking difference in averages was supported by the relatively low standard deviation values for both groups, indicating that the data distribution in each class was stable and homogeneous. Statistically, the test results indicate that the application of the Science Storming model has a more effective influence in improving conceptual understanding, the ability to interpret scientific phenomena, and the use of science-based evidence compared to conventional learning. These findings reinforce the assumption that the structured integration of Brainstorming strategies can optimize the development of elementary school students' science literacy more significantly.

The improvement in science literacy skills in the experimental class was also evident from the descriptive data (Table 1). The average pretest scores of both groups were the same (60), indicating homogeneous initial abilities. After the treatment, the average posttest score of the experimental class increased significantly to 85.64, while the control class only reached 67.25. These results are consistent with the findings of Chistyakov et al. (2023) that the STEAM-PjBL learning model is more effective in improving students' science literacy than traditional methods. Contextual and practice-based learning has been proven to strengthen scientific concept understanding (Hartina et al., 2025). The Science Storming model, which combines creative discussion and experimental activities, helps students build a deeper understanding of concepts than conventional learning.

Further statistical analysis supports all of these conclusions. Normality tests show that literacy data is normally distributed, allowing parametric analysis to be used. Paired t-test results show a significant increase in science literacy ($p < 0.05$), far exceeding the increase that occurred in the control class. These findings are in line with international research results that emphasize the importance of active learning. Similar evidence regarding the importance of strategic learning approaches and their influence on outcomes has also been discussed in studies published in the Moestopo International Review on Societies, Humanities, and Sciences (MIRSHUS) (Utami et al., 2024). PISA analysis shows that students with high science achievement are generally actively involved in scientific activities and receive teacher support through the use of various learning strategies and investigative activities (Yusmar & Fadilah, 2023). Internal factors such as motivation and self-efficacy, as well as external factors such as learning quality and learning environment support, also influence students' science literacy (Syofyan et al., 2025).

The findings of this study have a number of important implications for the development of science learning practices in elementary schools. First, the Science Storming model has been proven to significantly improve students' science literacy, so it can be recommended as a more effective alternative learning strategy compared to conventional teacher-centered approaches. The application of this model allows students to be actively involved in the learning process through idea exploration, scientific discussion, and the exchange of ideas that encourage the formation of a deeper conceptual understanding. Therefore, teachers are expected to begin integrating scientific brainstorming and creative discussion activities into the science learning process, so that students not only acquire factual knowledge but also develop scientific thinking skills, interpret scientific phenomena, and build science literacy in a more comprehensive and meaningful way.

The effectiveness of the Science Storming model observed in this study can also be interpreted from the perspective of constructivist learning theory. According to constructivist principles, knowledge is actively constructed by learners through interaction, discussion, and reflection on their experiences. In the Science Storming learning process, students are encouraged to generate ideas, formulate hypotheses, and discuss possible explanations for scientific phenomena. These activities allow students to connect new information with their prior knowledge, which strengthens conceptual understanding and promotes deeper learning. Furthermore, collaborative idea-generation activities provide opportunities for students to learn from their peers, negotiate meaning, and refine their scientific reasoning through discussion. Such processes are essential for the development of higher-order thinking skills and scientific literacy. Therefore, the implementation of Science Storming not only improves

students' learning outcomes but also creates a more interactive and meaningful learning environment that supports the development of inquiry skills, scientific reasoning, and collaborative learning in elementary science education

Another important implication of the findings relates to the development of students' 21st-century competencies. Scientific literacy is closely associated with skills such as critical thinking, problem solving, collaboration, and communication. The Science Storming learning model provides opportunities for students to actively engage in these competencies through collaborative discussion, hypothesis generation, and experimental activities. When students participate in brainstorming sessions and scientific exploration, they learn to express ideas, evaluate different perspectives, and construct explanations based on evidence. These learning experiences contribute not only to cognitive development but also to students' confidence in participating in scientific discussions. Therefore, integrating Science Storming into elementary science instruction may support the broader educational goal of preparing students to become scientifically literate citizens who are able to understand and respond to scientific issues in everyday life.

CONCLUSION

Based on the results of the research and data analysis, it can be concluded that the application of the Science Storming learning model is effective in improving the scientific literacy of elementary school students. This is demonstrated by a significant increase in science literacy scores in the experimental class compared to the control class, based on both descriptive statistical analysis and inferential tests such as the paired sample t-test and independent sample t-test. The Science Storming model encourages active student participation through idea exploration, scientific discussions, and critical thinking activities that help students understand scientific concepts more deeply and contextually.

From a practical perspective, the findings of this study suggest that teachers can integrate Science Storming strategies into science learning to create a more interactive and student-centered classroom environment. Teachers are encouraged to design learning activities that allow students to generate ideas, discuss scientific problems collaboratively, and connect scientific concepts with real-life situations. The use of structured brainstorming activities combined with simple experiments can help students develop scientific reasoning, interpretation skills, and evidence-based thinking.

However, this study has several limitations that should be considered. The research was conducted with a relatively small sample size and within a limited time frame. Therefore, future research is recommended to involve larger samples from different schools and educational contexts in order to obtain more generalizable results. Further studies could also explore the long-term impact of the Science Storming model on students' scientific literacy, as well as its potential influence on other learning outcomes such as critical thinking, creativity, and problem-solving skills.

Overall, the integration of brainstorming techniques through the Science Storming approach provides a promising alternative learning strategy to strengthen students' scientific literacy and support the development of meaningful and inquiry-based science learning in elementary education.

Based on the findings of this study, several research recommendations can be proposed. Future studies are encouraged to examine the implementation of the Science

Storming learning model in different educational contexts, grade levels, and science topics to obtain broader and more generalizable results. Researchers may also explore the long-term impact of Science Storming on students' scientific literacy development and investigate its potential influence on other important learning outcomes such as critical thinking, creativity, collaboration skills, and problem-solving abilities. In addition, further research could combine Science Storming with other innovative learning approaches, such as project-based learning or digital learning environments, in order to explore more effective strategies for strengthening scientific literacy in elementary science education.

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