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Scientific Approach With Inquiry Method to Improve Students' Science Literacy in Natural Changes

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ABSTRACT
The low level of elementary school students' scientific literacy requires innovative and student-centered learning methods. This study aims to determine the effectiveness of the scientific approach using the inquiry method in improving the scientific literacy of fifth-grade elementary school students regarding the topic of natural changes. This research employed a quantitative method with a pre-experimental design, specifically the One-Group Pretest-Posttest Design. The sample consisted of 26 students selected using a saturated sampling technique. Data collection methods included tests, observations, and documentation. The research instrument was an essay test developed based on the PISA 2022 scientific literacy indicators. Data analysis was conducted using the N-Gain formula to determine the level of improvement in students' scientific literacy. The results showed a significant increase in students' scientific literacy skills, with an average N-Gain score of 0.64, falling into the medium category. These findings indicate that the scientific approach combined with the inquiry method is highly effective in improving students' scientific literacy regarding natural change.

Kata Kunci:
literasi sains;
pendekatan saintifik;
metode inkuiri;
perubahan alam.

ABSTRAK
Rendahnya tingkat literasi sains siswa sekolah dasar memerlukan metode pembelajaran yang inovatif dan berpusat pada siswa. Penelitian ini bertujuan untuk mengetahui efektivitas pendekatan saintifik dengan metode inkuiri dalam meningkatkan literasi sains siswa kelas V sekolah dasar pada topik perubahan alam. Penelitian ini menggunakan metode kuantitatif dengan desain pra-eksperimental, khususnya *One-Group Pretest-Posttest Design*. Sampel penelitian terdiri dari 26 siswa yang dipilih menggunakan teknik sampling jenuh. Metode pengumpulan data meliputi tes, observasi, dan dokumentasi. Instrumen penelitian yang digunakan berupa tes esai yang dikembangkan berdasarkan indikator literasi sains PISA 2022. Analisis data dilakukan dengan menggunakan rumus *N-Gain* untuk mengetahui tingkat peningkatan literasi sains siswa. Hasil penelitian menunjukkan adanya peningkatan yang signifikan pada kemampuan literasi sains siswa, dengan rata-rata skor *N-Gain* sebesar 0,64 yang termasuk dalam kategori sedang.

Temuan ini menunjukkan bahwa pendekatan saintifik yang dipadukan dengan metode inkuiri sangat efektif dalam meningkatkan literasi sains siswa pada materi perubahan alam.

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INTRODUCTION

Science education at the elementary school level plays a crucial role in shaping students' scientific thinking skills from an early age.[1] Science education aims not only to help students master theoretical concepts but also to develop their ability to understand natural phenomena scientifically and relate them to daily life.[2] Therefore, science education must emphasize both conceptual understanding and the scientific process.

One of the key competencies that needs to be developed in science education is science literacy. Science literacy is an individual's ability to understand scientific concepts, explain phenomena scientifically, and apply that knowledge in decision-making.[3] Students with strong science literacy are expected to be able to think critically, solve problems, and address various science-related issues in daily life.[4]

However, in reality, students' science literacy remains relatively low. According to the PISA 2022.[5] results, Indonesian students' science literacy scores remain below the OECD average. This is influenced by several factors, one of which is a learning process that remains teacher-centered.[6] Under these conditions, students tend to be passive recipients of information and are not actively engaged in the learning process. Consequently, students have limited

[1] S. Suhelayanti, *Pembelajaran Ilmu Pengetahuan Alam Dan Sosial IPAS* (Yayasan Kita Menulis, 2023).
[2] Asri Ika Nurmaela and Muhammad Suwignyo Prayogo, "Upaya Meningkatkan Hasil Belajar Siswa Sekolah Dasar Melalui Metode Inquiry Pada Pembelajaran Ilmu Pengetahuan Alam," *Indonesian Journal of Science Learning (IJSL)* 3, no. 2 (2022): 34–44, https://doi.org/10.15642/ijsl.v3i2.2310.
[3] Ala Purnawati and Nurul Yakin, *Implementasi Kemampuan Literasi Sains dalam Pembelajaran IPA Terintegrasi di Sekolah Dasar*, 2025.
[4] Delia Monika, Sri Watini, and Athala Ardana, *Peran Program Kelas dalam Membina Literasi Sains pada Anak Usia Dini*, 2024.
[5] OECD, "PISA 2022 Science Framework," OECD Publishing, 2022, https://www.oecd.org/pisa/.
[6] Aprilia Windi Viola and Fitri Kurniati, "Penerapan Pembelajaran IPA di SD Negeri 12 Sungai Sapih: Studi Observasi dalam Konteks Kurikulum Merdeka," *Journal of Biology*, 2025.

opportunities to participate in scientific activities such as observing, asking questions, experimenting, and drawing conclusions.[7]

Based on preliminary observations, it was found that students are not very active in the learning process. Students rarely ask questions, have difficulty explaining scientific phenomena, and are not sufficiently engaged in inquiry-based activities. This situation contributes to low levels of students' science literacy, particularly in their ability to explain phenomena scientifically.[8]

To address these issues, a learning approach that actively engages students is needed. The scientific approach is one method that emphasizes the learning process through scientific activities such as observing, asking questions, experimenting, reasoning, and communicating.[9] This approach aligns with the objectives of science education because it encourages students to construct knowledge through direct experience.[10]

In addition, the inquiry method can be integrated with the scientific approach to increase student engagement. The inquiry method encourages students to actively seek answers, investigate problems, and build understanding through a process of exploration and discovery.[11] This method helps students understand concepts more deeply and fosters meaningful learning.[12]

From a theoretical perspective, the integration of the scientific approach and inquiry learning is strongly grounded in constructivist learning theory, which argues that knowledge is actively constructed through learners' interaction with their environment rather than passively transmitted by teachers. During inquiry activities, students continuously observe, formulate questions, investigate evidence, develop explanations, and communicate findings. These learning experiences encourage conceptual reconstruction and scientific reasoning, both of which constitute essential foundations of scientific literacy. Therefore, integrating scientific learning procedures with inquiry processes provides

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[7] Nurul Qolbi, Adrias, and Aissy Putri Zulkarnaen3, "Efektivitas Pendekatan Saintifik dalam Meningkatkan Hasil Belajar IPA Siswa SD," *Pentagon : Jurnal Matematika dan Ilmu Pengetahuan Alam* 3, no. 2 (2025), https://doi.org/10.62383/pentagon.v3i2.478.

[8] Desi Dwisetiarezi and Yanti Fitria, "Analisis Kemampuan Literasi Sains Siswa pada Pembelajaran IPA Terintegrasi di Sekolah Dasar," *Jurnal Basicedu* 5, no. 4 (2021): 1958–67, https://doi.org/10.31004/basicedu.v5i4.1136.

[9] Dina Liana, "Berpikir Kritis Melalui Pendekatan Saintifik," *MITRA PGMI: Jurnal Kependidikan MI* 6, no. 1 (January 2020): 15–27, https://doi.org/10.46963/mpgmi.v6i1.92.

[10] Yeni Yusella et al., "Implementation of Thematic Learning Through the Scientific Approach of Fifth Grader," *JIIP - Jurnal Ilmiah Ilmu Pendidikan* 6, no. 7 (2023): 5392–401, https://doi.org/10.54371/jiip.v6i7.2078.

[11] Khairun Khalid et al., "Implementasi Pembelajaran dengan Pendekatan Inkuiri Terbimbing untuk Peningkatan Hasil Belajar Taruna AAL," *Saintek: Jurnal Sains Teknologi dan Profesi Akademi Angkatan Laut* 16, no. 1 (2023): 44–50, https://doi.org/10.59447/saintek.v16i1.113.

[12] Maryam Maryam et al., "Pengaruh Model Pembelajaran Inkuiri Terhadap Keterampilan Berpikir Kritis Siswa," *Jurnal Pijar Mipa* 15, no. 3 (2020): 206–13, https://doi.org/10.29303/jpm.v15i3.1355.

meaningful opportunities for students to develop scientific understanding through authentic learning experiences.

Although the scientific approach and the inquiry method have been widely applied in science education in elementary schools, most previous studies have focused more on improving learning outcomes, science process skills, or students' critical thinking abilities.[13] Research specifically examining the integration of the scientific approach and inquiry-based methods in enhancing science literacy based on the PISA 2022 framework remains relatively limited, particularly in the context of elementary schools.

A review of recent empirical studies also indicates that research on scientific approaches and inquiry-based learning in elementary science education has predominantly emphasized students' academic achievement, critical thinking, science process skills, or conceptual understanding rather than science literacy as a multidimensional competency. For instance, previous studies have demonstrated the effectiveness of inquiry learning in improving science process skills and learning outcomes, while other investigations have primarily examined critical thinking development through inquiry-based instruction. Although several studies have begun to examine science literacy, most have focused on guided inquiry models or general science learning contexts without explicitly integrating the scientific approach (5M) with inquiry activities using the competency domains proposed in the PISA 2022 Science Framework. Consequently, empirical evidence explaining how this instructional integration contributes to the development of elementary students' science literacy remains limited.

The novelty of this study lies not merely in the adoption of the PISA 2022 science literacy framework, but in the pedagogical integration between the scientific approach mandated in elementary science instruction and inquiry-based learning activities designed to facilitate the three core competencies of scientific literacy, namely explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting scientific data and evidence. Furthermore, this study specifically examines the topic of natural changes, which provides authentic contexts that allow elementary students to connect classroom learning with real environmental phenomena encountered in everyday life.

Science literacy is not only related to conceptual mastery but also encompasses the ability to explain phenomena scientifically, evaluate and design scientific investigations, and interpret scientific data and evidence. Therefore, a learning approach is needed that can facilitate students' active engagement in the entire scientific process. This study aims to address this gap by examining the effectiveness of a scientific approach combined with the inquiry method in

[13] Abdillah Faizin, Endang Susantini, and Raharjo Raharjo, "Application of A Guided Inquiry Learning Model to Improve Students' Scientific Literacy Skills," *IJORER : International Journal of Recent Educational Research* 5, no. 2 (2024): 490–503, https://doi.org/10.46245/ijorer.v5i2.573.

improving the science literacy of fifth-grade elementary school students on the topic of natural changes.

METHODS

This study employed a quantitative approach using a pre-experimental design, specifically the One-Group Pretest-Posttest Design.[14] The independent variable in this study was the scientific approach using the inquiry method, while the dependent variable was students' science literacy skills. Structurally, the research was conducted at SDN 2 Jatisari, with the study population and sample consisting of all 26 fifth-grade students. A saturation sampling technique was applied, meaning the entire population served as the active study sample.

The One-Group Pretest–Posttest Design was selected because the primary objective of this study was to examine changes in students' science literacy before and after the implementation of the instructional intervention within an authentic classroom setting. This design is frequently employed in preliminary educational research to evaluate the potential effectiveness of an instructional innovation when random assignment or the establishment of a control group is not feasible in the school context[15]. Although this design does not permit strong causal inference compared with quasi-experimental or true experimental designs, it provides valuable empirical evidence regarding learning improvement following educational interventions.

The data sources for this investigation comprised primary data obtained directly from the students' pretest and posttest evaluation scores regarding natural changes. The treatment itself was administered over three sessions through the systematic integration of the steps of the scientific approach (observing, questioning, experimenting, reasoning, and communicating) with inquiry-based activities that emphasized the process of investigation and independent concept discovery.

Data collection techniques utilized in this study included tests, observations, and documentation. The primary research instrument consisted of an essay test designed based on the PISA 2022 science literacy framework, focusing specifically on the competence of explaining phenomena scientifically.[16] OECD, 2022. The evaluation of the instrument pilot test showed that 10 out of 15 test items were valid, with a Cronbach's Alpha reliability coefficient of 0.86, placing it in the very high reliability category. To ensure data validity and empirical trustworthiness without assuming generalized population distributions, an objective cross-examination framework was implemented using standardized evaluation rubrics, guaranteeing that the recorded pretest and posttest metrics directly align with verified construct criteria. Furthermore, the quantitative data were analyzed using Normalized Gain (N-Gain) scores to determine the exact

[14] Sugiyono, *Quantitative, Qualitative, and R&D Research Methods*, 2nd ed. (Bandung, 2019).
[15] Creswell, J. W., & Creswell, J. D. (2023). *Research Design* (6th ed.); Fraenkel, Wallen, & Hyun. (2019). *How to Design and Evaluate Research in Education.*
[16] OECD, "PISA 2022 Science Framework."

level of improvement in students' science literacy following the intervention. The individual and classical N-Gain values obtained were then categorized into low, moderate, or high classifications to determine the level of improvement after participating in the instruction.[17]

The N-Gain analysis was employed to measure the magnitude of students' improvement by comparing pretest and posttest scores relative to the maximum attainable score. Compared with the simple difference between pretest and posttest scores, the normalized gain provides a more objective estimate of learning improvement because it considers students' initial achievement levels[18]. The resulting N-Gain values were interpreted using three categories: low ($g < 0.30$), moderate ($0.30 \leq g \leq 0.70$), and high ($g > 0.70$), allowing the effectiveness of the instructional intervention to be evaluated descriptively.

In addition to empirical validity testing, the essay instrument was developed by aligning each item with the scientific literacy competencies described in the PISA 2022 Science Framework, ensuring content relevance to the intended construct. The scoring process employed an analytic scoring rubric that emphasized students' ability to explain scientific phenomena, justify arguments using scientific evidence, and interpret scientific information systematically. This approach was intended to minimize subjective judgment during scoring while maintaining consistency in evaluating students' responses[19]

RESULT AND DISCUSSION

Result

The research results indicate that there was an improvement in students science literacy skills following the implementation of the scientific approach using the inquiry method. This improvement is evident from the comparison between pretest and posttest results. The main way to assess students was a 10-question essay test that was carefully connected to the skills and abilities covered in the PISA 2022 framework. Items 1 to 4 check how well students can recognize scientific problems in everyday situations, like water pollution or areas where trees have been cut down. Items 5 through 7 check how well someone can explain natural events using science, like how the water cycle works and why the environment gets damaged. Lastly, items 8 to 10 check how well students understand and work with real data and scientific evidence. This detailed breakdown helps thoroughly assess how students' reading and writing skills

[17] R. R. Hake, "Analyzing Change/Gain Scores," Indiana University, 1999, http://www.physics.indiana.edu/~sdi/AnalyzingChange-Gain.pdf.
[18] Ibid.

[19] Brookhart (2013) *How to Create and Use Rubrics for Formative Assessment and Grading.*

develop in different areas of learning. The empirical data is outlined in the following table:

Table 1. Pretest and Posttest Scores

Class	N	Pretest (Mean)	Pretest (SD)	Posttest (Mean)	Posttest (SD)
Experiment	26	46.15	17.51	79.62	12.56

The data in Table 1 show an increase in students' science literacy skills after the intervention. The average pretest score of 46.15 increased to 79.62 on the posttest. In addition to the increase in the average score, the standard deviation also decreased from 17.51 to 12.56. This indicates that, in addition to an improvement in students' abilities, their learning outcomes became more evenly distributed following the instructional process.

Overall, the descriptive statistics indicate a consistent positive trend following the instructional intervention. The increase in the mean score was accompanied by a reduction in score variability, suggesting that learning improvement occurred not only among high-achieving students but also across students with different initial levels of science literacy. Although individual differences remained, the posttest results demonstrate a more homogeneous distribution of students' achievement after participating in the scientific inquiry-based learning activities.

Table 2. Summary of N-Gain Scores for Science Literacy

No.	Category	Score Range	Number of Student	Percentage
1	High	$g > 0.70$	**11**	42.3%
2	Moderate	$0.30 \leq g \leq 0.70$	**14**	53.8%
3	Low	$g < 0.30$	**1**	3.9%
Total			**26**	**100%**
Average N-Gain		**0.64**		**(MODERATE)**

Based on the N-Gain analysis results, an average score of 0.64 was obtained, which falls into the moderate category. These results indicate that the application of the scientific approach using the inquiry method has led to a fairly significant improvement in students science literacy skills.

In addition to the average N-Gain value, the distribution of improvement demonstrates that nearly all students benefited from the instructional intervention. Only one student remained in the low improvement category, whereas more than ninety percent of the participants achieved moderate or high levels of improvement. This distribution indicates that the learning strategy produced relatively consistent gains across the classroom rather than benefiting only a small proportion of students.

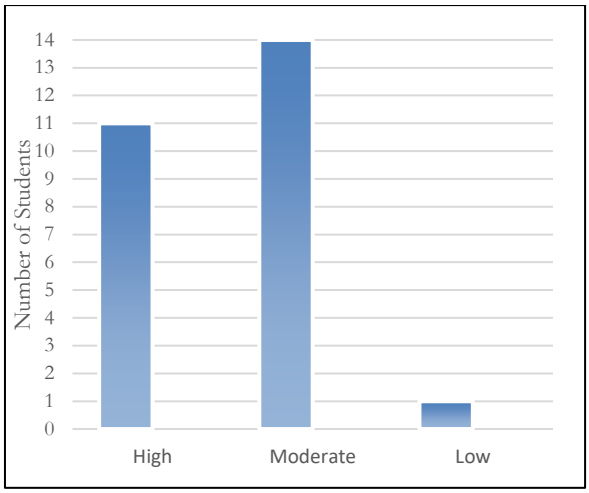

Figure 1. *Distribution of Science Literacy Improvement (N-Gain)*

The distribution of N-Gain categories shows that 11 students (42.3%) were in the high category, 14 students (53.8%) were in the moderate category, and only 1 student (3.9%) was in the low category. These findings indicate that the majority of students experienced an improvement. in their science literacy skills after participating in the instruction. Further analysis by indicator revealed varying degrees of improvement.

Table 3. N-Gain Scores by Science Literacy Indicator

No	Science Literacy Indicator	N-Gain	Categor y
1	Explaining phenomena scientifically	0.72	High
2	Developing and evaluating research designs	0.55	Moderate
3	Interpreting data and evidence scientifically	0.64	Moderate

The results of the analysis by indicator show that the ability to explain phenomena scientifically showed the highest improvement with an N-Gain value of 0.72, which falls into the high category. Meanwhile, the indicator for evaluating and designing scientific investigations obtained an N-Gain value of 0.55, and the indicator for interpreting data and evidence scientifically obtained an N-Gain value of 0.64, both of which fall into the moderate category.

The variation in N-Gain across the three science literacy competencies indicates that students demonstrated different levels of mastery depending on the nature of the competency being assessed. Competencies directly associated with conceptual explanation showed greater improvement than competencies requiring analytical evaluation and evidence interpretation. These descriptive findings suggest that different dimensions of science literacy may develop at different rates during short-term instructional interventions.

The differences in achievement across indicators suggest that the ability to explain scientific phenomena develops more easily through direct observation

and discussion during learning. Conversely, the ability to design and evaluate research and interpret data requires higher-order thinking skills that demand continuous practice. Simply put, even though students understand the concepts, they still need guidance in constructing systematic written arguments.

Overall, the descriptive findings consistently indicate that the implementation of the scientific approach integrated with inquiry-based learning was followed by improvements across all measured indicators of science literacy. The increase was observed in students' overall achievement, the distribution of individual learning gains, and each competency domain assessed using the PISA 2022 science literacy framework. The implications of these findings are discussed in the following section.

Discussion

The systematic integration of the scientific approach and inquiry method provided a structured pedagogical framework that directly drove the students' literacy transformation. At the start of the intervention, the Observing phase, which used real-world natural disaster videos, and the Questioning phase effectively created a baseline shift. Students moved from just listening to taking the lead in exploring issues about environmental damage. This first input started a big conversation between the starting performance and the results after the intervention; the students' overall science understanding went from a low level (average = 46.15) to a much higher score (average = 79.62), as shown in Table 1.[20]

From the perspective of constructivist learning theory, the observed improvement can be understood as a consequence of students' active knowledge construction throughout the learning process. Rather than receiving scientific concepts through direct instruction, students developed conceptual understanding by interacting with authentic environmental phenomena, discussing alternative explanations, and reconstructing prior knowledge based on empirical evidence. Such learning experiences are consistent with the constructivist view that meaningful learning occurs when learners actively organize and reinterpret their experiences[21]. Consequently, the improvement in science literacy observed in this study reflects not only increased content mastery but also the development of scientific reasoning fostered through inquiry-oriented learning experiences.

Additionally, this big improvement is clearly connected to specific skills that are part of the PISA 2022 framework. During the hands-on experimenting part, fifth-grade students explored the water cycle and physical and chemical changes.In the critical reasoning stage, they learned to directly work with real data

[20] H. Hidayat, I. Wayan Lasmawan, and I. Wayan Kertih, "Pengaruh Penggunaan Pendekatan Saintifik Terhadap Hasil Belajar IPAS Di Sekolah Dasar," *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)* 5, no. 3 (2025): 1610–18, https://doi.org/10.53299/jppi.v5i3.2314.

[21] National Research Council (2012). A Framework for K-12 Science Education.; Piaget & Inhelder (1969) *The Psychology of the Child.*

and variables. This active involvement created a conversation between their old beliefs and the real facts. As a result, the ability to explain things using science became the most advanced skill, with a high N-Gain score of 0.72 (see Table 3). This specific increase shows that students didn't just remember information; they were able to explain the reasons behind changes in the environment in a logical way.[22]

In the last step, called Communicating, students shared their group findings and explained their conclusions to their classmates. This way of working together helped them learn how to explain things using solid evidence. Higher-order skills such as interpreting scientific data (N-Gain = 0.64) and evaluating research designs (N-Gain = 0.55) stayed in the moderate range because they require more complex thinking.However, the overall classroom setting saw a more uniform development of skills across students. This is shown by the clear decrease in standard deviation from 17.51 to 12.56, which proves that the scientific-inquiry model effectively closed the achievement gap and created a more inclusive and higher level of science understanding for everyone in the classroom.

These findings are consistent with previous studies showing that students' active engagement in the scientific steps (5M) is highly effective in strengthening students' science literacy in elementary school.[23] Similar findings were also reported in other research stating that inquiry-based learning positively contributes to improving science literacy because students gain firsthand experience in developing scientific reasoning and interpreting evidence based on the results of their investigations.[24]

The relatively moderate improvement in evaluating scientific investigations and interpreting scientific evidence may also reflect developmental characteristics of elementary school learners. These competencies require higher-order cognitive processes, including analytical reasoning, evaluation of evidence, and abstract thinking, which continue to develop progressively during late childhood. Consequently, short-term instructional interventions are generally more effective in strengthening conceptual explanation than sophisticated scientific reasoning. This finding suggests that inquiry-based instruction should be implemented continuously across different grade levels to facilitate the gradual development of higher-order science literacy competencies.

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[22] Ardian Asyhari, "Profil Peningkatan Kemampuan Literasi Sains Siswa Melalui Pembelajaran Saintifik," *Jurnal Ilmiah Pendidikan Fisika Al-Biruni* 4, no. 2 (2015): 179–91, https://doi.org/10.24042/jpifalbiruni.v4i2.91.

[23] Kartimi Kartimi and Widodo Winarso, "Enhancing Students' Science Literacy Skills; Implications for Scientific Approach in Elementary School," *Al Ibtida: Jurnal Pendidikan Guru MI* 8, no. 2 (2021): 161, https://doi.org/10.24235/al.ibtida.snj.v8i2.9175.

[24] Gülüzar Eymur and Pınar Seda Cetin, "Investigating the Role of an Inquiry-Based Science Lab on Students' Scientific Literacy," *Instructional Science* 52, no. 5 (2024): 743–60, https://doi.org/10.1007/s11251-024-09672-w.

Observation results show that students become more active in asking questions, discussing, and expressing their opinions during the learning process. This increase in participation indicates that the inquiry-based method is capable of creating a learning environment that provides students with broader opportunities for exploration. These findings support prior research indicating that inquiry-based learning can increase student engagement by encouraging them to participate directly in the process of investigation and problem-solving.[25]

Increased classroom participation observed during the intervention also indicates a shift in students' learning orientation from passive knowledge reception toward active scientific inquiry. Students became more willing to formulate questions, communicate alternative explanations, and justify conclusions using available evidence. Such behavioral changes are important because science literacy encompasses not only cognitive competence but also students' disposition to engage with scientific issues critically and responsibly[26]. Consequently, the instructional benefits observed in this study extend beyond academic achievement to include the cultivation of scientific learning habits.

Based on an analysis by indicator, the greatest improvement occurred in the ability to explain phenomena scientifically. These results indicate that the observation and discussion activities conducted during instruction helped students connect scientific concepts with the natural phenomena they encounter in their daily lives. These findings align with evidence that students' active engagement in the scientific steps contributes to improved ability to explain phenomena scientifically.[27] Similar results were also reported indicating that students' involvement in scientific inquiry activities has a positive effect on their ability to use scientific concepts and evidence in explaining a phenomenon.[28]

The substantial improvement in this competency is also theoretically reasonable because explaining scientific phenomena represents the most immediate outcome of inquiry-oriented learning. During classroom investigations, students repeatedly connected observations with scientific concepts, enabling them to construct causal explanations based on evidence rather than memorizing isolated facts. According to the OECD (2022), the ability to explain phenomena scientifically reflects learners' capacity to integrate conceptual understanding with scientific reasoning in authentic contexts. Therefore, inquiry activities that continuously expose students to real-world

[25] Norsyazwani Muhamad Dah et al., "The Impacts of Open Inquiry on Students' Learning in Science: A Systematic Literature Review," *Educational Research Review* 43 (2024): 100601, https://doi.org/10.1016/j.edurev.2024.100601.

[26] OECD, 2022

[27] Qolbi, Adrias, and Aissy Putri Zulkarnaen3, "Efektivitas Pendekatan Saintifik dalam Meningkatkan Hasil Belajar IPA Siswa SD."

[28] De Van Vo and Geraldine Mooney Simmie, "Assessing Scientific Inquiry: A Systematic Literature Review of Tasks, Tools and Techniques," *International Journal of Science and Mathematics Education* 23, no. 4 (2025): 871–906, https://doi.org/10.1007/s10763-024-10498-8.

phenomena naturally provide opportunities for strengthening this dimension of science literacy.

Meanwhile, improvements in the indicators of evaluating and designing scientific investigations, as well as interpreting scientific data and evidence, remain in the moderate category. This suggests that higher-order scientific thinking skills require more intensive and sustained practice. These findings support the evidence that students need time to adapt to inquiry-based learning because this learning model demands more complex critical thinking, analytical, and problem-solving skills.[29] Furthermore, it is argued that differences in reasoning and information processing abilities among students can influence their success in interpreting data and drawing scientific conclusions.[30]

An N-Gain score of 0.64 indicates that the scientific approach using inquiry-based methods has a positive impact on improving students' science literacy. Specifically, this instructional model yielded the most substantial development in the students' capacity to explain phenomena scientifically, which achieved a high-tier N-Gain of 0.72, driven by the hands-on investigative activities regarding natural changes. These findings reinforce previous research showing that learning that integrates scientific activities and scientific inquiry can be an effective strategy for developing science literacy competencies.[31] It is also emphasized that the success of inquiry-based learning is influenced not only by the investigative activities themselves but also by the quality of the teacher's facilitation in guiding students throughout the learning process. Therefore, the teacher's role as a facilitator is a critical factor in the successful implementation of the scientific approach and inquiry-based methods in elementary schools.[32]

The findings of this study also provide theoretical implications for elementary science education. Specifically, they reinforce the proposition that science literacy should be viewed as the outcome of active scientific inquiry rather than the simple acquisition of scientific knowledge. The integration of scientific learning procedures and inquiry activities offers a pedagogical mechanism through which conceptual understanding, reasoning ability, and evidence-based thinking develop simultaneously. Therefore, science literacy instruction should emphasize authentic investigation and scientific discourse as integral components of classroom learning.

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[29] Faizin, Susantini, and Raharjo, "Application of A Guided Inquiry Learning Model to Improve Students' Scientific Literacy Skills."

[30] Yueqi Shi and Shaowei Qu, "The Effect of Cognitive Ability on Academic Achievement: The Mediating Role of Self-Discipline and the Moderating Role of Planning," *Frontiers in Psychology* 13 (2022): 1014655, https://doi.org/10.3389/fpsyg.2022.1014655.

[31] Fan Chen and Gaowei Chen, "Technology-Enhanced Collaborative Inquiry in K–12 Classrooms: A Systematic Review of Empirical Studies," *Science & Education* 34, no. 3 (2025): 1731–73, https://doi.org/10.1007/s11191-024-00538-8.

[32] Thifa Ramadhani, Liola Sinta, and Gusmaneli Gusmaneli, "Penggunaan Strategi Pembelajaran Inkuiri dalam Meningkatkan Kemampuan Berfikir Kritis Peserta Didik," *Journal of Creative Student Research* 2, no. 3 (June 2024): 167–79, https://doi.org/10.55606/jcsr-politama.v2i3.3856.

Nevertheless, this study has limitations because it used a *one-group pretest-posttest* design without a control group and involved a relatively small sample size. Therefore, the results of this study are more appropriately used to describe improvements in science literacy after the intervention was administered. In line with the views of.[33] future research is recommended to use a quasi-experimental design with a broader sample size to obtain stronger empirical evidence regarding the effectiveness of inquiry-based learning in improving students' science literacy.

From a practical perspective, the results suggest that elementary school teachers should consider integrating scientific inquiry activities systematically into daily classroom instruction rather than implementing inquiry only during laboratory or project-based lessons. School administrators and curriculum developers may also utilize these findings as empirical support for strengthening inquiry-oriented science learning within the implementation of the Merdeka Curriculum, particularly in fostering competencies aligned with international science literacy standards.

CONCLUSION

The application of the scientific approach combined with the inquiry method proved effective in improving the science literacy of fifth-grade students at SDN 2 Jatisari on the topic of natural changes. The research results showed an improvement in students' abilities from the low category to the moderate category, with an average *N-Gain* of 0.64. This improvement indicates that students' active engagement in scientific activities (5M) was able to transform passive learning patterns into exploratory ones, thereby enabling students to better explain natural phenomena scientifically. Consequently, the integration of this learning model can serve as an alternative solution for elementary school teachers to create science education that is more in-depth, meaningful, and relevant to the demands of global science literacy competencies.

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