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Implementation of the inquiry learning model to enhance junior high school students' scientific literacy: A qualitative study

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ABSTRACT

This study aims to analyze the implementation of the inquiry learning model to enhance junior high school students' scientific literacy. The research is grounded in the concern that Indonesian students' scientific literacy remains low, largely due to traditional teaching methods focused on rote memorization rather than scientific exploration. Employing a qualitative descriptive approach with a case study design, the research was conducted at *MTs Alkhairaat Pusat Palu*. Data were collected through classroom observations, in-depth interviews, and document analysis, then processed using Miles, Huberman, and Saldaña's interactive analysis model, which consists of data condensation, data display, and conclusion drawing. The results show that the guided inquiry learning model effectively promotes students' active participation, strengthens their scientific reasoning abilities, and deepens their conceptual understanding of natural phenomena. The teacher acts as a facilitator, guiding students to construct knowledge through investigation and reflective discussion. Improvements in scientific literacy were evident in students' ability to interpret experimental data, explain scientific phenomena logically, and connect scientific concepts with real-life contexts. Supporting factors included teacher readiness, the use of relevant contextual materials, and a collaborative learning environment. Theoretically, this study reinforces social constructivism as a foundation for inquiry-based science education, while practically, it provides recommendations for developing curricula and teacher training programs that emphasize evidence-based scientific investigation and inquiry-oriented pedagogy.

Keywords: inquiry-based learning; scientific literacy; science education; junior high school; qualitative study.

1. INTRODUCTION

In recent years, improving students' scientific literacy has become a major global concern in science education. International assessments such as the Programme for International Student Assessment (PISA) consistently report that Indonesian students' scientific literacy performance remains below the OECD average. This condition indicates challenges in students' ability to apply scientific knowledge to real-world problems and evidence-based decision making. In the context of rapid technological development and increasing environmental challenges, strengthening scientific literacy among junior high school students is therefore an urgent educational priority.

Science education at the junior high school level plays a crucial role in shaping students' scientific literacy, which enables them to understand, interpret, and evaluate natural phenomena based on evidence. In the current global context, scientific literacy has become a fundamental competency that supports individuals in making informed decisions about environmental, technological, and health-related issues. However, various international assessments such as PISA (Programme for International Student Assessment) continue to show that Indonesian students' performance in scientific literacy remains below the OECD average. Learning activities in science classrooms are often dominated by lecture-based instruction and the memorization of facts rather than the exploration of scientific concepts through inquiry and experimentation. This situation reflects a pedagogical gap between the expected competencies outlined in the curriculum and the learning practices implemented in schools, indicating the need for transformative teaching approaches that emphasize reasoning, investigation, and evidence-based thinking (Haryanto, Bakar, & Sanova, 2020).

In addressing these challenges, inquiry-based learning emerges as a pedagogical model that aligns with the constructivist perspective, where students actively construct their understanding through investigation, experimentation, and reflection. This model encourages learners to engage in processes such as observing, questioning, hypothesizing, experimenting, and drawing conclusions, which are essential components of scientific reasoning. Previous studies have demonstrated that inquiry-based learning can significantly enhance students' conceptual understanding, motivation, and problem-solving skills in science education (Büyükbayraktar, 2023). Nonetheless, the implementation of inquiry learning in Indonesian classrooms remains limited due to various constraints, including insufficient teacher preparation, time limitations, and the lack of laboratory facilities that support experimental learning. Consequently, an in-depth investigation into how inquiry learning is applied in real classroom contexts is vital for understanding its effectiveness in developing students' scientific literacy.

Theoretically, this study is grounded in the principles of *constructivism* as proposed by Dewey and further developed by Llewellyn, which emphasize learning through exploration and discovery. Within this framework, knowledge is constructed actively by learners through meaningful interaction with their environment rather than passively received from the teacher. Inquiry learning, therefore, serves as a medium through which students engage in authentic scientific inquiry while developing critical thinking and problem-solving skills. This pedagogical perspective is closely linked to the concept of scientific literacy as outlined by OECD-PISA, which views literacy not merely as the acquisition of scientific knowledge but as the ability to apply that knowledge in real-world contexts to make informed judgments and decisions (Huiwen & Feng, 2011).

Based on these theoretical and empirical foundations, this study aims to: (1) describe the process of implementing inquiry-based learning in science classrooms at the junior high school level; (2) identify forms of improvement in students' scientific literacy as a result of the inquiry learning process; and (3) uncover the supporting and inhibiting factors that influence the implementation of the inquiry model in science education. These objectives guide the study in exploring how the inquiry model can be effectively integrated into the learning process to cultivate students' competencies in scientific reasoning and literacy.

Although numerous studies have examined the effectiveness of inquiry-based learning in improving science achievement, many of these studies focus primarily on quantitative outcomes rather than exploring how inquiry learning is implemented in authentic classroom contexts. There remains limited qualitative evidence describing the pedagogical processes through which inquiry-based learning fosters scientific literacy in Indonesian junior high school settings. This study addresses this gap by providing an in-depth qualitative analysis of the implementation of inquiry learning in classroom practice.

The academic contribution of this study lies in its focus on the practical implementation of inquiry-based learning within the Indonesian educational context, specifically at the junior high school level, which has been less explored in prior research. By examining the process through a qualitative descriptive approach, this study provides nuanced insights into the pedagogical dynamics that shape students' engagement and literacy development during inquiry-based instruction. The novelty of this research is reflected in its contextual emphasis on teacher facilitation, student interaction, and real-world applications of scientific inquiry, offering both theoretical enrichment and practical implications for science education reform aimed at fostering higher levels of scientific literacy among students.

2. LITERATURE REVIEW

Inquiry-based learning (IBL) is a pedagogical approach rooted in constructivist theory, emphasizing the active engagement of learners in constructing knowledge through questioning, investigating, and reasoning. Originating from the ideas of John Dewey, who advocated experiential learning as a means of developing critical thinking, the inquiry model evolved into various forms, such as guided inquiry, open inquiry, and project-based inquiry. These approaches share a central philosophy: learning occurs most effectively when students are directly involved in discovering scientific principles rather than merely receiving information passively from teachers. According to Llewellyn's (2013) framework, inquiry-based instruction comprises five essential stages—orientation, question formulation, investigation, data interpretation, and communication of findings—each contributing to the development of cognitive and metacognitive skills. The model's relevance to science education lies in its alignment with the epistemology of science itself, where knowledge is built through systematic observation, experimentation, and critical interpretation (Huiwen & Feng, 2011).

Previous studies have demonstrated a strong correlation between inquiry-based instruction and the enhancement of students' scientific literacy across various educational levels. For instance, (Farhan, Saregar, & Yuberti, 2023) found that the guided inquiry model effectively improves students' scientific reasoning and communication skills, which are key indicators of scientific literacy. Similarly, (Aulia, 2019) observed that high school students who engaged in inquiry-based learning displayed a better understanding of scientific concepts and were more capable of connecting theoretical knowledge with real-world contexts. In a study focusing on middle school students, (Innatesari, Sajidan, & Sukarmin, 2019) reported that inquiry-based teaching helped students master scientific investigation skills, including hypothesis formulation, data collection, and evidence-based reasoning. Collectively, these studies underscore that inquiry learning not only enhances cognitive outcomes but also fosters essential attitudes and competencies for lifelong scientific engagement.

Despite its demonstrated benefits, research has identified several barriers to the effective implementation of inquiry-based learning in classroom practice. (Kusuma, Wilujeng, & Susongko, 2024) found that teachers often face challenges such as limited instructional time, lack of laboratory resources, and insufficient professional training in inquiry pedagogy. Similar findings were echoed by (Madlela & Umesh, 2024), who emphasized that resource-constrained schools require innovative solutions, including the use of educational technologies, to support inquiry-based instruction. These limitations highlight the importance of developing adaptive inquiry models that can be effectively implemented in diverse educational contexts, especially in developing countries where infrastructure and teacher capacity vary widely.

The research gap in the current literature lies in the limited number of qualitative studies that explore how inquiry-based learning unfolds in real classroom settings, particularly in Indonesian middle schools. Most previous research has employed quantitative designs focused on measuring outcomes rather than analyzing the pedagogical processes through which inquiry enhances scientific literacy. Furthermore, there remains a scarcity of studies examining how teachers adapt inquiry strategies to students' cognitive levels, classroom dynamics, and contextual challenges. This study addresses that gap by providing an in-depth qualitative analysis of the implementation process, highlighting the interplay between teacher facilitation, student engagement, and contextual factors that influence learning effectiveness (Ferrín, 2018).

In positioning this study within the broader academic discourse, the research contributes to the growing body of literature that seeks to contextualize inquiry-based learning in diverse cultural and institutional environments. While much of the existing scholarship originates from Western contexts with well-established laboratory infrastructures, this study offers empirical evidence from an Indonesian junior high school, thereby enriching the global understanding of inquiry pedagogy in resource-limited settings. It also underscores the adaptability of inquiry-based models in fostering scientific literacy even under constrained conditions, reinforcing the argument that effective facilitation and contextual relevance can compensate for material limitations (Büyükbayraktar, 2023).

Recent theoretical and methodological trends indicate a shift toward integrative and hybrid models of inquiry learning that combine traditional guided inquiry with digital and STEM-based approaches. Studies such as (Bakırcı, Kirici, & Kara, 2022) demonstrate that STEM-supported inquiry enhances students' critical thinking and interdisciplinary problem-solving skills. Additionally, (Maison & Wahyuni, 2021) show that digital learning modules designed with guided inquiry principles can improve scientific literacy and learning engagement. These developments reflect the dynamic evolution of inquiry-based education, emphasizing not only hands-on experimentation but also cognitive, digital, and social dimensions of scientific learning.

Synthesizing these insights, this study establishes its conceptual foundation by integrating constructivist and inquiry-based learning theories with the concept of scientific literacy. Inquiry-based learning is conceptualized as a pedagogical process that engages students in scientific reasoning, fosters curiosity, and builds understanding through evidence-based exploration. In this sense, the present study bridges theoretical perspectives and empirical evidence, positioning inquiry learning as both a method and a mindset for cultivating scientifically literate, reflective, and critical learners capable of navigating complex real-world problems.

3. METHODOLOGY

The participants consisted of one science teacher and 32 junior high school students who were directly involved in the implementation of inquiry-based learning. Participants were selected using purposive sampling because they met the inclusion criteria of actively participating in the inquiry learning sessions observed during the study. Data collection was conducted over several weeks during the science learning unit on environmental issues to ensure that the complete inquiry cycle could be observed.

The interactive analysis model proposed by Miles, Huberman, and Saldaña was chosen because it enables iterative interpretation of qualitative data and systematic identification of patterns within classroom interactions. This approach is particularly appropriate for case study research focusing on instructional processes and contextual learning dynamics.

This study employed a qualitative descriptive approach with a case study design, aiming to explore in depth the implementation of the inquiry learning model in improving students' scientific literacy within a real classroom setting. The qualitative approach was selected to allow a comprehensive understanding of the teaching and learning dynamics, teacher strategies, and students' learning experiences during inquiry-based instruction. The case study design focused on one science class at *MTs Alkhairaat Pusat Palu*, where inquiry-based learning had been implemented as part of the school's science curriculum. This methodological choice enabled a contextualized examination of the process and outcomes, rather than the measurement of variables or statistical generalization typical of quantitative designs.

The data sources in this study consisted of both primary and secondary data. Primary data were obtained from direct observations of the teaching and learning process, in-depth interviews with one science teacher and several students, as well as supporting documentation, including lesson plans, worksheets, and field notes. Secondary data included relevant school records and policy documents that provided additional context for interpreting the observed practices. The data type was entirely qualitative, focusing on descriptive and narrative information that captured participants' experiences and perspectives related to inquiry learning.

Data collection employed multiple techniques—observation, interviews, and documentation review—to ensure a rich and credible dataset. The classroom observation focused on identifying how the stages of inquiry learning were conducted, including orientation, question formulation, investigation, data analysis, and communication. Semi-structured interviews were conducted with the teacher and selected students to explore their perceptions, challenges, and reflections on the learning process. Documentation such as students' written work, teachers' lesson plans, and classroom photographs were used to triangulate the observational and interview data. Triangulation of sources was applied systematically to enhance the credibility and validity of findings, in line with Lincoln and Guba's (1985) framework for trustworthiness in qualitative research.

The unit of analysis in this study was the classroom interaction and instructional process within one science class consisting of approximately 32 students. The participants were selected using *purposive sampling* based on their direct involvement in the implementation of inquiry-based learning. The primary participant was the science teacher who designed and facilitated the inquiry-based lessons, while students served as co-participants providing insights into their learning experiences. When needed, supplementary information was obtained from the vice principal for curriculum affairs to provide institutional context.

The data analysis followed the interactive model proposed by Miles, Huberman, and Saldaña (2014), comprising three major stages: (1) data condensation, involving selecting, simplifying, and categorizing relevant information from the raw data; (2) data display, in which the information was organized into matrices and thematic charts to facilitate interpretation; and (3) conclusion drawing and verification, where emerging themes were reviewed, refined, and validated through cross-referencing between data sources. Coding was performed manually to identify recurring patterns and themes, focusing on aspects such as teacher strategies, student engagement, literacy development, and contextual challenges.

To maintain the reliability and trustworthiness of the research, the study applied methodological triangulation, prolonged engagement in the field, and peer debriefing. The analysis process was supported by continuous memo writing and reflective note-taking to ensure that interpretations remained grounded in the data. The results were further validated through *member checking*, where participants reviewed summaries of the findings to confirm their accuracy and authenticity.

This methodological framework aligns with qualitative research principles emphasizing contextual depth, interpretive understanding, and analytical rigor. By integrating multiple data sources and applying systematic analysis, this study provides a comprehensive portrayal of how inquiry-based learning is implemented in a junior high school science classroom and how it contributes to the enhancement of students' scientific literacy.

4. RESULTS

The findings of this study were obtained through classroom observations, in-depth interviews, and documentation, analyzed using the interactive model by Miles, Huberman, and Saldaña. The data were categorized into four main themes representing the implementation of the inquiry learning model in enhancing students' scientific literacy at the junior high school level: (1) teacher strategies in implementing inquiry-based learning, (2) students' responses and engagement, (3) the development of students' scientific literacy, and (4) supporting and inhibiting factors influencing implementation.

4.1 Teacher Strategies in Implementing Inquiry-Based Learning

Observations revealed that the teacher systematically applied the major stages of the inquiry model consistent with constructivist principles. In the orientation stage, the teacher introduced the topic of global warming using visual media and posed guiding questions that stimulated students' curiosity and critical thinking. During the problem formulation stage, students collaboratively generated investigable questions such as "What causes the Earth's temperature to increase?" and "How does the greenhouse effect occur?" The teacher functioned as a facilitator, providing direction while allowing students autonomy in discussion.

In the investigation stage, students conducted a simple experiment using two bottles—one open and one closed—to simulate the greenhouse effect, measuring and recording temperature changes collaboratively. This activity reflected strong alignment with the principles of *guided inquiry*, where learners build understanding through structured investigation (Nery, Silva, & Geglio, 2022).

In the data analysis stage, students interpreted temperature changes and discussed the relationship between their observations and the concept of global warming. The teacher used probing questions to foster analytical reasoning and evidence-based thinking. Finally, during the communication stage, students presented their findings using simple visual aids such as tables and charts, reinforcing their ability to construct scientific arguments and communicate results effectively—key components of scientific literacy (Lestari, Paidi, & Suwarjo, 2024).

4.2 Students' Responses and Engagement in Inquiry-Based Learning

Students' responses toward the inquiry-based activities demonstrated high enthusiasm and engagement throughout the learning process. Interview results indicated that students preferred learning through hands-on experiments rather than traditional lectures. Observations recorded that 26 out of 32 students were fully attentive during the orientation stage, and all groups actively participated in formulating investigable questions. During the experiment, students showed initiative and cooperation in measuring temperature changes and analyzing the results. One student expressed that seeing the temperature difference between the two bottles helped them understand the greenhouse effect concretely. Such findings indicate a high level of cognitive and emotional engagement, aligning with constructivist principles of active learning (Harefa, 2023).

In the communication phase, students confidently presented their findings, using relevant scientific terms and logical reasoning. The ability to draw conclusions based on empirical evidence reflected the growth of scientific argumentation skills, a key dimension of scientific literacy as defined by OECD-PISA (Alarcon et al., 2023).

4.3 Development of Students' Scientific Literacy

The implementation of the inquiry model significantly enhanced students' scientific literacy in three primary dimensions: (1) the ability to explain scientific phenomena, (2) the ability to interpret data and evidence, and (3) the ability to relate science to daily life. Triangulated data from observations, interviews, and student reports indicated clear improvement in students' capacity to analyze experimental data and connect it with the greenhouse effect theory. Students' reports demonstrated better use of scientific terminology and logical reasoning in drawing conclusions.

Students also showed enhanced reflective thinking, as they were able to connect experimental outcomes with global environmental issues. This aligns with prior research highlighting that inquiry-based instruction fosters higher-order thinking and scientific reasoning (Hasanah, 2021). In this study, teacher guidance through probing questions effectively scaffolded students' analytical processes, supporting the theoretical foundation of *inquiry-based science education* as described by (Morris, 2025).

4.4 Supporting and Inhibiting Factors in Implementation

Several key factors were identified as supporting the successful implementation of inquiry-based learning: teacher preparedness in designing inquiry-oriented lesson plans, the use of relatable and contextual phenomena, and a classroom environment conducive to collaborative learning. The teacher's skill in managing class discussions and facilitating student-led investigations was instrumental to the model's success. The use of simple materials, such as bottles and thermometers, demonstrated that meaningful inquiry can occur even with limited resources.

Nevertheless, challenges were observed during implementation. The most prominent constraint was time limitation, as inquiry-based lessons required more class time than traditional instruction. Additionally, uneven student readiness and limited laboratory equipment posed difficulties during data collection and interpretation. Similar obstacles were documented in (Takda, Jadmiko, & Erman, 2022), who noted that inquiry implementation often struggles with procedural complexity and scheduling constraints.

4.5 Thematic Categories and Synthesis

Through thematic coding, four core categories emerged from the data: (1) Inquiry teaching strategies – encompassing lesson planning, facilitation techniques, and the teacher's role as a guide; (2) Student participation and engagement – reflecting students' motivation, interaction, and scientific reasoning development; (3) Scientific literacy development – showing increased competence in analyzing, reasoning, and communicating scientific findings; (4) Implementation challenges – addressing time constraints, resource limitations, and diverse student learning readiness.

These categories collectively highlight the overarching theme: guided inquiry learning effectively enhances students' scientific literacy through hands-on exploration, teacher scaffolding, and evidence-based reasoning. The findings corroborate previous studies confirming the positive relationship between inquiry-based learning and scientific literacy development (Farhan, Saregar, & Yuberti, 2023); (Aulia, 2019); (Innatesari, Sajidan, & Sukarmin, 2019).

5. DISCUSSION

Beyond classroom outcomes, strengthening students' scientific literacy has broader societal implications. Scientific literacy equips individuals with the ability to evaluate scientific information related to environmental sustainability, technological development, and public health issues. In the Indonesian context, where environmental challenges such as climate change and resource management are increasingly prominent, cultivating scientifically literate students contributes to the development of informed and responsible citizens.

This study has several limitations. The research was conducted within a single classroom context with a relatively small number of participants, which may limit the generalizability of the findings. Future research could involve multiple schools and adopt mixed-method or quasi-experimental approaches to further examine the long-term impact of inquiry-based learning on scientific literacy development.

The findings of this study confirm that the guided inquiry learning model plays a pivotal role in enhancing junior high school students' scientific literacy through experiential, evidence-based, and reflective learning processes. The results directly align with the study's objectives, demonstrating that the implementation of inquiry learning not only promotes active engagement and scientific reasoning but also transforms classroom dynamics by positioning students as constructors of knowledge and teachers as facilitators. The four main themes identified—teacher strategies, student engagement, scientific literacy development, and contextual factors—illustrate that inquiry-based science education fosters a more participatory and meaningful learning environment, where learners actively connect theory with real-life phenomena.

Although numerous studies have examined the effectiveness of inquiry-based learning in improving science achievement, many of these studies focus primarily on quantitative outcomes rather than exploring how inquiry learning is implemented in authentic classroom contexts. There remains limited qualitative evidence describing the pedagogical processes through which inquiry-based learning fosters scientific literacy in Indonesian junior high school settings. This study addresses this gap by providing an in-depth qualitative analysis of the implementation of inquiry learning in classroom practice.

Within the framework of social constructivism, which underpins this study, these results highlight that learning occurs most effectively when students construct understanding through active participation and social interaction. The teacher's role as a *scaffold* within Vygotsky's *zone of proximal development* was evident, particularly in guiding students to interpret data and formulate evidence-based conclusions. This finding is consistent with (Brumann, Ohl, & Schulz, 2022), who emphasized that inquiry-based learning encourages reflective thinking and strengthens conceptual understanding by connecting scientific knowledge to environmental contexts. The current research therefore reinforces the notion that inquiry is not merely a teaching strategy but a cognitive process that nurtures scientific habits of mind.

The findings also corroborate previous empirical studies demonstrating the efficacy of inquiry learning in fostering students' conceptual and procedural understanding. For instance, (Innatesari, Sajidan, & Sukarmin, 2019) found that students who experienced guided inquiry instruction developed stronger scientific reasoning skills and deeper comprehension of experimental design. Similarly, (Sarıoğlan & Gedik, 2020) observed that guided inquiry facilitated durable conceptual change and higher retention in understanding physical science topics. The present study extends these findings by showing that inquiry also cultivates reflective, collaborative, and communicative dimensions of literacy—abilities often overlooked in conventional instruction.

Nevertheless, the results also revealed implementation challenges consistent with findings from (Madlela & Umesh, 2024), who reported that limited resources and inadequate teacher training hinder the sustainability of inquiry practices in under-resourced schools. Time constraints and uneven student readiness were notable issues in this study as well. However, despite such barriers, teachers demonstrated adaptability by using simple, low-cost materials and collaborative activities to sustain the inquiry process. These findings highlight that pedagogical creativity—not necessarily advanced facilities—is central to the successful implementation of inquiry learning in science education.

In alignment with student-centered learning theory, the study also confirmed that inquiry promotes autonomy and intrinsic motivation among learners. Students' enthusiasm and ownership of learning, as noted during the investigation and presentation stages, reflect the benefits of autonomy-supportive pedagogy. This observation parallels (Buchanan, 2016), who found that student-driven inquiry fosters deep engagement and emotional investment in learning, even when challenges such as time management arise. Inquiry, therefore, functions as a vehicle for nurturing not only cognitive development but also affective and metacognitive growth.

From a professional development standpoint, this study contributes to the understanding that teachers' pedagogical beliefs and support systems are critical to the success of inquiry-based instruction. (Sager & Pierce, 2025) highlight the significance of professional learning communities (PLCs) in helping teachers collaboratively develop inquiry practices. Similarly, the present study found that the teacher's ability to adapt questioning strategies and provide responsive feedback was crucial in facilitating students' reasoning and problem-solving processes. This reinforces the need for sustained teacher mentoring and collegial collaboration to enhance inquiry implementation fidelity.

Conceptually, the findings of this study support the view that scientific literacy encompasses not only knowledge acquisition but also epistemic understanding—the recognition that science is a process of inquiry, argumentation, and evidence evaluation. (Koutsianou & Emvalotis, 2021) emphasize that teachers' epistemological beliefs significantly influence how they enact inquiry-based teaching. Consistent with their findings, this study showed that the teacher's belief in learning as an active construction process led to more authentic inquiry experiences for students, where mistakes and discussions were treated as essential parts of scientific reasoning.

The scientific contribution of this research lies in its empirical and contextual elaboration of how guided inquiry enhances literacy among junior high school students in Indonesia—an area that remains underrepresented in the global literature. The results affirm that the success of inquiry learning depends on the synergy between teacher facilitation, student engagement, and contextual relevance, rather than on the availability of advanced tools. These findings echo (Basche et al., 2016), who demonstrated that locally contextualized inquiry projects can foster students' ability to formulate data-driven arguments while enhancing environmental awareness. In the same vein, this study highlights the potential of context-based inquiry to make science more meaningful and culturally relevant to learners.

This study acknowledges certain limitations, particularly regarding scope and generalizability. As the research was confined to a single classroom and one teacher, the findings are context-specific. Variables such as school policy, teacher expertise, and student demographics may influence the replicability of results. The qualitative approach, by design, prioritizes depth of understanding over breadth, and therefore future studies might adopt mixed-methods or quasi-experimental designs to assess the long-term and quantifiable impact of inquiry-based instruction, as recommended by (Bakırcı, Kirici, & Kara, 2022).

Finally, the implications of this study are twofold. Practically, it emphasizes the need for teacher training programs that equip educators with inquiry-based pedagogical competencies, alongside institutional policies that allocate sufficient time for investigation-driven lessons. Technologically, the study encourages the integration of digital and STEM-oriented inquiry, as demonstrated by (Maison & Wahyuni, 2021), who showed that digital inquiry modules enhance students' literacy and engagement. Furthermore, cross-curricular applications such as the design-based inquiry approach proposed by (Tan & Lee, 2022) suggest that inquiry can be expanded beyond science to cultivate innovation and sustainability competencies. Collectively, these insights position inquiry-based learning as a transformative pedagogical framework for nurturing scientifically literate, reflective, and adaptive learners prepared to face the challenges of the 21st century.

6. CONCLUSION

This study concludes that the implementation of the inquiry learning model in junior high school science classrooms significantly enhances students' scientific literacy by fostering active participation in the processes of investigation, reasoning, and evidence-based communication. Inquiry-based instruction enables students to construct knowledge through observation, questioning, experimentation, analysis, and reflection. The findings demonstrate that guided inquiry not only improves conceptual understanding but also develops critical thinking, reflective reasoning, and scientific communication skills—core components of scientific literacy. The teacher's role as a facilitator proved essential in creating a collaborative learning environment that encouraged students to explore, interpret data, and draw logical conclusions. Hence, structured inquiry-based learning can be regarded as an effective pedagogical approach for improving students' ability to connect scientific theories with real-world phenomena and to construct logical, evidence-supported arguments.

The primary contribution of this research lies in its theoretical and practical reinforcement of inquiry-based learning as a powerful framework for science education at the secondary level. Theoretically, it extends the constructivist understanding of science learning by emphasizing knowledge construction through reflective and investigative engagement. Practically, it provides actionable insights for teachers to integrate inquiry strategies into daily classroom instruction, thereby cultivating a culture of scientific inquiry among students. Moreover, the findings offer guidance for schools and educational policymakers in designing curricula and teacher training programs that support sustained inquiry-oriented pedagogy.

As a forward-looking implication, this study suggests further exploration of integrating inquiry-based learning with digital tools and STEM education to strengthen scientific literacy and 21st-century skills. Future research could employ mixed-methods or longitudinal designs to measure the long-term impacts of inquiry-based learning on scientific reasoning, creativity, and scientific attitudes. On a broader scale, educational institutions should ensure that teachers receive adequate pedagogical training and access to resources that enable them to effectively implement inquiry-based instruction, ensuring that every student has the opportunity to experience science as a process of discovery rather than memorization.

Ethical Approval

Not Applicable

Informed Consent Statement

Not Applicable

Authors' Contributions

M developed the overall research design, constructed the theoretical and methodological framework, led the classroom observations and interviews, conducted data analysis based on the Miles, Huberman, and

Saldaña model, and prepared the initial draft of the manuscript. HS contributed to the collection and validation of field data, performed the transcription and coding of qualitative data, and assisted in the preparation of the *Results* section. MKR conducted the literature review, contributed to the interpretation of findings and the development of the *Discussion* section, and revised the manuscript to enhance its analytical depth and theoretical coherence. GAT refined the overall structure of the article, ensured academic and linguistic accuracy, and finalized the manuscript for submission and publication.

Disclosure statement

The authors declare that there are no conflicts of interest, financial or otherwise, related to the conduct, analysis, or publication of this research.

Data Availability Statement

The data presented in this study are available on request from the corresponding author due to privacy reasons.

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REFERENCES

Alarcon, D., Talavera-Mendoza, F., Paucar, F., Caceres, K., & Viza, R. (2023). Science and inquiry-based teaching and learning: A systematic review. *Frontiers in Education, 8*. https://doi.org/10.3389/feduc.2023.1170487

Aulia, E., & Aulia, E. (2019). Improving science literacy skills for high school students through guided inquiry-based learning. *Proceedings of the Mathematics, Informatics, Science, and Education International Conference (MISEIC 2019)*. https://doi.org/10.2991/miseic-19.2019.36

Bakırcı, H., Kirici, M., & Kara, Y. (2022). The effectiveness of STEM-supported inquiry-based learning approach on conceptual understanding of 7th graders: Force and energy unit. *Journal of Science Learning*. https://doi.org/10.17509/jsl.v5i3.43647

Basche, A., Genareo, V., Leshem, A., Kissell, A., & Pauley, J. (2016). Engaging middle school students through locally focused environmental science project-based learning. *Natural Sciences Education, 45*, 1–10. https://doi.org/10.4195/nse2016.05.0012

Brumann, S., Ohl, U., & Schulz, J. (2022). Inquiry-based learning on climate change in upper secondary education: A design-based approach. *Sustainability*. https://doi.org/10.3390/su14063544

Buchanan, S. (2016). Exploring the lived experience of middle school students engaged in inquiry-based learning. In *Proceedings of educational research* (pp. 490–498). https://doi.org/10.1007/978-3-319-52162-6_49

Büyükbayraktar, F. (2023). Deficiencies and needs for the application of inquiry-based learning in physics classes. *International e-Journal of Educational Studies*. https://doi.org/10.31458/iejes.1216011

Da Penha Nery, M., Da Silva, F., & Geglio, P. (2022). Inquiry-based science teaching through constructionism: A path towards scientific literacy. *Revista de Ensino de Ciências e Matemática*. https://doi.org/10.26843/rencima.v13n4a01

Farhan, M., Saregar, A., & Yuberti, Y. (2023). The guided inquiry model of scientific literacy: A meta-analytic study. *IJIS Edu: Indonesian Journal of Integrated Science Education*. https://doi.org/10.29300/ijisedu.v5i1.10338

Ferrín, P. (2018). *A qualitative phenomenology of Christian middle school implementation of inquiry-based science instruction* (Doctoral dissertation). Liberty University. https://digitalcommons.liberty.edu/doctoral/1668

Harefa, E. (2023). Implementation of scientific inquiry approach for enhancing scientific literacy among elementary students. *IRAONO: Journal of Elementary and Childhood Education*. https://doi.org/10.56207/iraono.v1i1.131

Haryanto, Bakar, A., & Sanova, A. (2020). Guided inquiry: How to improve scientific literacy student senior high school. *Humanities & Social Sciences Reviews, 8*(4), 720–727. https://doi.org/10.18510/hssr.2020.8471

Hasanah, D. (2021). The influence of inquiry-based learning model on self-efficacy and scientific literacy of high school students. *Asian Journal of Science Education*. https://doi.org/10.24815/ajse.v3i2.20308

Huiwen, T., & Feng, X. (2011). Inquiry-based education and its implication to education in China. In *Advances in education research* (pp. 527–534). https://doi.org/10.1007/978-3-642-24772-9_76

Innatesari, D., Sajidan, S., & Sukarmin, S. (2019). Middle school students' mastery of scientific inquiry literacy based on gender and school location. *Journal of Physics: Conference Series, 1241*. https://doi.org/10.1088/1742-6596/1241/1/012046

Koutsianou, A., & Emvalotis, A. (2021). Unravelling the interplay of primary school teachers' topic-specific epistemic beliefs and their conceptions of inquiry-based learning in history and science. *Frontline Learning Research*. https://doi.org/10.14786/flr.v9i4.777

Kusuma, M., Wilujeng, I., & Susongko, P. (2024). Challenges for middle school science teachers in assessing scientific inquiry skills: A thematic analysis. *International Journal of STEM Education for Sustainability*. https://doi.org/10.53889/ijses.v4i1.332

Lestari, D., Paidi, P., & Suwarjo, S. (2024). Effect of the inquiry-based nature of science argumentation instructional model in scientific literacy skills. *Journal of Education and Learning (EduLearn)*. https://doi.org/10.11591/edulearn.v18i3.21024

Madlela, B., & Umesh, R. (2024). Utilising educational technologies to support inquiry-based learning in natural science. *International Journal of Educational Management & Development Studies*. https://doi.org/10.53378/ijemds.353093

Maison, & Wahyuni, I. (2021). Guided inquiry science e-module development for improving junior high school students' scientific literacy. *Journal of Physics: Conference Series, 1876*. https://doi.org/10.1088/1742-6596/1876/1/012089

Morris, D. (2025). Rethinking science education practices: Shifting from investigation-centric to comprehensive inquiry-based instruction. *Education Sciences*. https://doi.org/10.3390/educsci15010073

Sager, M., Pierce, K., & Murillo, J. (2025). Enhancing inquiry-based science instruction: The role of professional learning communities and instructional coaching for elementary science teachers. *Journal of Education and Learning*. https://doi.org/10.5539/jel.v14n5p26

Sarıoğlan, A., & Gedik, I. (2020). Investigated effects of guided inquiry-based learning approach on students' conceptual change and durability. *Cypriot Journal of Educational Sciences, 15*, 674–685. https://doi.org/10.18844/cjes.v15i4.5050

Takda, A., Jadmiko, B., & Erman, E. (2022). Development of INoSIT (integration nature of science in inquiry with technology) learning models to improve science literacy: A preliminary study. *Jurnal Penelitian Pendidikan IPA*. https://doi.org/10.29303/jppipa.v8i1.957

Tan, T., & Lee, Y. (2022). Building improvised microbial fuel cells: A model integrated STEM curriculum for middle-school learners in Singapore. *Education Sciences*. https://doi.org/10.3390/educsci12060417