

The Role of Inquiry Based Learning in Science Learning: A Systematic Review of Literature

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Abstract: This study aims to examine the role of Inquiry-Based Learning (IBL) in improving the quality of science learning through a systematic literature review. The methodology followed the PRISMA framework, analyzing 17 reputable scientific articles retrieved from the Scopus database between 2018 and 2024. The results of the study indicate that IBL has a significant positive impact on science learning, particularly in enhancing students' conceptual understanding, scientific process skills, and critical thinking abilities. Additionally, IBL contributes to increasing students' motivation and positive attitudes toward science through active engagement in the learning process. Further discussion reveals that the success of IBL implementation is influenced by various factors, such as teacher readiness, availability of facilities, and learning time management. Nevertheless, IBL remains an effective approach in supporting student-centered science learning. Overall, this study concludes that IBL has great potential in improving the quality of science learning, but requires appropriate support and implementation strategies to be applied optimally.

Keywords: Critical thinking; Inquiry-based learning; Motivation to learn; Science education; Science process skills

Introduction

The progress of a nation can be gauged by the quality of its educational standards. These educational standards are influenced by various factors, such as teacher effectiveness, student achievement, and the quality of educational facilities and infrastructure (Nurulwati et al., 2020). Furthermore, education in the modern era is expected to focus not only on the mastery of knowledge but also on the development of 21st-century skills such as critical thinking, creativity, communication, and collaboration (Arafat et al., 2024). These skills are crucial for addressing increasingly complex and dynamic global challenges (Darling-Hammond et al., 2020). Therefore, the education system must adopt innovative, student-centered learning approaches to produce graduates who are competent and adaptable to changing times; this necessitates special attention to the implementation of learning across various subjects, including science.

One of the subjects considered difficult and less popular among students in Indonesia is physics (Citra et

al., 2020). Physics is a branch of science that studies the phenomena of the universe and the application of technology in everyday life (Aprilia et al., 2023). However, learning physics is often considered difficult because its concepts are abstract and require a high level of mathematical understanding (Rasyid et al., 2025). Furthermore, a teacher-centered approach to learning results in students being less actively engaged in the learning process (Busa & Chung, 2024). Consequently, students' conceptual understanding is suboptimal, necessitating a more innovative and student-centered approach to learning, which highlights the importance of implementing inquiry-based learning.

Studying physics is important for students because it equips them with skills that are useful in today's daily life (Susanti et al., 2021; Zudaire et al., 2022). Physics education helps prepare students to excel and compete in the 21st century (Bao & Koenig, 2019). However, results from the Programme for International Student Assessment (PISA) indicate that students' science achievement in various countries, including Indonesia, remains below the international average (Ayu et al.,

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2025). This situation highlights a gap between learning objectives and actual outcomes, necessitating more effective learning strategies to improve the quality of student learning outcomes—one of which can be achieved through Inquiry-Based Learning.

Inquiry-Based Learning (IBL) is a problem-based learning approach in which students engage in an investigative process, much like scientists, to discover knowledge (Ullrich et al., 2024). This approach allows students to learn actively through exploration, experimentation, and data analysis (Pedaste et al., 2015; Slapničar et al., 2024). Research indicates that inquiry-based learning can significantly enhance student engagement and conceptual understanding compared to conventional methods (Gomez, 2025). In this approach, teachers act as facilitators who guide students through the learning process (Furtak et al., 2012). Thus, IBL is a relevant approach for improving the quality of science learning, and its implementation warrants further study.

Science learning using an inquiry-based approach is one of the most widely accepted methods across various levels of education (Harleni et al., 2025). This approach facilitates the modeling of laws and theories about the world around us, making science easier to understand and more relevant to everyday life (Talavera-Mendoza et al., 2024). Furthermore, recent research indicates that students' active engagement in inquiry-based learning positively contributes to science learning outcomes and motivation (Meulenbroeks et al., 2024). This suggests that inquiry-based learning holds significant potential for improving the quality of learning, warranting further analysis through a systematic literature review.

In science education research, various efforts have been made to develop student-centered learning strategies aimed at enhancing conceptual understanding and reducing misconceptions (Brookes et al., 2020). IBL is grounded in constructivist theory, which emphasizes that knowledge is constructed through direct experience and social interaction (Aidoo, 2024). Research indicates that the implementation of IBL, when accompanied by appropriate scaffolding, can significantly improve student learning outcomes (Waked et al., 2024). Thus, this approach not only enhances conceptual understanding but also students' scientific process skills, which warrant further in-depth examination based on existing research findings.

Various studies have shown that inquiry-based learning can enhance students' conceptual understanding, scientific process skills, and critical thinking abilities (Gómez & Suárez, 2020; Rusdiyana et al., 2024). Additionally, this approach can also boost students' motivation and foster positive attitudes toward science learning (Nuutila et al., 2020). However, the implementation of IBL still faces various challenges,

such as time constraints, teacher readiness, and a lack of learning support facilities (Roslan et al., 2023). Therefore, a more comprehensive study is needed to understand the role and effectiveness of Inquiry-Based Learning in science education across various educational contexts.

Based on the above discussion, it can be concluded that Inquiry-Based Learning holds great potential for improving the quality of science education; however, a more in-depth analysis through a systematic literature review is still needed. Therefore, this study aims to conduct a systematic review of the literature regarding the role of Inquiry-Based Learning in science education in order to provide a comprehensive overview and serve as a foundation for the development of more effective teaching strategies in the future.

Method

The following section outlines the research that will be utilized in this study. Three main components will be addressed in this study: i) the impact of inquiry-based learning on learning; ii) students' attitudes toward science; and iii) future challenges and strategies. This systematic section will review and synthesize the journal literature to identify, select, and examine relevant research on inquiry-based learning. Subsequently, the findings will be synthesized and categorized, and future developments in inquiry-based learning will be identified.

A literature review is a systematic, explicit, and reproducible method used to identify, evaluate, and synthesize the research findings and ideas of previous researchers (Okoli, 2015). In this study, the PRISMA 2020 framework was used as a guideline (Page et al., 2021). PRISMA also places greater emphasis on evaluating randomized controlled trials in survey studies. This is a crucial feature for systematizing various types of research. To evaluate this research method, the Scopus electronic database was utilized. In the literature review, this database covers information on social sciences, learning or education, and some information technology. This is because there is currently no comprehensive and perfect database. In this study, the systematic review process was divided into three parts, selecting the most relevant articles at each stage of the research.

Identification

This review consisted of three main stages, each responsible for selecting and determining the relevant articles in this study. The first stage was the identification stage, where relevant literature was searched through various databases. At this stage, the steps involved entering keywords, relevant terms, as well as selecting the databases to be used. The researcher ensured that the search process was specific and

comprehensive to obtain relevant and targeted research. Therefore, all relevant keywords were identified, and search strings were applied, particularly in databases such as Scopus. Table 1 provides detailed information on

the search strings used in each database. In this study, a total of 459 journals were retrieved from the databases at the initial stage of this review.

Table 1. The Search String

Databases	Search strings
Scopus	(TITLE-ABS-KEY ("Inquiry Based Learning") AND TITLE-ABS-KEY ("Attitude") AND TITLE-ABS-KEY (Science) AND TITLE-ABS-KEY (education OR learning)) AND PUBYEAR > 2018 AND PUBYEAR < 2025

Screening

The next stage was the screening stage, which focused on selecting articles and conference proceedings relevant to the topic of this study. Articles and conference proceedings were prioritized because they are considered to be the main sources that provide important information regarding the role of Inquiry Based Learning in improving students' attitudes in science learning. To maintain the focus of the study, other publications such as book reviews and meta-analyses were not included in this review. In addition, only journals written in English were included to ensure the completeness and relevance of the review. The study also set a time span of the last six years, from 2018 to 2024, to ensure that the sources used were current.

At this stage, duplicated journals were also identified and eliminated from the list. The screening process was conducted by applying strict criteria, which resulted in 442 journals that did not meet the requirements being excluded from the total initial pool. Thus, the most relevant and up-to-date journals related to this topic could be identified and selected to support the research.

Table 2. Category Selection

Category	Inclusion	Exclusion
Language	English	Non-English
Period	2018-2024	<2019
Types of literature	Journal (Article)	Journal

Eligibility

Journals that pass the screening stage are further evaluated in the eligibility stage. This stage ensures that the selected journals meet research standards, are of good quality, and are relevant to the review. The evaluation process covers methods, population, research results, clarity of questions, quality of design, and appropriateness of analysis. Openness and potential replication of the research were also important considerations. At this stage, 459 journals were examined to ensure their topics and ideas fit the research objectives. After evaluation, 442 journals were removed as they did not meet the criteria. Only journals that were truly relevant and of high quality were selected for the final study.

Data Abstraction and Analysis

The screening stage focused on selecting articles relevant to research on the role of inquiry-based learning on student attitudes in science education. Publications such as book reviews and meta-analyses were excluded to maintain focus. Only English-language journals from the last 6 years (2018-2024) were selected, with duplicate journals removed. From this process, 442 journals were eliminated for not meeting the criteria, so only recent and relevant journals were retained.

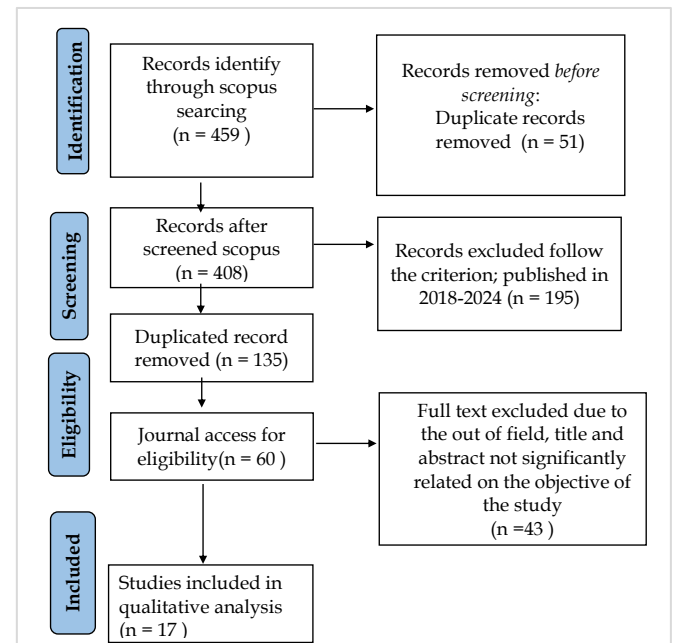


Figure 1. Flow diagram of the proposed search study

The data synthesized in this study will identify the impact of inquiry-based learning on students' attitudes in science education and provide an overall evaluation of the effectiveness of the method. This research utilizes a qualitative approach in both data collection and analysis. In addition, this study also examines trends, challenges and gaps in future research in relation to previous findings. Some of the results discussed are based on previous research. A more in-depth review will also provide valuable insights for the academic community, including researchers and educators, in utilizing technology, particularly inquiry-based learning, to enhance problem-solving skills. The analysis

conducted will provide guidance and goals for future research. The ultimate goal of this analysis is to make a meaningful contribution to the development of science education theory and practice, particularly in terms of the role of inquiry-based learning.

Result and Discussion

Based on the results of a systematic literature review, a number of relevant articles were identified regarding the application of Inquiry-Based Learning (IBL) in science education. The analysis results indicate that the majority of studies report positive impacts of IBL on various aspects of learning, particularly conceptual understanding, scientific process skills, critical thinking skills, and student motivation. These findings suggest that IBL is an effective learning approach for improving the overall quality of science education.

First, regarding conceptual understanding, the study's findings indicate that inquiry-based learning helps students develop a deeper understanding compared to conventional learning. This is because students are directly involved in the processes of investigation, experimentation, and data analysis, making the concepts they learn more meaningful. This finding aligns with the research by Gómez et al. (2020), which states that IBL has a significant effect on improving students' science achievement. Additionally, other studies have shown that active engagement in the inquiry process allows students to construct knowledge independently, thereby reducing misconceptions (van der Graaf, 2020). Thus, IBL plays a crucial role in building strong conceptual understanding, which in turn impacts students' science process skills.

Second, regarding science process skills, the analysis results indicate that IBL consistently enhances students' abilities to make observations, formulate hypotheses, conduct experiments, and draw conclusions. This is because IBL positions students as the primary agents in the scientific process. Research by Rapi et al. (2025) indicates that the implementation of IBL significantly enhances students' science process skills. Furthermore, this approach trains students to think systematically and scientifically through structured investigative stages. Therefore, IBL focuses not only on learning outcomes but also on the learning process itself, which is closely linked to the development of critical thinking skills.

Third, regarding critical thinking skills, the study's findings indicate that IBL makes a significant contribution. Through inquiry-based activities and problem-solving, students are trained to analyze information, evaluate evidence, and make decisions based on data. Research by Anugrah et al. (2025) shows that inquiry-based learning effectively improves

students' critical thinking skills. Additionally, Gómez et al. (2020) also confirm that IBL is capable of developing the higher-order thinking skills that are essential for 21st-century learning. Thus, IBL is a relevant approach for developing students' critical thinking competencies, which in turn influences their motivation and learning attitudes.

Fourth, regarding students' motivation and attitudes toward science learning, the research findings indicate that IBL significantly enhances students' interest and motivation to learn. This is because inquiry-based learning provides a more active, engaging, and contextual learning experience. Research by Potvin et al. (2014) indicates that IBL positively contributes to increased intrinsic motivation and positive student attitudes toward science. Additionally, Attard et al. (2021) also found that direct engagement in scientific activities can enhance students' interest in learning.

However, despite its many advantages, the study's findings also indicate that the implementation of IBL still faces various challenges. Several studies reveal that limited instructional time is one of the main obstacles in the implementation of IBL, as the inquiry process requires more time compared to conventional methods. Additionally, teacher readiness and competence are also critical factors, as not all teachers possess the ability to effectively design and manage inquiry-based learning (Kang, 2022). Research by Roslan et al. (2023) also indicates that limitations in facilities and learning resources contribute to challenges in IBL implementation. Therefore, support from various stakeholders—including teacher training and the provision of adequate resources—is necessary to ensure IBL is implemented optimally.

Overall, the results of this systematic review indicate that Inquiry-Based Learning plays a crucial role in enhancing the quality of science education, encompassing students' cognitive, skill-based, and affective aspects. However, the success of its implementation is greatly influenced by various supporting factors, such as teacher readiness, availability of facilities, and learning time management. Therefore, appropriate strategies are needed in implementing IBL so that its benefits can be maximized in science learning.

These findings were obtained through a systematic literature review utilizing the Scopus database as the primary source of reputable scientific literature. The data collection process involved the selection and analysis of 17 journal articles relevant to the research topic. These articles were selected based on specific criteria to ensure their relevance and contribution to the study. Basic information from the selected journals, such as author names, article titles, and other details, was then summarized and presented in Table 3. This table serves as a comprehensive list of articles that have undergone

the selection and analysis process in accordance with the criteria established in this study.

Table 3. Extracted Journal Data for Analysis

Author	Title
Toma, R. B., Greca, I. M.	The effect of integrative STEM instruction on elementary students' attitudes toward science
Ramnarain, U, Hlatswayo	Teacher beliefs and attitudes about inquiry-based learning in a rural school district in South Africa
Hofer, E, Lembens, A	Putting inquiry-based learning into practice: How teachers changed their beliefs and attitudes through a professional development program
Kiernan, D A, Lotter, C	Inquiry-Based Teaching in the College Classroom: The Nontraditional Student
Letina, A	Factors influencing the frequency of use of inquiry- based approach to teaching primary science
Shi, W.-Z., Ma, L, Wang, J	Effects of inquiry-based teaching on Chinese university students' epistemologies about experimental physics and learning performance
Correia, C F, Harrison, C	Teachers' beliefs about inquiry-based learning and its impact on formative assessment practice
Langbeheim, E, Perl, D,	Science Teachers' Attitudes towards Computational Modeling in the Context of an Inquiry-
Yerushalmi, E	Based Learning Module
Van Uum, M S J, Peeters, M,	Professionalising Primary School Teachers in Guiding Inquiry-Based Learning
Verhoeff, R P	
Valle, N et al.	Community Science, Storytelling, or Inquiry-Based Learning? Evaluating Three Technology-Enhanced Pedagogical Approaches in an Online Botany Course
Salchegger, S	Explaining Waldorf students' high motivation but moderate achievement in science: is inquiry-based science education the key?
Lupi3n-Cobos, T et al.	Building STEM Inquiry-Based Teaching Proposal Through Collaborations Between Schools and Research Centres: Students' and Teachers' Perceptions
Slim, T et al.	Struggling or Succeeding in Science and Technology Education: Elementary School Students' Individual Differences During Inquiry- and Design-Based Learning
Nzomo, C M, Rugano, P,	Relationship between inquiry-based learning and students' attitudes towards chemistry
Njoroge, J M	
Wu, L et al	Investigating Student-Generated Questioning in a Technology-Enabled Elementary Science Classroom: A Case Study
Khurma, O A, El Zein, F	Inquiry skills teaching and its relationship with UAE secondary school students' criticalthinking: Systematic review of science teachers' perspectives
Slapni3ar, M et al.	Inquiry-Based Chemistry Education Activities in a Non-formal Educational Setting for Gifted Students

The Impact of Inquiry-based Learning in Science Learning

Inquiry-based learning (IBL) aims to help students acquire knowledge through the process of inquiry, rather than simply receiving information directly from the teacher (Salchegger et al., 2021). Inquiry-based learning greatly helps students develop skills in designing and implementing new ideas. IBL creates a learning environment that encourages students to engage in innovative behavior (Acar & Tuncdogan, 2019). Thus, IBL not only plays a role in improving conceptual understanding but also fosters students' creative and innovative thinking skills in addressing various problems.

In the context of teaching, the principles of science education emphasize the importance of students' active participation in the learning process, in contrast to passive educational approaches in which the teacher plays the primary role (Manishimwe et al., 2023). Teaching methods are a key factor influencing students' attitudes toward science lessons, and students' attitudes can also influence these methods (Kousloglou et al., 2023). Therefore, the implementation of learning approaches that involve active student participation is

key to fostering positive attitudes and improving the quality of science education.

In this context, inquiry-based learning (IBL) has been identified as one of the approaches that supports active learning methods. Through IBL, students are directly involved in finding solutions to problems presented through questions, proposing various ways to solve the problems, and presenting their findings. IBL is an active learning approach in which students acquire knowledge through questions or problems they solve, based on their existing experiences or knowledge. With these characteristics, IBL is an effective approach for encouraging students to construct knowledge independently while developing critical thinking skills during the learning process.

Students' Attitude towards Science

Concerns about students' attitudes toward science have long been a focus of attention, and various factors influencing them have been studied. Research shows that the environment in which students learn science has a direct impact on their future attitudes toward science (Toma & Greca, 2018). Students' attitudes and views toward science play a crucial role in determining their

level of engagement, which ultimately influences their conceptual understanding and academic achievement. Students who recognize the impact of science in daily life tend to be more motivated to engage in scientific thinking (Jeffery et al., 2016). Students' positive attitudes toward science show a significant improvement in inquiry-based learning (IBL). This improvement is particularly evident in several key aspects, such as students' interest in science topics, confidence in understanding scientific concepts, and appreciation for the relevance of science in daily life. The IBL approach allows students to be more actively involved in the learning process, thereby reinforcing their view of the importance of science and its role in building knowledge (Kiernan & Lotter, 2019). Thus, the implementation of inquiry-based learning (IBL) not only enhances students' positive attitudes toward science but also strengthens their engagement, motivation, and understanding, thereby leading to an overall improvement in the quality of learning outcomes.

Benefits of Inquiry-Based Learning

Research findings indicate that students have a positive attitude toward the use of inquiry-based methods in science teaching and learning. They also recognize the benefits of this approach, such as increased motivation to learn and its role in helping them understand abstract scientific concepts (Correia & Harrison, 2020). Collaboration in inquiry-based learning successfully encourages students to understand science across various fields. Students are also trained to communicate their knowledge and findings effectively, helping them better convey the learning process and outcomes (Lupi3n-Cobos et al., 2022). Thus, inquiry-based learning methods not only enhance motivation and understanding of scientific concepts but also optimally develop students' communication and collaboration skills throughout the learning process.

The implementation of inquiry-based learning (IBL) in science education offers numerous benefits. This method enables students not only to understand theories but also to apply the scientific method in their investigations. This is crucial for developing critical and analytical thinking skills, which are essential components of the scientific competencies that students need to cultivate (Fadliya et al., 2024). IBL encourages students to become more independent and take responsibility for their own learning process. Thus, they are trained to seek answers and solutions through active inquiry.

Challenges in IBL Implementation

Although IBL offers many benefits, its implementation often faces challenges, particularly regarding teachers' attitudes and beliefs toward this method. Research indicates that teachers who hold

positive views regarding the effectiveness of IBL are more likely to adopt and implement it in classroom instruction (Chen et al., 2023). Consequently, teachers' attitudes and beliefs are key factors determining the success of IBL implementation; therefore, efforts to enhance teachers' understanding and provide training are necessary to ensure that IBL is implemented effectively.

Conclusion

Overall, Inquiry-Based Learning (IBL) has proven effective in improving the quality of science education, particularly in terms of students' conceptual understanding, scientific process skills, and critical thinking abilities. Furthermore, IBL is also capable of boosting students' motivation and fostering a positive attitude toward science through active engagement in the learning process. However, its implementation still faces several challenges, such as time constraints, teacher readiness and competence, and a lack of supporting facilities; therefore, appropriate strategies and support are needed to ensure its implementation runs optimally.

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Author Contributions

Conceptualization, formal analysis by Ainun Nadira (AN), Insih Wilujeng (IW), Heru Kuswanto (HK), Nisya Indriyanti Irawan (NII), and Malik Wira Gustama (MWG); Ainun Nadira (AN), initial draft writing, results and discussion; Nisya Indriyanti Irawan (NII), and Malik Wira Gustama (MWG), methodology, supervision and review; Insih Wilujeng (IW) and Heru Kuswanto (HK), supervision, conclusion and review.

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Conflicts of Interest

The authors declare that there are no relevant conflicts of interest in this study. All aspects of the research, including data collection and analysis, were conducted with high academic

integrity and without any influence from third parties that could affect the results or interpretation of the research.

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