Journal of Pedagogical Sociology and Psychology
Volume 7, Issue 4, 2025
https://doi.org/10.33902/jpsp.202532540

Review Article

Systematic literature review of inquiry-based learning models for optimizing learning outcomes at various educational levels

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Received 28 November 2025; Revised 9 March 2025; Accepted 8 April 2025

This study conducts a systematic literature review to examine and analyze inquiry-based learning models across various educational contexts, aiming to identify the most effective inquiry phases for optimizing learning outcomes at different educational levels. Widely recognized for fostering critical thinking, collaboration, and problem-solving skills, inquiry-based learning models' effectiveness largely depends on how specific inquiry phases are implemented, especially across different educational stages. Using Scopus as the primary data source, we followed PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) guidelines to identify, screen systematically, and include studies that explicitly present inquiry phases, ultimately selecting 22 relevant articles for detailed analysis. The data collected were synthesized across four main research questions: (1) primary contributions of different inquiry-based approaches, (2) common patterns in inquiry phases, (3) the impact of varied learning objectives on the inquiry structure, and (4) differences in learning outcomes based on educational contexts and approaches. The results provide insights into optimal phase sequencing across educational levels and reveal how certain phases support achieving diverse learning objectives, from enhancing critical thinking to deepening conceptual understanding. This study offers valuable guidance for educators and policymakers in designing inquiry-based models adapted to students' needs across educational stages.

Keywords: Inquiry-based learning, educational contexts, inquiry phases, systematic literature review

1. Introduction

The IBL model has proliferated in the last two decades as a practical approach to developing 21st-century student skills, such as critical thinking, collaboration, communication, and creativity (Chu et al., 2017; Novitra et al., 2021). This approach is based on constructivist theory that sees learning as an active process in which students construct their knowledge and understanding through direct interaction with the environment and social interaction with others (de Jong et al., 2024). In science learning, IBL involves students in the scientific process through various stages, from asking questions and investigating to finding data to drawing conclusions based on the data obtained (Pedaste et al., 2015). Various studies support the effectiveness of this approach, especially in improving students' conceptual understanding, analytical skills, and problem-solving abilities in science and technology (Lazonder & Harmsen, 2016; Pedaste et al., 2020).

The growing emphasis on 21st-century skills in education has necessitated a shift from traditional teacher-centered approaches to more student-centered methodologies like IBL. This shift is driven by the need to prepare students for a rapidly changing world where critical thinking, problem-solving, and collaboration are essential for success (Trilling & Fadel, 2009). Inquiry-based learning, with its focus on active engagement and exploration, aligns well with these educational goals (Fadillah et al., 2024a). However, despite its widespread adoption, there is a lack of consensus on how to effectively implement IBL across different educational levels and contexts. This gap in understanding underscores the importance of this study, which seeks to provide a comprehensive analysis of IBL models and their phases to optimize learning outcomes.

However, the effectiveness of the inquiry learning model is highly dependent on how it is implemented, including how the inquiry phases are organized and emphasized. The structure of the phases in this approach can vary depending on the educational context, level of education, and expected learning objectives (Fadillah et al., 2024b; Kuhlthau et al., 2015). Various studies have shown that some phases, such as orientation, investigation, and reflection, are crucial in creating active engagement and critical thinking in students (Minner et al., 2010; Pedaste et al., 2015). For example, the orientation phase is often used to arouse students' interest in the topic and provide sufficient context for further investigation. In contrast, the investigation phase allows students to explore the problem directly. However, there are challenges in adapting these phases across different educational levels. At the primary school level, the orientation phase may need to be more structured to help students who are just beginning the process of learning science. In contrast, at the university level, the self-investigation phase becomes more relevant as students are expected to be able to think abstractly and explore topics more independently (Chen et al., 2024; Mulyono et al., 2024).

The variability in the implementation of IBL across educational levels highlights the need for a systematic review to identify best practices and optimal phase sequencing. This is particularly important given the diverse learning objectives and student needs at different stages of education. For instance, while younger students may require more guidance and structured inquiry phases, older students may benefit from greater autonomy and complex problem-solving tasks. Understanding these nuances is critical for designing effective IBL models that cater to the unique needs of learners at each educational level.

Previous research has provided some frameworks and models to understand the phases in IBL. However, it has yet to offer specific guidelines that can be adapted for different levels of education or to achieve different learning outcomes. For example, Pedaste et al. (2015) identified an inquiry cycle consisting of five main phases: Orientation, Conceptualization, Investigation, Conclusion, and Discussion, with several sub-phases. While this study provides a comprehensive framework, it has yet to explore how the structure of the inquiry cycle can be adapted to the needs at each level of education or for specific learning objectives. Khalaf (2018) highlighted the advantages of IBL in improving students' knowledge and skills compared to traditional methods. However, this study found limitations in implementing IBL to meet educational expectations in developing students' skills without addressing how the inquiry phase structure can be adapted for specific learning outcomes.

A meta-analysis by Lazonder and Harmsen (2016) showed that the success of IBL is strongly influenced by the type of assistance provided to students. However, this study should have examined how each inquiry phase can be adapted to meet needs based on age or education level. Bogar (2019) discusses various models of IBL in science education but focuses more on general descriptions of the models without exploring specific adaptations based on specific educational levels or learning objectives. Meanwhile, Strat et al. (2024), in their review of IBSE in teacher education, identified the importance of inquiry approaches in pre-service teacher training. However, this research is still limited to the context of teacher education and needs to provide specific inquiry phase guidelines for each level of education.

This study is significant because it addresses a critical gap in the literature by systematically analyzing how IBL models can be tailored to different educational levels and learning objectives. By synthesizing findings from existing research, this study aims to provide educators and policymakers with evidence-based guidelines for implementing IBL effectively. Furthermore, this research contributes to the broader discourse on educational innovation by highlighting the importance of adapting teaching methodologies to meet the evolving needs of learners in the 21st century. This research aims to fill these gaps by compiling a systematic literature review to identify and analyze the most effective inquiry phases at each level of education. In addition, this research will explore how certain phases of inquiry can be specifically applied to achieve various learning outcomes. By identifying the optimal phase patterns, this research is expected to provide clear guidance for educators and policymakers in designing and implementing inquiry learning models that suit the characteristics and needs of students at each level of education.

2. Research Questions [RQ]

Based on the research objectives, the following research questions were formulated:

RQ 1)What are the main contributions of the approaches used in various inquiry-based learning models?

RQ 2) What is the general pattern of stages used in various inquiry learning models?

RQ 3) How do variations in learning objectives affect the structure of the applied inquiry phases?

RQ 4) How do learning outcomes differ according to the educational context and the main approaches in inquiry learning models?

3. Methods

3.1. Research Design

This study uses a systematic literature review approach to review and analyze inquiry-based learning models applied in various educational contexts. This study aims to identify, evaluate, and synthesize findings from existing research to understand the phases of inquiry that are most effective in optimizing learning outcomes at various levels of education.

3.1. Search Strategy and Data Sources

The first step in this research was to design a comprehensive and focused search strategy to find relevant articles. The Scopus database was chosen due to its broad coverage of high-quality and recognized scientific literature, including peer-reviewed journals, conferences, and other academic publications (Fadillah et al., 2025a; 2025b; Zyoud et al., 2023). Scopus is also known for its rigorous source selection process, thus ensuring the validity and reliability of the data obtained (Airyalat et al., 2019; Falagas et al., 2008). For the search strategy, researchers used the query: (TITLE("inquiry learning model" OR "inquiry-based learning model" OR "inquiry learning model")). The search was conducted without time limitation and focused on English articles to ensure consistent and easy-to-analyze results.

3.2. Article Selection Process

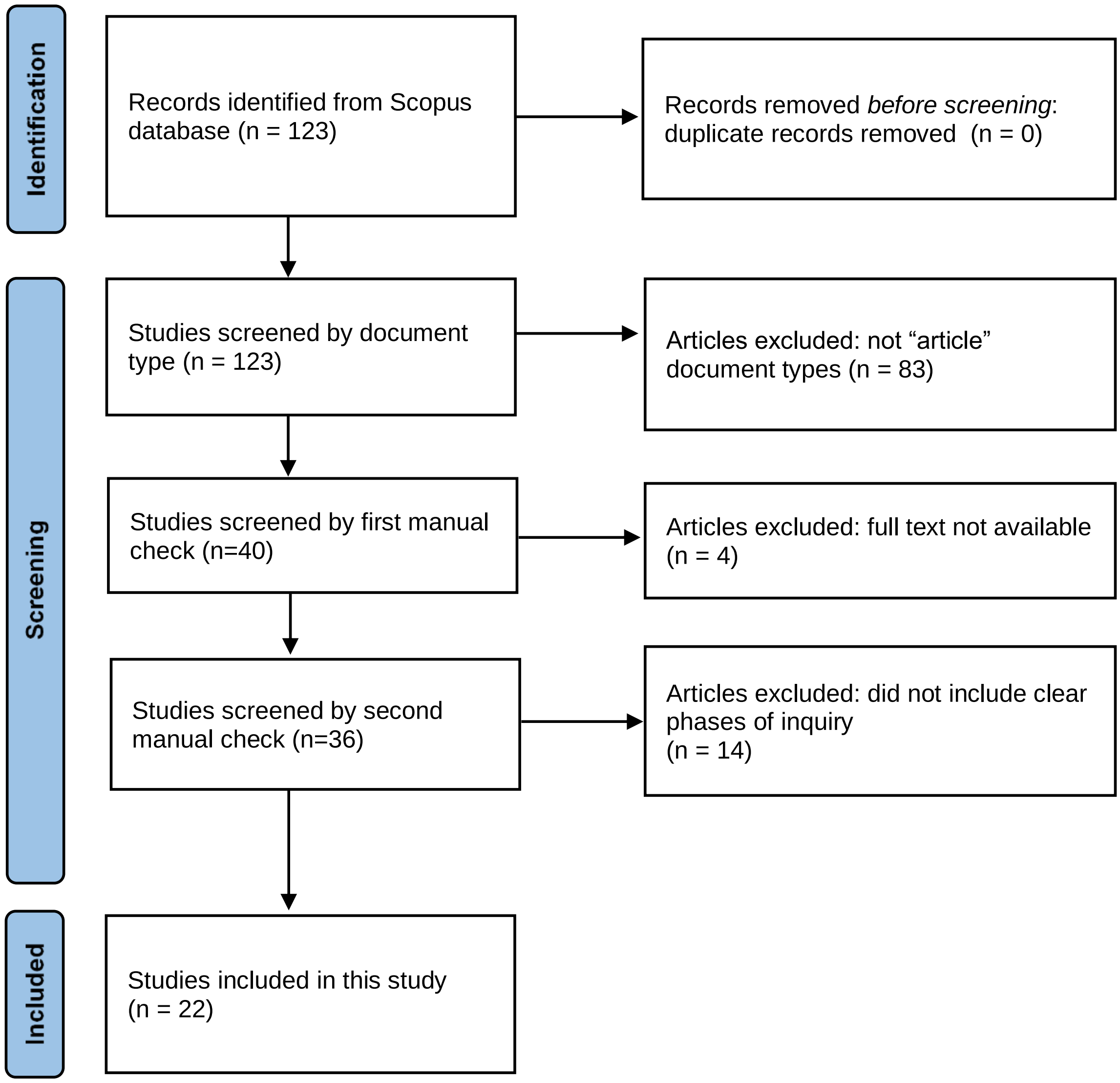
Article selection was conducted following the PRISMA Guidelines in three stages: Identification, Screening, and Inclusion (see Figure 1). At the Identification stage, an initial search on Scopus yielded 123 relevant articles, as all articles were from the same database, and no duplicates needed to be removed. The next Screening stage was conducted to ensure article eligibility based on document type. At this stage, only articles with the document type "article" were included, while the remaining 83 articles were excluded because they were not in the "article" format. As a result, 40 articles were retained for further examination.

After filtering by document type, a manual check was conducted to ensure the availability of the full text of the articles. Four articles were excluded at this stage because the full text was unavailable, leaving 36 articles for further analysis. The Inclusion stage was the final stage, where manual checks were conducted to ensure that the remaining articles explicitly presented the phases of inquiry in their learning models. From this stage, 14 articles were excluded as they needed to include clear phases of inquiry. Thus, 22 articles were finally included in the final analysis of this study.

3.3. Inclusion and Exclusion Criteria

This study set some inclusion and exclusion criteria to ensure that only relevant articles were analyzed. The inclusion criteria used included (1) articles written in English, (2) articles available in full text, and (3) articles that explicitly present the phases of inquiry in the learning model. On

Figure 1
PRISMA flow diagram



the other hand, the exclusion criteria included (1) document types other than "article," such as editorials, reviews, and short reports; (2) articles that were not available in full text; and (3) articles that did not explicitly present the phases of inquiry.

3.4. Data Analysis

The data collected from the 22 selected articles were analyzed based on the four research foci: the contribution of the inquiry approach (RQ1), common patterns in the stages of the model (RQ2), the effect of variation in learning objectives on the structure of the inquiry phases (RQ3), and differences in learning outcomes based on educational context (RQ4). These data are then synthesized to provide a deep understanding of the effectiveness of inquiry phases at different levels of education and how variations of the inquiry model can be adapted according to different learning objectives.

4. Results

Inquiry-based learning models have demonstrated various approaches and structures to improve learning outcomes across different levels and educational contexts. Studies show this model enriches students' cognitive skills and develops 21st-century competencies such as critical thinking, collaboration, and communication. Of the 22 studies reviewed (see Table 1), the inquiry

Table 1
Summary of the main contributions of various inquiry learning models and the results obtained

No	*Author(s)*	*Target group*	*Subject matter*	*Inquiry model*	*Phases of the model*	*Outcome*
1	Novitra et al. (2021)	Senior high school students	Straight motion and newton's laws	Online-based inquiry	1. Online orientation, 2. Problem identification in e-resources, 3. Exploration using ICT tools, 4. Report findings, 5. Closure	Enhances creativity, critical thinking, collaboration, and communication
2	Mulyono et al. (2024)	Adult learners	Local wisdom and culture	Ethnoscience-based inquiry	1. Cultural and local knowledge, 2. Integration orientation, 3. Formulating the problem, 4. Formulating a hypothesis, 5. Collecting data, 6. Testing the hypothesis, 7. Formulate culture-integration, 8. Conclusions	Enhances engagement and scientific literacy by integrating cultural context
3	Chen et al. (2024)	University students	Intelligent vehicle tech	ChatGPT-based inquiry	1. Orientation, 2. Conceptualization, 3. Investigation, 4. Conclusion, 5. Discussion	Improves problem-solving skills and critical information analysis
4	Yuliarti et al. (2023)	Senior high school students	Dilemma story	Local wisdom-based inquiry	1. Observing scientific texts, 2. Questioning, 3. Extracting information, 4. Synthesizing knowledge	Enhances critical thinking and scientific writing skills
5	Cahaya et al. (2020)	Kindergarten students		Guided inquiry model for creativity	1. Posing questions, 2. Finding answers, 3. Exploring probabilities, 4. Presenting findings, 5. Reflection	Promotes creativity through hands-on group activities
6	Ong et al. (2021)	Elementary school students	Electricity	5E-based inquiry	1. Engagement, 2. Exploration, 3. Explanation, 4. Elaboration, 5. Evaluation	Improves science achievement, especially for lower-performing students
7	Kolkhorst et al. (2001)	University students	Exercise physiology	Guided inquiry for active learning	1. Introduction, 2. Body composition assessment, 3. Motor unit recruitment, 4. Metabolic measurements, 5. Cardiovascular responses, 6. Research project	Increases enthusiasm and engagement in hands-on learning

Table 1 continued

No	*Author(s)*	*Target group*	*Subject matter*	*Inquiry model*	*Phases of the model*	*Outcome*
8	Al Musawi et al. (2012)	University students	Visual design	Web-based inquiry objects	1. Ask, 2. Investigate, 3. Create, 4. Discuss, 5. Reflect	Fosters engagement, creativity, and self-directed learning
9	Gunawan et al. (2020)	Senior high school students	Work and energy	Advance organizer-based inquiry	1. Advance organizer presentation, 2. Orientation, 3. Conceptualization, 4. Investigation, 5. Conclusion, 6. Discussion, 7. Integrative reconciliation	Significantly enhances problem-solving skills
10	Ong et al. (2020)	University pre-service & in-service teachers	Electric circuit	Stem-based 5E inquiry model	1. Engagement, 2. Exploration, 3. Explanation, 4. Elaboration, 5. Evaluation	Improves science content knowledge, inquiry skills, and classroom management
11	Hsiao et al. (2017)	Elementary students	Moon	FPOEIL model (prediction-observation-explanation)	1) present science question, 2) guide thinking directions, 3) provide learning tools, 4) provide similar examples, 5) answer and explain	Improved scientific learning performance on moon concepts
12	Nurohman et al. (2021)	Not report	Natural phenomena	Digital tool-assisted real-world inquiry	1) real-world problem orientation, 2) conceptualization, 3) digital analysis tool-assisted investigation, 4) generalizing findings, 5) analyzing process	Effective integration of real-world problems with digital tools
13	Kolovou and Kim (2020)	Junior high school students	Biological unit	Drama-based inquiry	1) orienting, 2) questioning, 3) investigating, 4) communicating/reflecting	Enhanced student achievement and intrinsic motivation
14	Rohaeti et al. (2020)	University students	Chemistry	Research-oriented collaborative inquiry	1) Initiating, 2) hypothesizing, 3) experiment, 4) writing, 5) evaluating and reflecting	Improved scientific attitudes
15	Abaniel (2021)	Senior high school students	Energy and momentum	Open inquiry	1) kwl chart, 2) research, 3) presentation, 4) drafting questions, 5) conducting experiments, 6) presenting results	Enhanced conceptual understanding, 21st-century skills, and learning attitudes

Table 1 continued

No	Author(s)	Target group	Subject matter	Inquiry model	Phases of the model	Outcome
16	Ong, Keok et al. (2020)	Elementary students	Magnet	5E inquiry	1) engagement, 2) exploration, 3) explanation, 4) elaboration, 5) evaluation	Significant improvement in science achievement
17	Panjaitan and Siagian (2020)	Junior high school students	Temperature and heat	Inquiry-based learning	1) orientation, 2) problem definition, 3) submission of hypotheses, 4) hypothesis testing, 5) evaluation and follow-up	Significant improvements in science process skills and scientific creativity
18	Chandra et al. (2020)	Junior high school students		Guided inquiry	1) problem identification, 2) formulate hypothesis, 3) design investigation, 4) data interpretation, 5) making conclusions	Enhanced analysis skills
19	Rifai et al. (2020)	University students	Air digital	Guided inquiry	1) orientation, 2) organization, 3) introduction to concepts, 4) publication	Improved learning outcomes and motivation
20	Setiawan et al. (2016)	Elementary students	Electrical materials	General inquiry	1) orientation, 2) formulate problems, 3) formulate hypotheses, 4) collect data, 5) test hypothesis, 6) formulate conclusions	Improved knowledge, skills, and attitudes on electrical topics
21	Zhao et al. (2021)	Elementary students	Light refraction	POE inquiry	1) prediction, 2) observation, 3) explanation	Enhanced understanding of light refraction concepts and epistemological beliefs
22	Riza et al. (2018)	Special education students	Occurrence of day and night	Multimedia-based inquiry	1) creating situation, 2) stimulating thinking, 3) independent inquiry, 4) collaborative exchange, 5) summarize to improve	Improved attitudes, knowledge, and skills in understanding day and night phenomena

learning model was applied at various levels of education, showing significant results at each level. One study showed that inquiry helps develop students' creativity through group activities in kindergarten. Seven studies at the primary school level showed increased science achievement and concept understanding through inquiry models such as 5E and POE. At the junior high school level, three studies indicated that the inquiry approach improved students' analytical thinking skills and motivation. Five studies in senior high school showed that inquiry strengthens critical thinking and problem-solving skills, which are essential in science learning.

Meanwhile, in higher education, six studies showed that the inquiry model supports the development of analytical skills, active engagement, and problem-solving in more complex learning contexts. In adult education, one study showed that inquiry based on local wisdom improved scientific literacy and engagement by integrating cultural context. Another study in special education showed that a multimedia-based inquiry model can help improve students' attitudes, knowledge, and skills in understanding natural phenomena.

4.1. Contribution of Key Approaches in the Inquiry Learning Model

Inquiry-based learning models have contributed to improving the quality of learning at various levels of education. Research results show that this approach is effective in developing 21st-century skills, integrating local cultural contexts into learning, and utilizing digital technology to enrich the learning experience (see Table 2). Each inquiry model is designed to achieve specific objectives according to the needs of learners and the learning context.

4.1.1. Development of 21st century skills

One of the main contributions of inquiry models is the development of 21st-century skills, which include creativity, critical thinking, collaboration, and communication. The online-based inquiry model (Novitra et al., 2021) is designed to enhance these skills by utilizing information and communication technology (ICT). Senior High school students who learned physics through this model showed improvements in creativity, critical thinking, and collaboration skills. The 5E-based inquiry approach (Ong et al., 2021), applied to elementary students in science learning, also improved academic achievement, especially for students who previously had low achievement. Other models, such as Drama-based inquiry (Kolovou & Kim, 2020), applied in biology learning at the junior high school level, showed increased intrinsic motivation and academic achievement through creative and reflective activities.

4.1.2. Integration of cultural and local contexts

Some inquiry models utilize cultural and local contexts to enhance the relevance of learning. Ethnoscience-based inquiry (Mulyono et al., 2024) is one model that integrates local cultural knowledge into science learning for adult learners. This approach enhances learners' engagement with scientific concepts relevant to everyday life. Similarly, Local wisdom-based inquiry (Yuliarti et al., 2023) uses local wisdom-based dilemma stories to develop senior high school students critical thinking skills and scientific writing ability. This model strengthens the understanding of scientific concepts and maintains the sustainability of cultural values.

4.1.3. Utilization of digital technology

Digital technology is essential in some inquiry models to increase learning engagement and effectiveness. ChatGPT-based inquiry (Chen et al., 2024) utilizes artificial intelligence to assist university students in analysis and problem-solving. This technology allows students to conduct more in-depth and reflective investigations. Web-based inquiry (Al Musawi et al., 2012), designed for university students in visual design, offers a self-directed learning platform using digital objects. Other approaches, such as Digital Tool-Assisted Real-World Inquiry (Nurohman et al., 2021), integrate real-world problems with digital analysis tools, providing contextualized and relevant learning experiences.

Table 2
Some key contributions of the inquiry learning model approach

Author(s)	*Inquiry model*	*Main contribution*	*Contribution respectively*
Novitra et al. (2021)	Online-based inquiry	Development of 21st century skills	Develop creativity, critical thinking, collaboration, and communication through ICT
Ong et al. (2021)	5E-based inquiry		Improve science achievement, especially for low-ability students
Kolovou and Kim (2020)	Drama-based inquiry		Improve academic achievement and intrinsic motivation
Mulyono et al. (2024)	Ethnoscience-based inquiry	Integration of local culture	Increasing engagement with science through local cultural contexts
Yuliarti et al. (2023)	Local wisdom-based inquiry		Improving critical thinking skills with the context of local wisdom
Chen et al. (2024)	ChatGPT-based inquiry	Digital technology	Improve analytical and problem-solving skills using AI
Al Musawi et al. (2012)	Web-based inquiry		Enhance creativity and self-directed learning
Nurohman et al. (2021)	Digital tool-assisted real-world inquiry		Effective in integrating real problems with digital tools

4.2. Pattern of Common Stages in the Inquiry Learning Model

Inquiry-based learning models vary in stages, although some general patterns can be identified (see Table 3). The first pattern, Exploration, and Synthesis-based Inquiry emphasizes the importance of exploration through digital tools or interactive media, followed by synthesis and deep understanding through a collaborative process. The first step in this pattern is Initial Orientation, where learners are introduced to a topic or phenomenon that interests them and provides the initial context for exploring the material. This stage refers to the inquiry model developed by Novitra et al. (2021) and Chen et al. (2024), which uses initial orientation to prepare learners to understand the problem. Next, learners enter the Problem Identification and Question Formulation stage, where they actively formulate relevant problems or questions to guide further investigation. This stage is adopted by Mulyono et al. (2024) and Nurohman et al. (2021), emphasizing the importance of question formulation to direct inquiry. The third stage, Exploration and Data Collection, relies on using digital tools or other media to explore information and collect the necessary data, per the model developed by Gunawan et al. (2020) and Al Musawi et al. (2012). The next stage is Synthesis and Analysis, where learners integrate the data or information they have collected to produce a more profound understanding or conclusion. This stage, adopted from Kolovou and Kim (2020), and Chandra et al. (2020), aims to strengthen analysis and synthesis skills. After that, learners enter the Presentation and Discussion stage, which presents their findings or analysis results in a discussion format to deepen their understanding through collaboration. This stage was inspired by the research of Rifai et al. (2020) and Rohaeti et al. (2020). This pattern ends with the Evaluation and Reflection stage, where learners reflect on the final results and evaluate the learning process to develop critical thinking skills, according to the model from Cahaya et al. (2020) and Ong et al. (2021).

The second pattern, Context-Based Collaborative Inquiry, focuses the learning approach on using relevant local or cultural contexts in science learning to build scientific skills and positive attitudes toward science. This pattern begins with Contextual Orientation, where learners are introduced to local or cultural contexts related to the topic to be explored, as described by Mulyono et al. (2024) and Yuliarti et al. (2023), who use contextual approaches as an essential part of the inquiry. The next phase is Problem and Hypothesis Formulation, where learners formulate problems or questions based on the context that has been introduced and develop hypotheses as a basis for research. This phase is adopted from models by Abaniel (2021) and Setiawan et al. (2016), emphasizing the importance of hypothesis formulation to direct the inquiry process. After that, learners proceed to the Collaborative Exploration and Investigation stage, where they work collaboratively in the process of data collection or exploration, either through technology or other resources, according to the model of Riza et al. (2018) and Rohaeti et al. (2020) model that emphasizes the importance of cooperation in data collection. The next stage is Analysis and Discussion, where learners discuss their findings together or reflect on the collected data to build a more comprehensive understanding, as suggested in the models of Kolkhorst et al. (2001) and Yuliarti et al. (2023). The process ends with the Conclusions and Contextual Implementation stage, where learners relate their findings or conclusions to the local or cultural context to strengthen the integration between cultural and scientific knowledge. This stage is rooted in the research of Mulyono et al. (2024). The final stage, Evaluation of Results and Learning, is a process of reflection on learning outcomes and a final evaluation of the whole inquiry process, as done in the models of Ong et al. (2020) and Cahaya et al. (2020).

Table 3
The stage pattern of the inquiry learning model

Learning stages	*Pattern 1: Exploration and synthesis-based inquiry*	*Pattern 2: Context-based collaborative inquiry*
1. Orientation	Initial orientation (Chen et al., 2024; Novitra et al., 2021)	Contextual orientation (Mulyono et al., 2024; Yuliarti et al., 2023)
2. Problem formulation	Problem identification and question formulation (Mulyono et al., 2024; Nurohman et al., 2021)	Problem and hypothesis formulation (Abaniel, 2021; Setiawan et al., 2016)
3. Exploration	Data exploration and collection (Al musawi et al., 2012; Gunawan et al., 2020)	Collaborative exploration and investigation (Riza et al., 2018; Rohaeti et al., 2020)
4. Analysis	Synthesis and analysis (Chandra et al., 2020; Kolovou & Kim, 2020)	Analysis and discussion (Kolkhorst et al., 2001; Yuliarti et al., 2023)
5. Presentation	Presentation and discussion (Rifai et al., 2020; Rohaeti et al., 2020)	Conclusions and contextual implementation (Mulyono et al., 2024)
6. Evaluation	Evaluation and reflection (Cahaya et al., 2020; Ong et al., 2021)	Evaluation of results and learning (Cahaya et al., 2020; Ong et al., 2020)

4.3. Effect of Variation in Learning Objectives on Inquiry Phase Structure

Different learning objectives affect the phase structure in inquiry-based learning models. Each model is designed to achieve specific outcomes, such as improving 21st-century skills, scientific literacy, or problem-solving. This variation is reflected in the stages emphasized in each model (see Table 4). For example, the Online-Based Inquiry model (Novitra et al., 2021) emphasizes the stages of Online Orientation and Exploration Using ICT Tools to develop creativity and collaboration. In contrast, the Ethnoscience-Based Inquiry model (Mulyono et al., 2024) adds unique phases, such as cultural knowledge integration to connect scientific learning with cultural contexts, aiming to increase adult student engagement and culturally based scientific literacy.

Learning models for younger levels, such as Guided Inquiry for Creativity Development (Cahaya et al., 2020), have a more straightforward yet interactive phase structure, such as Exploring Probabilities and Presenting Findings, designed to facilitate creativity through hands-on activities. In contrast, models aimed at higher-level students, such as Research-Oriented Collaborative Inquiry (Rohaeti et al., 2020), emphasize scientific stages such as Hypothesis and Experimentation, aiming to improve scientific attitudes through collaboration and reflection. Learning objectives such as improved problem-solving require more structured exploration and data analysis phases. ChatGPT-Based Inquiry (Chen et al., 2024) has Investigation and Discussion stages to support critical information analysis. Advance Organizer-Based Inquiry (Gunawan et al.,

2020) adds an Integrative Reconciliation phase to unify students' understanding after investigation.

Table 4
Influence of learning objectives on the phase structure of the inquiry model

Author(s)	*Inquiry model*	*Learning objectives*	*Different phase structure*	*Key impacts*
Novitra et al. (2021)	Online-based inquiry	Creativity and 21st century skills	1. Online orientation, 2. Problem identification, 3. Exploration, 4. Report findings, 5. Closure	Improve creativity, communication, collaboration
Mulyono et al. (2024)	Ethnoscience-based inquiry	Integration of cultural context with scientific literacy	1. Cultural knowledge, 2. Problem formulation, 3. Hypothesis, 4. Data collection, 5. Culture integration	Culture-based scientific literacy
Chen et al. (2024)	ChatGPT-based inquiry	Problem solving and information analysis	1. Orientation, 2. Conceptualization, 3. Investigation, 4. Conclusion, 5. Discussion	Problem-solving skills
Cahaya et al. (2020)	Guided inquiry for creativity	Creativity in kindergarten	1. Posing questions, 2. Finding answers, 3. Exploring, 4. Presenting, 5. Reflection	Encourage creativity through exploration
Gunawan et al. (2020)	Advance organizer-based inquiry	Problem solving through conceptual understanding	1. Advance organizer, 2. Orientation, 3. Conceptualization, 4. Investigation, 5. Integrative reconciliation	Significantly improves problem-solving skills
Rohaeti et al. (2020)	Research-oriented collaborative inquiry	Scientific and collaborative attitudes	1. Initiating, 2. Hypothesis, 3. Experiment, 4. Writing, 5. Reflecting	Improve scientific attitudes and reflective abilities

4.4. Differences in Learning Outcomes based on Educational Context and Primary Approach

The learning outcomes from implementing inquiry-based learning models vary significantly depending on the educational context and approach. These differences are evident across various educational levels, from kindergarten to higher education, as well as in specialized learning and adult education contexts (see Table 1). Analyzing these differences is essential to understanding the effectiveness of inquiry models in different learning settings.

4.4.1. Kindergarten

At the kindergarten level, the Guided Inquiry for Creativity Development model (Cahaya et al., 2020) is designed to foster creativity among young learners. Through phases such as Questioning, Finding Answers, and Reflection, this model encourages students to engage in hands-on, exploration-based group activities. The results showed a significant increase in creativity through social interaction and practical activities.

4.4.2. Elementary education

In elementary education, inquiry models are applied in varied ways, depending on specific science topics. The FPOEIL model (Hsiao et al., 2017), using a Prediction-Observation-Explanation approach, was applied to teach the moon's phases. Key steps include presenting scientific questions, guiding thinking, providing tools and similar examples, and improving the understanding of lunar concepts. The General Inquiry model (Setiawan et al., 2016) was applied to teach electrical concepts, enhancing students' knowledge, skills, and attitudes on electrical topics through systematic stages from orientation to hypothesis testing. The 5E Inquiry Model used in teaching electricity concepts (Ong et al., 2021) and magnet (Ong, Keok, et al., 2020), and the POE Inquiry Model (Zhao et al., 2021) for light refraction showed success at the elementary level by emphasizing engagement and explanation phases for deep conceptual mastery.

4.4.3. Secondary education

Learning outcomes vary between junior and senior high school levels in secondary education. For junior high students, the Drama-Based Inquiry model (Kolovou & Kim, 2020) uses drama as a medium for learning biology: orientation, investigation, and communication increase students' intrinsic motivation and academic achievement. The Guided Inquiry model for temperature and heat topics (Panjaitan & Siagian, 2020) enhances students' analytical skills and scientific creativity by following steps from problem identification to conclusion-making.

At the senior high level, the Open Inquiry approach (Abaniel, 2021), applied in physics learning on energy and momentum, has proven effective in developing 21st-century skills, including critical thinking and collaboration. The advanced organizer-based Inquiry model by Gunawan et al. (2020) also shows significant improvement in problem-solving skills on work and energy topics through structured inquiry stages. Additionally, the Online-Based Inquiry Model (Novitra et al., 2021) applied to straight motion and Newton's laws effectively enhance creativity, critical thinking, collaboration, and communication through online-based phases supported by ICT tools.

4.4.4. Higher education

In higher education, inquiry models are structured to improve understanding of course content and practical skills. Kolkhorst et al. (2001) employed the Guided Inquiry model in an exercise physiology course, increasing enthusiasm and engagement in hands-on, lab-based learning. In visual design, Al Musawi et al. (2012) implemented the Web-Based Inquiry Model with stages such as investigation and reflection, enhancing creativity and self-directed learning. The STEM-Based 5E Inquiry Model (Ong, Luo, et al., 2020), used in professional teacher training, improves science content knowledge and classroom management skills. Rifai et al. (2020) reported that the Guided Inquiry model enhanced learning outcomes and motivation for air digital topics. Other technology-based models, such as ChatGPT-Based Inquiry and Research-Oriented Collaborative Inquiry (Rohaeti et al., 2020), contribute to advanced inquiry skills development in chemistry and data analysis.

4.4.5. Special education and adult learning

In special education and adult learning, inquiry models are adapted to meet the needs and contexts of these learners. The Multimedia-Based Inquiry model (Riza et al., 2018) effectively supports special needs students in science learning, using multimedia technology in structured inquiry activities to help them understand scientific phenomena. In adult learning, the Ethnoscience Inquiry model (Mulyono et al., 2024) integrates local cultural knowledge into science learning, improving scientific literacy and engagement through culturally relevant inquiry stages.

5. Discussion

The results of this study show that inquiry-based learning models significantly impact the quality of learning at various levels of education, ranging from kindergarten to higher education. The inquiry models reviewed have specific characteristics tailored to learners' needs and their respective learning contexts. These key findings highlight how inquiry approaches make diverse contributions to developing 21st-century skills and integrating local cultural contexts, enriching learning processes and outcomes.

First, technology-based inquiry models such as online inquiry and ChatGPT-based inquiry, applied to senior high school and university students, show improvements in creative, critical thinking, collaboration, and communication skills through the utilization of ICT (Chen et al., 2024;

Novitra et al., 2021). These technologies expand students' opportunities to engage in learning relevant to the demands of the digital age, provide access to a broader range of information sources, and support independent learning (Fadillah et al., 2024a, 2024c; Tanjung et al., 2025). The use of technology in inquiry learning allows students to understand scientific concepts in depth and apply that knowledge in a real-world context, as seen in the Digital Tool-Assisted Real-World Inquiry model (Nurohman et al., 2021).

Second, the results of this study highlight the importance of integrating local cultural contexts into inquiry learning models. Models such as ethnoscience-based inquiry and local wisdom-based inquiry applied to adult learners and seniro high school students are proven to increase student engagement and understanding by utilizing cultural contexts relevant to their daily lives (Mulyono et al., 2024; Yuliarti et al., 2023). This integration increases students' learning motivation and conceptual understanding of science and supports the preservation of local cultural values. By incorporating cultural elements into the learning model, education can serve as a means to maintain and pass on cultural heritage while building scientific literacy.

Third, the findings confirm that the inquiry learning model contributes to learning outcomes in the cognitive domain and the development of 21st-century essential competencies. Critical thinking, collaboration, and communication skills are honed through collaborative processes and inquiry, as found in the drama-based model for junior high school students and the advanced organizer-based approach for senior high school students (Gunawan et al., 2020; Kolovou & Kim, 2020). By engaging students in in-depth exploration, analysis, and reflection stages, inquiry learning enables students to develop higher-order thinking skills that are much needed in today's workforce.

However, the successful implementation of these models is highly dependent on several contextual factors. For example, technological readiness is an important element, especially in online and technology-based learning (Fadhilah & Husin, 2023; Mohamed Yusof & Mohammed, 2024). Institutional support, such as adequate facilities and teacher capacity building, is also needed to encourage teacher engagement in inquiry learning (Lee, 2023). Specific challenges faced by education in Indonesia, including limited access to technology and teachers' low understanding of inquiry learning, need to be addressed for optimal and equitable implementation of this model (Rasimin et al., 2024).

This study's limitations include using the Scopus database as the sole source of articles. Although Scopus is a comprehensive academic database often used in review research (Boateng et al., 2024; Fadillah et al., 2025a; 2025b; Festiyed et al., 2024; Le Thi Tuyet et al., 2024; Maral, 2024; Medias et al., 2024), the limitation to one data source may lead to the exclusion of some crucial publications found in other databases, such as PubMed or Web of Science. This study's findings may limit generalizability, even though Scopus is widely recognized in academic circles. Future studies could use a cross-database approach to produce a more comprehensive review.

6. Conclusion

This research shows that the inquiry model is widely applied from kindergarten to higher education, including special and adult education, with results that vary by educational level. At the kindergarten level, the model supports creativity; at the elementary school level, it aids understanding of science concepts; at junior high school, it increases motivation and analytical skills; and at senior high school and university, it develops critical thinking and problem-solving skills. In addition, the inquiry model has been shown to support 21st-century skills, such as critical thinking, collaboration, and communication at different levels of education. The application of technology, such as ChatGPT in higher education, as well as the integration of local culture through an ethnoscience approach in adult education, strengthens the effectiveness of the inquiry model in improving learning outcomes according to the context of the learners. This research can provide clear guidance for educators and policymakers in designing and implementing inquiry learning models that suit the characteristics and needs of students at each level of education.

Author contributions: All authors have contributed sufficiently to this research and agree with its results and conclusions.

Declaration of interest: The authors declare that no competing interests exist.

Data availability: This study was conducted using the document analysis method. The documents used were obtained from publicly available sources and can be provided by the author(s) upon request.

Ethical declaration: This study does not require ethics committee approval, as it is based on documentary analysis and does not involve human or animal subjects.

Funding: No funding was obtained for this study.

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