26 (3), 2025, 1893-1908

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

https://jpmipa.fkip.unila.ac.id/index.php/jpmipa

The Role of Guided Inquiry to Improve Critical Thinking Skills in Physics Education: A Systematic Review of Indonesian Studies

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Abstract: This study aims to systematically analyze the role of the Guided Inquiry model in improving students' critical thinking skills in physics education in Indonesia, while also identifying current research trends, implementation strategies, and gaps in the literature. The study employed a systematic literature review (SLR) using the PRISMA framework, complemented by a bibliometric analysis, to substantiate the results. Articles were retrieved from the SINTA, DOAJ, and Google Scholar databases with a publication period from 2018 to early 2025 using the Boolean string ("inkuiri terbimbing" OR "guided inquiry") AND ("berpikir kritis" OR "critical thinking" OR "higher-order thinking skills"). Of the 117 articles identified, 27 met the inclusion criteria and were further analyzed. The analysis was descriptive, based on the year of publication, research design, educational level, instruments, and data analysis methods, as well as bibliometric mapping using VOSviewer to identify research clusters and emerging gaps. The results of the study show that the guided inquiry model is most commonly used at the upper secondary level, often employing quasi-experimental research designs, particularly pre-test-post-test control groups, and data analysis methods such as t-tests and N-gain. The dominant instrument is the essay test, although it has the disadvantage of subjectivity in assessment. The bibliometric visualization reveals that keywords such as critical thinking, guided inquiry model, and data analysis are the focus of research, while the aspect of practical applicability remains relatively underinvestigated. Another interesting finding is that the assessment indicators show the highest increase, as guided inquiry encourages students to compare the experiment results with the theoretical framework. In contrast, the self-regulation indicators show the lowest increase, which is attributed to a lack of reflective exercises and the limitations of the assessment tools. Overall, guided inquiry has proven effective in promoting various dimensions of critical thinking, especially in physics topics that require logical thinking and data analysis. However, the aspect of self-reflection is not yet sufficiently addressed and requires more attention in lesson design and assessment strategies. This study contributes to the field by providing a systematic and bibliometric mapping of the relevant literature, which can serve as a reference for teachers, researchers, and policymakers in designing more innovative, context-based physics lessons focused on strengthening 21st-century skills.

Keywords: guided inquiry, critical thinking skills, physics learning.

▪ INTRODUCTION

Critical thinking skills are among the most essential skills that learners in the 21st century must possess. The Assessment and Teaching of 21st Century Skills (ATC21S) categorizes 21st-century skills into three aspects: ways of thinking, ways of working, and the ability to live in the real world. Critical thinking is included in the "way of thinking" aspect, which includes the ability to analyze, evaluate, and reflect on a problem (Lolanessa et al., 2020). In physics learning, this skill is essential to help students

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DOI: http://dx.doi.org/10.23960/jpmipa.v26i3.pp1893-1908
Received: 02 July 2025
Accepted: 05 September 2025
Published: 26 September 2025

understand concepts in depth, solve problems logically, and make informed decisions (Riyanto, 2024). Facione (1990) formulated that critical thinking involves six main indicators, namely: interpretation (interpreting meaning), analysis (analyzing information), evaluation (assessing arguments), inference (drawing conclusions), explanation (explaining logically), and self-regulation (reflecting and correcting one's own thinking). These six indicators serve as the foundation for developing critical thinking skills overall.

Current research shows that integrating technology, particularly artificial intelligence (AI), into research-based learning strengthens students' scientific inquiry skills while improving their higher-order thinking skills (Zhai et al., 2023). AI plays a role in providing adaptive feedback, analyzing experimental data, and enabling science-based simulations that are difficult to achieve in traditional classrooms. With this support, students not only receive a more interactive learning experience but are also encouraged to ask questions, design experiments, and critically evaluate the results. International studies also confirm that the use of AI in research-based learning can improve students' collaboration, creativity, and problem-solving skills when tackling complex real-world problems. This confirms that research-oriented science learning, especially with the support of modern technologies, is increasingly meeting the demands of the 21st century.

However, the reality in the field shows that the critical thinking skills of students in Indonesia are still relatively low. The results of Hanida's research (2023) showed that the average value of students' critical thinking skills was 61.68, which fell into the very poor category. This is exacerbated by the dominance of conventional learning methods such as lectures/teachers, which provide less space for students to think analytically and reflectively. Other studies have also found that a teacher-centered learning approach still dominates physics classes at various levels of education (Nurmayani, 2018; Yulisa, 2020). In line with this, various international studies emphasize that sustainability-based education requires critical thinking as the basis for scientific and social decision-making in addressing global issues (Lozano et al., 2025).

To overcome these problems, a learning model is needed that encourages learners' active involvement and provides space for exploration and investigation. One of the relevant approaches is the Inquiry model, particularly Guided Inquiry, which provides a clear learning structure while still allowing learners to actively build their own knowledge. Guided Inquiry provides learners with structured direction and guidance, enabling them to not only experience the scientific process but also develop critical thinking skills through observation, data interpretation, and reflection on learning outcomes (Sanita, 2020). In the context of physics, international studies even show that understanding Newton's laws of cooling can be deepened through an approach based on critical thinking, which also trains students' analytical skills (Árpád et al., 2024).

A number of studies have shown that the Guided Inquiry model is effective in improving critical thinking skills, but most are empirical and do not systematically map trends, contexts of application, or bibliographies of research. For example, Aras et al. (2024), Isnawati et al. (2020), Istiana et al. (2023), and Lindriani et al. (2023) examined the effectiveness of Guided Inquiry at various levels of education; however, they did not investigate the direction of development or thematic clusters. Fitriani (2020), Safitri et al. (2024), and Ocvianti et al.(2021) focused on developing teaching tools, while Samadun et al. (2023) examined learning outcomes without exploring the broader context. Even

Adi et al. (2021), although in the form of an SLR, only discussed critical thinking trends in general without a specific focus on Guided Inquiry. Furthermore, it has been shown that a creative approach to physics teaching, which combines natural sciences with humanities, arts, and everyday life, increases student engagement while promoting critical thinking (Rouret et al., 2025). This gap underscores the need for systematic research that specifically examines the application of guided inquiry in the context of critical thinking skills in physics education in Indonesia.

Theoretically, learning physics can be seen as fertile ground for developing critical thinking skills, as it requires a deep conceptual understanding, logical thinking, and the ability to connect abstract phenomena with real-world applications. International studies show that understanding physical concepts, such as Newton's Law of Cooling, becomes more meaningful when students are trained to interpret data and draw conclusions using critical thinking (Árpád et al., 2024). Furthermore, integrating research with modern technology, including artificial intelligence, helps students navigate the complexity of experiments and sharpen their analytical skills (Zhai et al., 2023). An approach to physics that links concepts to global issues such as sustainability also underscores the importance of critical thinking as a bridge between scientific theory and social practice (Lozano et al., 2025). In fact, teaching physics in conjunction with the arts, humanities, and everyday life has been shown to broaden students' perspectives while promoting reflective thinking (Rouret et al., 2025).

This research aims to systematically examine the role of Guided Inquiry in improving critical thinking skills in physics education in Indonesia. It aims to provide a comprehensive picture for researchers, teachers, and policymakers in designing more effective physics learning.

▪ METHOD

Research Design

This study employed a Systematic Literature Review (SLR) design, adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. This design was chosen because it allows researchers to present a comprehensive synthesis of studies related to the role of Guided Inquiry in improving critical thinking skills in physics learning in Indonesia. The SLR approach emphasizes transparency, repeatability, and systematization in determining the literature, ensuring that the results obtained are more credible and accountable.

Search Strategy

The article search was conducted across several databases, including SINTA, DOAJ, and Google Scholar, with a publication period spanning from 2018 to 2025. These databases were chosen because they provide coverage of literature relevant to the context of education in Indonesia while also providing open public access. Although major international databases such as Scopus or Web of Science have broader literature coverage, this study did not utilize them due to limited full access at the time of the study and considerations of the research focus, which explicitly examined the context of physics education in Indonesia. Thus, the selection of SINTA, DOAJ, and Google Scholar is considered more representative in capturing national and regional publication dynamics. The author realizes that this strategy may limit the coverage of international literature, so

that in future studies, the integration of global databases is still recommended in order to obtain a more comprehensive picture of the contributions of Indonesian researchers at the international level. The search strategy was conducted using a combination of keywords in Indonesian and English, employing Boolean operators: ("inkuiri terbimbing" OR "guided inquiry") AND ("berpikir kritis" OR "critical thinking" OR "higher-order thinking skills"). The search yielded 117 articles. The screening process was conducted according to the PRISMA flow, which consisted of identification, screening, eligibility assessment, and final inclusion (as shown in Figure 1).

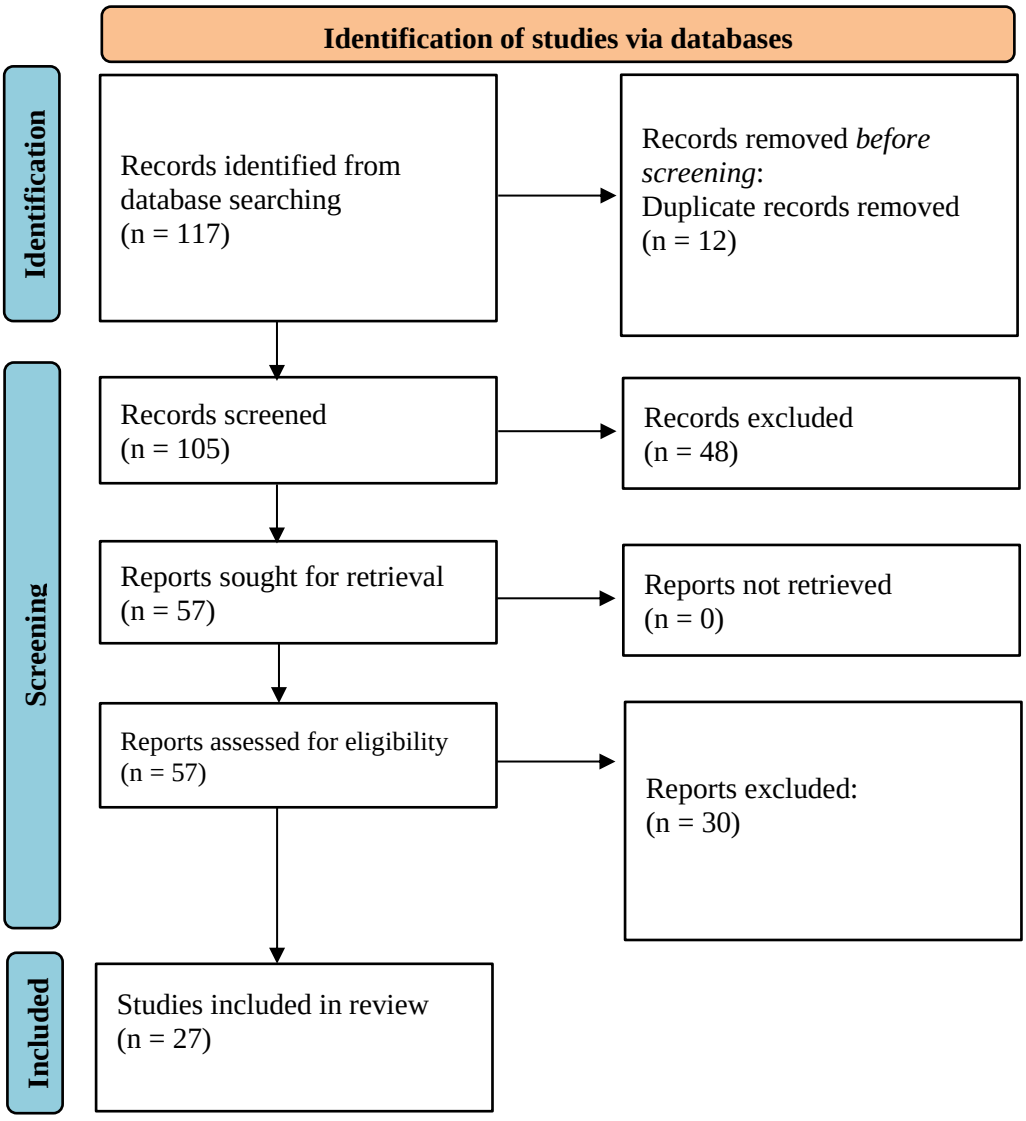

Figure 1. Article selection process

Inclusion and Exclusion Criteria

The inclusion criteria applied are: (1) articles in the form of empirical research published in accredited national journals or reputable international journals; (2) explicitly discussing the application of Guided Inquiry in physics learning; (3) research focusing on

students' critical thinking skills; (4) articles are available in open access; and (5) published between 2018 and 2025. The exclusion criteria include: (1) articles in the form of conference proceedings, seminars, or non-journal reports; (2) articles that do not present empirical data; (3) articles that do not explicitly explain the use of Guided Inquiry; and (4) articles that are not relevant to the context of physics education or critical thinking. The limitation of literature to accredited national journals and reputable international journals was chosen to ensure the quality standards of the publications reviewed. However, this strategy has the potential to cause publication bias, as relevant research published through university journals or reputable national proceedings may not be fully accommodated. The authors acknowledge these limitations and recommend that future studies consider expanding the literature sources to obtain a more inclusive picture.

Data Analysis

A total of 27 articles that met the inclusion criteria were further analyzed. The analysis was conducted in two stages. First, a descriptive analysis was performed based on the year of publication, research design, education level, learning model, instruments, and analysis techniques. Second, a bibliometric analysis was conducted using VOSviewer software. The units of analysis were author keywords and index keywords. The calculation method used full counting, and the minimum threshold for term occurrence was set at three or more times. This analysis was used to map the interrelationships between topics, dominant trends, and research clusters. In addition, to ensure the quality of the synthesized literature, a quality appraisal was conducted using the Mixed Methods Appraisal Tool (MMAT). This instrument enables the assessment of quantitative, qualitative, and mixed-methods studies. The results of the quality appraisal indicated that the majority of articles had a low to moderate risk of bias, making them suitable for generalizing the findings.

▪ RESULT AND DISSCUSSION

The initial search conducted by researchers resulted in 117 articles relevant to the topic of critical thinking skills. However, after going through a selection process that includes screening based on inclusion and exclusion criteria such as topic suitability, year of publication, type of article, and relevance to the guided inquiry learning model, the number of articles that meet the final requirements is 27. These selected articles are then further analyzed in a systematic review.

The 27 articles that met the inclusion criteria in this systematic review were published in various national and international journals relevant to the theme of applying Guided Inquiry to enhance critical thinking skills in learning. The articles cover a variety of approaches, ranging from the development of learning tools such as Student Work Sheet and e-modules based on Guided Inquiry (Fitriani, 2020; Safitri et al., 2022; Novarensa, 2023), the application of specific strategies such as gallery walk and STEM integration (Ramadhani et al., 2022; Syukri et al., 2023), to the study of the effectiveness of using the Guided Inquiry model in various levels of education (Aras et al., 2020; Istiana et al., 2021; Samadun et al., 2021). Some articles also focus on training critical thinking skills through a lesson study approach (Isnawati et al., 2021) or the use of technology such as virtual labs and Google Classroom (Ocvianti et al., 2022). In addition, there are also studies that analyze research trends related to critical thinking in physics education in Indonesia more broadly (Adi et al., 2021). Based on the results of these studies, the

majority show that the application of the Guided Inquiry model consistently improves students' critical thinking skills, encompassing aspects such as interpretation, analysis, evaluation, inference, explanation, and reflection, in accordance with Facione's critical thinking indicators. This increase occurs because the Guided Inquiry model allows students to actively observe, formulate problems, conduct experiments, collect and analyze data, and draw conclusions independently and collaboratively. Thus, all articles analyzed corroborate that Guided Inquiry is one of the effective learning models for building students' critical thinking skills, especially in physics learning, which emphasizes scientific processes.

The relationship between the two articles was identified through an analysis of their titles and abstracts. This identification is achieved by paying attention to the scope of references and the focus of the discussion, which reveals thematic linkages, thereby enabling a more systematic and effective clustering process. Based on the mapping results obtained using VOSviewer software, a visualization network is created that displays keywords interconnected between articles. Words that often appear together or have a close meaning are then grouped into the same cluster. Thus, articles with similar keywords will be incorporated into a single cluster, as visualized in Figure 2.

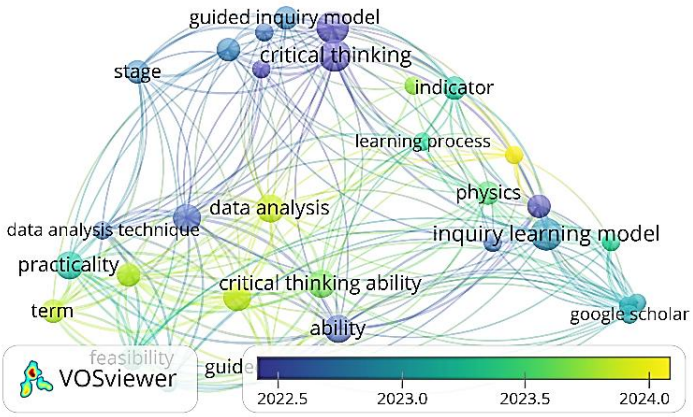

Figure 2. VOSviewer screenshot on word relevance

The VOSviewer visualization map can also be used to highlight research gaps in the analyzed literature. The mapping results show that clusters with the keyword “practicality” are relatively far from the core clusters that emphasize the “guided inquiry model” and “critical thinking.” This distance indicates that research on the effectiveness of Guided Inquiry focuses more on the conceptual and experimental domains. At the same time, studies on the practical aspects of implementing this model in the classroom are still rare. In other words, there is an imbalance between the development of a strong theoretical model and research discussing its real implementation by teachers in the field. This confirms the opportunity for further research to examine strategies, challenges, and practical solutions in integrating Guided Inquiry into everyday physics learning practices, so that this model is not only effective in theory but also applicable in the context of real education. Based on Figure 2, the following table presents clusters in physics critical thinking skills research, organized by color and keyword linkage, as commonly used in bibliometric analysis.

Table 1. Clusters in critical thinking skills research

Cluster Color	Primary Keyword	Cluster Description
Dark Blue	guided inquiry model, critical thinking, inquiry learning model, physics, stage	This cluster focuses on inquiry-based learning models, particularly guided inquiry models, which are a crucial approach in physics education. The keywords critical thinking and inquiry learning model indicate that this research examines how these models are used to improve learners' critical thinking skills in physics, including the stages in their application.
Yellow	indicator, learning process, physics, feasibility	This cluster indicates research that is more focused on indicators and learning processes in the context of critical thinking skills. Feasibility is a related keyword, indicating that this research also considers the practical implementation of learning models in the physics classroom, including an evaluation of their effectiveness in improving critical thinking skills.
Light Green	critical thinking ability, data analysis, data analysis technique, term, practicality	This cluster focuses on developing learners' critical thinking skills and applying data analysis techniques in physics research. Keywords such as data analysis technique and practicality indicate that this study also examines evaluation methods and data collection practices to assess critical thinking skills. The term shows the importance of proper terminology in studies related to critical thinking skills.
Light Blue	ability, stage, Google Scholar, guided	This cluster relates to critical thinking skills (ability) and stages of the learning process (stage). It also includes Google Scholar, which may point to important literature sources relevant to this topic. The word guided refers to the guidance aspect in the guided inquiry model to help learners develop critical thinking skills in physics.

The VOSviewer tool also provides a density map visualization of the results of bibliometric analysis using VOSviewer, which shows the frequency and relevance of keywords in research on critical thinking skills in physics education, particularly those related to guided inquiry, as illustrated in the following figure.

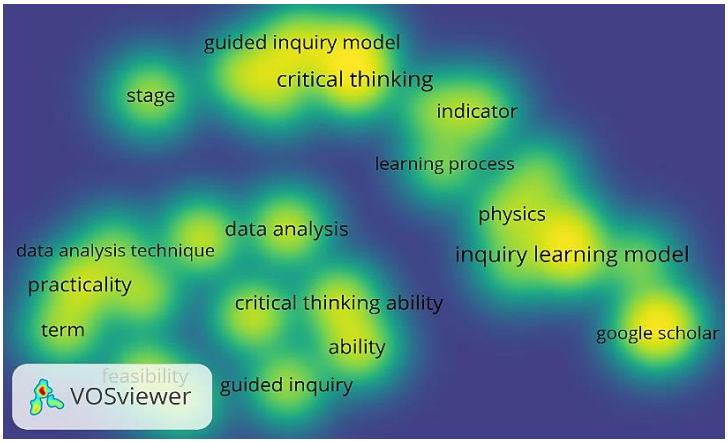

Figure 3. VOSviewer screenshot of density visualization

The density map image from the VOSviewer analysis displays the keywords that appear most frequently in the guided inquiry-based physics research on critical thinking skills. The bright yellow color marks the main keywords, such as critical thinking and the guided inquiry model, while the green and blue colors show supporting keywords, such as learning process, indicator, and feasibility. This visualization indicates that the research focus is on developing critical thinking through a guided inquiry approach in physics learning.

Aspects of Research Methods and Design

Based on the review's results, the most dominant research method employed was quantitative, utilizing a quasi-experimental design. In addition, some articles also used R&D, qualitative, and mixed methods approaches according to their respective research objectives. The following is a recapitulation table of research methods and designs.

Table 2. Recapitulation of research methods

Type of Research Method	Number of Articles	Description
Quantitative	17	Predominantly uses a quasi-experimental design with a pretest-posttest approach.
Qualitative	2	Used for in-depth exploration, such as interviews or process observations.
Mixed Methods	3	Combines quantitative and qualitative data, usually tests and interviews.
Research and Development (R&D)	5	Generally used to develop guided inquiry-based teaching tools.

Table 3. Recapitulation of research design

Type of Research Design	Number of Articles	Description
Quasi-Experiment	14	Most commonly used, comparing experimental and control classes.
Pre-Eksperiment	3	Without a control group, only measures changes after treatment.
Deskriptive	2	Explains the phenomenon or learners' perceptions of the guided inquiry model.
4D / ADDIE / Borg & Gall	8	Used in R&D studies to develop and test the validity of products.

Based on an analysis of 27 selected articles, it was found that quantitative methods with quasi-experimental designs were most commonly used to assess the effectiveness of the Guided Inquiry model in improving critical thinking skills. The most common design was a pretest–posttest control group with statistical analyses such as t-tests and N-Gain, which allowed for measurable and systematic measurement of the direct impact of the treatment. However, quasi-experimental designs have inherent weaknesses, particularly the absence of strict randomization, which can lead to selection bias and limitations in controlling for external variables. These conditions can affect the internal validity of the research, as the improvement in critical thinking skills cannot be entirely attributed to the

application of Guided Inquiry. The field's reliance on quasi-experimental designs also impacts external validity, as generalizing the results to broader educational contexts still needs to be done with caution. Thus, although the majority of studies support the effectiveness of Guided Inquiry, further research using pure experimental designs or longitudinal approaches is needed to provide stronger and more comprehensive evidence regarding the sustainability of this model's influence.

In addition, several studies also adopted a research and development (R&D) design, particularly in the development of guided inquiry-based teaching tools, such as student worksheets, modules, or interactive media, using development models like ADDIE, 4D, or Borg & Gall. Mixed methods and qualitative approaches are also employed, although not dominant, to explore learners' perceptions and examine the learning process. This reflects that research in this field is not only result-oriented, but also on developing contextual and applicable learning innovations.

Aspects of Research Subjects

Based on the analysis results, it is evident that the most dominant research subjects in studies related to guided inquiry and critical thinking skills are high school students, particularly at the X grade level. This is because at this level, students are introduced to physics concepts that are more complex and require higher-level thinking skills. In addition, at this level, students are considered to have sufficient cognitive abilities to follow the inquiry-based learning process actively and independently.

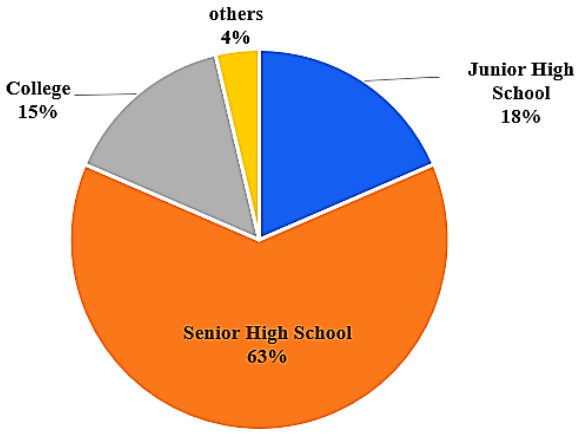

Figure 4. Distribution of research subjects

In addition to high school students, there are also several studies involving junior high school students and physics education students as subjects. Research on junior high school students generally aims to instill inquiry experiences from an early age. In contrast, research on university students focuses more on developing teaching tools or training prospective teachers in critical thinking skills. However, the dominance of research at the high school level shows that this level is a “hot spot” for the application of Guided Inquiry. This condition is understandable because the high school physics curriculum begins to include abstract and complex concepts, while at the same time, students are at the formal operational stage of cognitive development, which is relatively ready to respond to inquiry-based learning. In addition, high school is a strategic level in preparing

students for higher education, so critical thinking skills are seen as an important competency that must be developed. This dominance implies that physics education at the junior high school and university levels still has considerable room for improvement through research. At the junior high school level, the Guided Inquiry model may need to be modified to be simpler and more contextual in order to suit the cognitive abilities of students who are still transitioning to formal thinking. Conversely, in higher education, especially in physics education study programs, Guided Inquiry can be adapted into an advanced inquiry form that emphasizes experimental design, small-scale research, and more in-depth critical reflection. Thus, these findings indicate the need for differentiation in the application of Guided Inquiry across educational levels so that the potential for developing critical thinking skills can be optimized.

Aspects of Data Collection Instruments

Based on the analysis of 27 articles that discuss the role of guided inquiry in improving critical thinking skills in physics learning, it is known that the most widely used instrument is a description or essay test. The following diagram illustrates the distribution of data collection instruments used.

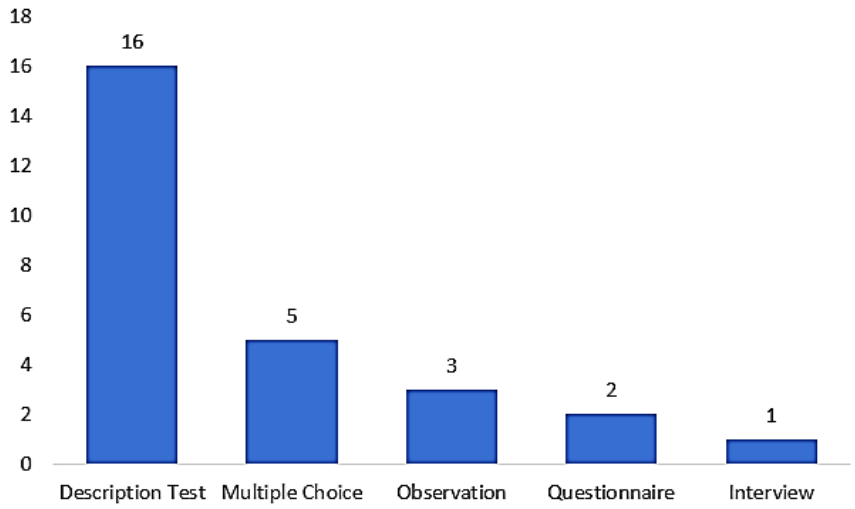

Figure 5. Distribution of data collection instruments

Description tests are used because they are considered capable of exploring students' critical thinking skills in greater depth, such as the ability to analyze, evaluate, and provide arguments based on physics concepts. These instruments are generally developed independently by researchers based on indicators tailored to the characteristics of the material being taught. However, the use of essay tests also has weaknesses, including the potential for subjectivity in the assessment process and the tendency for students to write answers that meet the teacher's expectations rather than authentically representing their way of thinking. Therefore, diversification of assessment instruments is needed to obtain a more holistic picture. A relevant alternative is performance-based assessment, such as assigning students to design follow-up experiments or solve open-ended problems, which allows for the measurement of creativity and knowledge application. Additionally, portfolio assessments that compile various student work over a

specified period can also demonstrate the development of critical thinking more comprehensively, particularly in the dimensions of self-regulation and reflection. Thus, a combination of written tests, performance-based assessments, and portfolios will provide a more balanced evaluation of students' critical thinking skills.

In addition to description tests, some studies also use multiple-choice instruments with HOTS (Higher Order Thinking Skills)-based question types, although the number is smaller. This instrument is generally used because it is easier to score and more efficient when applied on a large scale. Some articles also complement the quantitative instruments with observation sheets, questionnaires, or interviews, especially in R&D or mixed-methods studies, to gain a more comprehensive understanding of the process and learners' responses to guided inquiry learning.

The dominance of test instruments shows that the researchers' main focus is on measuring critical thinking skills directly and objectively. This is in accordance with the research objectives that aim to assess the extent to which the guided inquiry model can improve students' critical thinking skills in understanding and solving physics problems.

Aspects of Data Collection Instruments

In studies that examine the effectiveness of guided inquiry models on students' critical thinking skills in physics learning, the most widely used data analysis method is inferential statistical analysis, specifically the t-test. This test is used to compare pretest and posttest results between experimental and control groups. In addition, the N-Gain calculation method is also widely used to determine the improvement of students' critical thinking skills after guided inquiry-based learning treatment.

Some other studies employ quantitative descriptive analysis, such as calculating the average, percentage, and standard deviation, particularly in studies that do not use a control group or focus solely on one experimental group. In the context of research and development (R&D), data is analyzed using validity, practicality, and effectiveness rating scales, both through expert assessments and learner responses. In qualitative or mixed-methods research, researchers also employ thematic or descriptive qualitative analysis of the results from interviews and observations.

Table 4. Data analysis methods

Type of Research Method	Number of Articles	Description
T-test	14	Used to test the difference in scores between the pretest and posttest in two groups.
N-Gain	10	Used to measure the improvement of learning outcomes after treatment.
Quantitative Descriptive Analysis	5	Includes mean, percentage, and standard deviation.
Validity/Practicality Score	4	Generally used in R&D research.
Thematic/Qualitative Analysis	2	Used to interpret non-numerical data such as interview or observation results.

The data in the table shows that the majority of studies used inferential statistical analysis, specifically the t-test and N-Gain, to measure the effectiveness of the guided

inquiry model in improving students' critical thinking skills quantitatively and measurably.

Linkage of Guided Inquiry Syntax and Critical Thinking Skills Indicators

Each syntax in the Guided Inquiry model has a close relationship with critical thinking indicators according to Facione (1990), and consistently contributes to improving students' critical thinking skills. The relationship between Guided Inquiry syntax and critical thinking indicators can be seen clearly in the following table.

Table 5. Linkage of guided inquiry syntax and critical thinking indicators

Syntax Guided Inquiry	Related Indicators	Indicators Most Improved	Average Improvement	Source of Findings
Problem orientation	Interpretation, Explanation	Interpretation	~70%	Aras et al. (2021); Putri et al. (2022); Lindriani et al. (2023); Sari et al. (2023)
Formulate hypothesis	Inference, Evaluation	Inference	0.68–0.72	Ramadhani et al. (2023); Rahma et al. (2022); Tyas et al. (2023); Haris et al. (2025)
Collect data	Analysis, Explanation	Explanation	0.71–0.76	Isnawati et al. (2022); Safitri et al. (2024); Fitriani (2022); Ocvianti et al.(2021)
Analyze data	Evaluation, Self-Regulation	Evaluation	0.72–0.77	Istiana et al. (2023). Safitri et al. (2023); Sutiani et al. (2023); Novarensa (2024)
Formulate conclusion	Inference, Explanation, Self-Regulation	Self-Regulation	~65%	Pertiwi et al. (2023); Samadun et al. (2022); Sintiawati et al. (2023); Isnawati et al. (2020)

In the first syntax, namely orientation to the problem, interpretation and explanation indicators are most often sharpened because students are required to understand the phenomenon or context of the problem. The increase in interpretation indicators is recorded on average to reach around 70%, as seen in the research of Aras et al. (2021), Putri et al. (2022), and Lindriani et al. (2023).

Furthermore, at the stage of formulating hypotheses, students are trained to make initial guesses based on prior knowledge, which involves inference and evaluation skills. The inference indicator improved with an N-Gain between 0.68 and 0.72, as reported in the studies of Ramadhani et al. (2023) and Rahma et al. (2022). The syntax of collecting data is closely related to the activities of observation and recording information, which encourage the development of analysis and explanation skills. The explanation indicator shows the highest improvement at this stage, with an average N-Gain between 0.71 to 0.76, as shown by Isnawati et al. (2022) and Safitri et al. (2024).

In the syntax of analyzing data, the dominant critical thinking skills are evaluation and self-regulation, because students are asked to assess the results of experiments and reflect on their thinking process. The evaluation indicator shows the most improvement across all articles, with an average N-Gain of between 0.72 and 0.77, as demonstrated in

the studies by Istiana et al. (2023) and Safitri et al. (2023). Finally, in the stage of formulating conclusions, students are guided to draw conclusions based on data and learning experiences. This is related to the indicators of inference, explanation, and self-regulation, with the highest increase observed in the self-regulation indicator, at around 65%, as reflected in the studies by Pertiwi et al. (2023) and Sintiawati et al. (2023).

Overall, the results of this study demonstrate that the Guided Inquiry model is capable of developing nearly all dimensions of Facione's critical thinking skills, with varying emphases depending on the syntactic stage being focused on in learning. The evaluation indicator experienced the greatest and most consistent improvement. This is understandable because in physics learning, the Guided Inquiry process naturally encourages students to continuously compare experimental results (empirical data) with existing hypotheses or theories (theoretical frameworks). The activities of comparing, assessing suitability, and interpreting the meaning of data are at the core of evaluation skills, so this indicator is integrated into almost every stage of learning. Conversely, the self-regulation indicator tends to experience the smallest increase in value. This condition is likely due to the design of student worksheets, which generally do not include metacognitive questions, time constraints that often cause teachers to skip the reflection phase, and limitations in assessment instruments that are unable to effectively capture aspects of self-regulation. Thus, although Guided Inquiry is theoretically reflective, the implementation of deep reflection in physics classroom practice is still relatively neglected.

These findings have clear practical implications for physics teachers. First, student worksheets need to be modified so that they not only guide the inquiry process but also stimulate self-reflection. One strategy that can be implemented is to add a Reflection Journal session at the end of each Guided Inquiry activity, with prompting questions such as: “Which part of this experiment was the most difficult for me?”, “What strategies did I use to overcome that difficulty?”, and “If I were to repeat this, what would I do differently?”. Second, assessment strategies can also be expanded through the use of process-based formative assessment. For example, teachers can ask students to submit draft conclusions for peer review. This peer review process emphasizes the improvement of arguments and the quality of reasoning, thereby directly training the aspect of self-regulation in critical thinking. With these concrete steps, the dimension of self-regulation that has been neglected can be more integrated into Guided Inquiry learning practices.

▪ CONCLUSION

The results of a systematic review of 27 articles indicate that the guided inquiry model makes a significant contribution to enhancing Indonesian students' critical thinking skills in physics learning. The main findings indicate that the application of this model is primarily carried out at the high school level, employing a quantitative approach, particularly a quasi-experimental design. The dominant instrument used is a description test, which is effective for measuring critical thinking dimensions such as evaluation, inference, and explanation. In general, the guided inquiry model has been proven to encourage students to be more active in the learning process and develop higher-order thinking skills in accordance with the demands of the 21st century.

However, this study also has several limitations. In addition to the focus of the analysis, which only covers articles published between 2018 and 2025 and the dominance

of quantitative studies, another major limitation is that no comprehensive formal quality assessment of the analyzed articles was conducted. This implies that the strength of the claim regarding the effectiveness of Guided Inquiry still depends on the assumption that all studies included have equivalent methodological quality.

Further research recommendations are specifically designed to address the identified gaps. First, research needs to be conducted that focuses on developing and testing interventions specifically targeting the improvement of self-regulation indicators within the Guided Inquiry framework, for example, by incorporating structured reflective components into student worksheets. Second, qualitative or ethnographic studies are necessary to understand the real challenges faced by teachers in implementing this model in crowded and time-constrained classrooms, so that implementation strategies can be more contextually relevant and applicable. Thus, this study makes an important contribution in the form of a systematic mapping of the literature related to the application of Guided Inquiry, while also opening up directions for further research that is more focused and relevant to the needs of physics education in Indonesia.

▪ REFERENCES

Adi Putri, S., Nisa, K., & Kuswanto, H. (2024). *Trends of physics critical thinking skill research in indonesia: a systematic literature review*. https://doi.org/10.21009/1

Aras, N. F., Lestari, M., Pendit, S. S. D., & Sani, N. K. (2024). The critical thinking skills of students through guided inquiry models in elementary school. *Jurnal Studi Guru Dan Pembelajaran*, *7*(3), 1142–1152. https://doi.org/10.30605/jsgp.7.3.2024.4703

Aragón, L., Opora, R. & Casanova, J. (2025). "Pre-Service early childhood teachers' perceptions of critical thinking and sustainability: a comparative study between spain and poland," *Sustainability*, 17(15), p. 7129. Available at: https://doi.org/ 10.3390/su17157129.

Árpád, I.W., Kiss, J.T., and Kocsis, D. (2024). "Role of the volume-specific surface area in heat transfer objects: A critical thinking-based investigation of Newton's law of cooling," *International Journal of Heat and Mass Transfer*, 227. Available at: https://doi.org/10.1016/j.ijheatmasstransfer.2024.125535.

Berpikir, K., Siswa, K., Graha, U., Muara, K., & Jambi, B. (n.d.). *Pengembangan lembar kerja peserta didik (LKPD) berbasis inkuiri terbimbing pada materi segitiga untuk meningkatkan*.

Facione, P.A. (1990). Critical thinking: a statement of expert consensus for purposes of educational assessment and instruction, research findings and recommendations. California: California State University, Fullerton.

Fitriani N., Sujana A., Syahid, A. A. (2020). *Pengembangan lembar kerja peserta didik berbasis inkuiri terbimbing terhadap kemunculan berpikir kritis materi panas dan perpindahannya. Jurnal Pena Ilmiah.* 3(2). https://doi.org/10.17509/jpi.v3i2.27226

Haris Ulul Azmi, R., & Yonisa Kurniawan, R. (2025). Empowering student critical thinking skills: how guided inquiry enhances critical skills in economics-noncommercial-sharealike 4.0 international license (CC BY-NC-SA 4.0). In *Journal Eduscience (JES)* (Vol. 12, Issue 1).

Isnawati, L. Z., Caswita, & Noer, S. H. (2020). Implementation of lesson study through the guided inquiry learning model to improve students' critical thinking. *Journal of*

Physics: Conference Series, *1563*(1). https://doi.org/10.1088/1742-6596/1563/1/012050

Istiana, I., Jatmiko, B., & Prahani, B. K. (2023). Effectiveness of implementing guided inquiry to improve students' critical thinking skills. *SAR Journal - Science and Research*, 275–280. https://doi.org/10.18421/sar64-07

Kunnath, A.J. & Botes, W. (2025). "Transforming science education with artificial intelligence: Enhancing inquiry-based learning and critical thinking in South African science classrooms," *Eurasia Journal of Mathematics, Science and Technology Education*, 21(6). Available at: https://doi.org/10.29333/ejmste/16532.

Lindriani, S., & Suwarna, I. P. (2023). Effectiveness of guided inquiry model in enhancing students' critical thinking on light waves. *Berkala Ilmiah Pendidikan Fisika*, *11*(3), 339. https://doi.org/10.20527/bipf.v11i3.16388

Mayaza, P., 1∗, B., Hariyani, S., Suminar, T., Sekolah, K., Unnes, P., & Semarang, B. N. (2024). Development of science worksheet based on multiple intelligences with guided inquiry model to improve critical thinking skills of elementary school students article info. *Journal of Primary Education*, *13*(1), 23–34. https://journal.unnes.ac.id/sju/index.php/jpe

Muhan, L. A., & Nasrudin, H. (2021). The correlation analysis between critical thinking skills and learning outcomes through implementation of guided inquiry learning models. *Jurnal Pendidikan Sains (JPS)*, *9*(1), 33. https://doi.org/10.26714/jps.9.1.2021.33-41

Nurmayani, L., & Doyan, A. (2018). *Pengaruh model pembelajaran inkuiri terbimbing terhadap hasil belajar fisika peserta didik. Jurnal Penelitian Pendidikan IPA, 4(2).*

Ocvianti, M. A., & Sulisworo, D. (2021). *Pembelajaran berbasis laboratorium virtual melalui google classroom pada materi hukum ohm untuk meningkatkan kemampuan berpikir kritis. Jurnal Kumparan Fisika*, *4*(1), 67–76. https://doi.org/10.33369/jkf.4.1.67-76

Pertiwi, N. W., & Jatmiko, B. (n.d.). *Efektivitas model pembelajaran guided inquiry berbantuan E-LKPD liveworksheets untuk meningkatkan keterampilan berpikir kritis peserta didik SMA.* In *Jurnal Inovasi Pendidikan* (Vol. 7, Issue 6).

Putri, J. K., Gunawan, C. W., & Wiyatmo, Y. (2024). Implementation of guided inquiry to increase students' interest in learning physics and critical thinking skills. *Jurnal Pendidikan Fisika Dan Teknologi*, *10*(2), 257–263. https://doi.org/10.29303/jpft.v10i2.7091

Rahma, E. A., & Novita, D. (2024). Development of electronic student worksheet inquiry-based with multiple representations of chemistry on reaction rate material to practice students critical thinking skills. *Jurnal Pijar Mipa*, *19*(3), 423–428. https://doi.org/10.29303/jpm.v19i3.6628

Ramadhani, S. P., & Jatmiko, B. (n.d.). *Keefektifan pembelajaran guided inquiry berbantuan strategi gallery walk dengan media phet untuk meningkatkan keterampilan berpikir kritis peserta didik.*

Rouret, B. *et al.* (2025). *Helping introductory physics students connect physics with the humanities, art, social sciences, and everyday life*.

Riyanto, M., Asbari, M., & Latif, D. (2024). *Efektivitas problem based learning terhadap keterampilan berpikir kritis mahapeserta didik.* Journal of Information Systems and Management (JISMA), 3(1), 1-5.

Safitri, D., & Kustijono, D. R. (2018). *SNF) 2018 "Membumikan fisika dan pembelajaran fisika dalam membangun kearifan global" surabaya*.

Safitri, R., Jumadi, J., & Simamora, N. N. (2024a). Development of guided inquiry-based physics e-lkpd to improve students' critical thinking abilities. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *9*(3), 353. https://doi.org/10.26737/jipf.v9i3.4821

Safitri, R., Jumadi, J., & Simamora, N. N. (2024b). Development of guided inquiry-based physics e-lkpd to improve students' critical thinking abilities. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *9*(3), 353. https://doi.org/10.26737/jipf.v9i3.4821

Samadun, S., Setiani, R., Dwikoranto, D., & Marsini, M. (2023). Effectiveness of inquiry learning models to improve students' critical thinking ability. *IJORER : International Journal of Recent Educational Research*, *4*(2), 203–212. https://doi.org/10.46245/ijorer.v4i2.277

Sari, N., & Siti Jahro, I. (2023). *Pengembangan lembar kerja peserta didik (lkpd) berbasis inkuiri terbimbing untuk meningkatkan kemampuan berpikir kritis siswa pada materi penyusun partikel benda. Jurnal Pendidikan Sosial Dan Humaniora*, *2*(3). https://publisherqu.com/index.php/pediaqu

Sanita, R., & Anugraheni, I. (2020). *Meta analisis model pembelajaran inquiry untuk meningkatkan hasil belajar peserta didik sekolah dasar. Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran, 6(3),* 567-577.

Sutiani, A., Situmorang, M., & Silalahi, A. (2021). Implementation of an inquiry learning model with science literacy to improve student critical thinking skills. In the *International Journal of Instruction* (Vol. 14, Issue 2). www.e-iji.net

Syukri, M., Herliana, F., & Artika, W. (2023). *Development of physics worksheet based on stem integrating engineering design process (EDP) through guided inquiry model to improve students' critical thinking*. https://doi.org/10.21009/1

Tyas, B. W., & Novita, D. (2023). POGIL (process oriented guided inquiry learning) e-worksheet to improve critical thinking skills on reaction rate material. *PENDIPA Journal of Science Education*, *7*(2), 224–231. https://doi.org/10.33369/pendipa.7.2.224-231

Worachak, S. P., Damnoen, P. S., & Hong, D. A. C. (2023). Analysis of critical thinking skills in problem-based learning and inquiry learning models. *EduFisika: Jurnal Pendidikan Fisika*, *8*(3), 282–293. https://doi.org/10.59052/edufisika.v8i3.29442

Yani, M., & Misbah, &. (2021). Development of solid elasticity modules with guided inquiry model to train critical thinking skills

Yulisa, Y., Hakim, L., & Lia, L. (2020). *Pengaruh video pembelajaran fisika terhadap pemahaman konsep peserta didik SMP. Jurnal Luminous: Riset Ilmiah Pendidikan Fisika, 1(1),* 37-44.