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# Effective Strategies for Developing Critical Thinking in Science Learning: A Systematic Literature Review

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**Abstract:** Critical thinking skills are very important skills in education. Critical thinking skills are one of the high-level thinking skills that are indispensable in the 21st century. Critical thinking skills can form students who are independent and can think effectively. There are many strategies that can be used in learning to improve critical thinking skills in students. This study aims to what are the strategies used in learning to improve critical thinking skills (CT), identify the factors that lead to improved critical thinking skills. The method in this research is a systematic literature review using PRISMA. In this study, the process of identification, synthesis and analysis of scientific articles relevant to effective strategies to improve critical thinking skills in science learning was carried out. The articles analysed are primary articles that discuss critical thinking skills. The data base in this research is Scopus, Eric and Science Direct. The results of this study are strategies that can be used in improving critical thinking skills vary. The strategies used are proven to improve students' critical thinking skills. The most widely used instrument to measure critical thinking skills is the test.

**Keyword:** *Strategy, Critical thinking, Systematic literature review*

## 1. INTRODUCTION

Critical thinking skills are important skills that students must have. This is due to the challenges encountered in the real world and the need for a multidisciplinary approach from various fields of science. Critical thinking skills in education are complex, critical thinking skills are very important for students. Because it is relevant to academic success and professional life for the student's personality. Many students find it difficult to develop critical thinking skills. This is due to various factors such as inadequate curriculum, ineffective teaching methods and lack of resources. Research exploring effective strategies in improving critical thinking skills exists, but a systematic literature review is needed to integrate the findings.

According to (Fathonah et al., 2024) the components of critical thinking include the skill of expressing opinions, the skill of making inferences (deduction and induction thinking), and the skill of evaluating, and making the best solution. According to (Khurma & El Zein, 2024) critical thinking is the process of examining available data, facts, evidence, observations, and arguments to reach conclusions and produce sustainable knowledge.

This systematic research aims to collect and analyse various effective strategies to improve critical thinking skills implemented in science learning. It also aims to explore what instruments can be used to see the improvement of critical thinking skills in students. By understanding effective strategies and their outcomes, educators can design better teaching models, strategies, approaches or methods to prepare students for future challenges.

This study can provide insights for policy makers, educators and researchers on effective strategies in improving critical thinking skills that can improve the quality of education and equip students with the skills needed in the 21st century. The contribution of this study is to provide a comprehensive synthesis of existing research on effective strategies in improving critical thinking skills, which helps in identifying knowledge gaps and directions for future research. In addition, this study can help improve learning outcomes, especially in terms of critical thinking skills in students.

The novelty in this study is that it focuses on effective strategies in improving critical thinking skills and the instruments used to measure those skills. This could be an important contribution to the literature, especially if the review covers a range of educational contexts and student demographics.

## 2. METHODS

### 2.1 Research design

The method used to review the selected articles, including publication standards, databases, eligibility and exclusion criteria, stages of the review process (identification, screening, eligibility) is the PRISMA Preferred Reporting Items for Systematic reviews and Meta-Analyses) method. Articles were selected from 2020 to 2024.

### 2.2 Formulating research questions

This research provides accurate data and information on effective strategies to improve critical thinking skills in science learning. The researcher formulated the following research questions: a) What are the effective strategies used to improve critical thinking skills in science learning? b) What instruments are used to see the improvement of critical thinking skills in science learning?

### 2.3 Searching literature for reviewed

At this stage, researchers conducted a literature search on several databases using several keywords which can be seen in the following table.

**Table 1.** Basic Selection Criteria (2020-2024)

Category	Scopus	Eric	Science Direct
Keyword	“Critical Thinking” AND “Science Learning”	“Critical Thinking” AND “Science Learning”	“Critical Thinking” AND “Science Learning”
	“CriticalThinking”AND“Science Learning”	“Critical Thinking” AND “Science Learning”	“Critical Thinking” AND “Science Learning”

### 2.4 Inclusion and Exclusion Criteria

Articles were selected based on inclusion and exclusion criteria. inclusion criteria in the search for articles in this study are 1) primary articles. 2) Relevant to the topic. 3) article coverage from 2020 to 2024. Exclusion criteria in the search are: 1) Books and conference proceedings. 2) Not relevant to the research topic. 3) 2019 and earlier.

### 2.5 Identification of the Relevant Articles

Based on the identification results from the Scopus, Eric and Science Direct databases, which totalled 532 articles. Scopus database obtained from 272 articles, 197 articles from Eric database and 63 articles from Science Direct database. Before the screening process, some articles were deleted due to several reasons such as duplicate articles, not open access, not in accordance with the field of study. There were 28 fulltext articles that were excluded and 504 articles that were screened. After screening, 62 articles were assessed for eligibility and screened again to 50 articles that were in accordance with the research objectives. As for duplicate articles as many as 5 articles and journals that were excluded as many as 18 articles. So that 27 articles will be reviewed in accordance with the research objectives. The following is explained in figure 1.

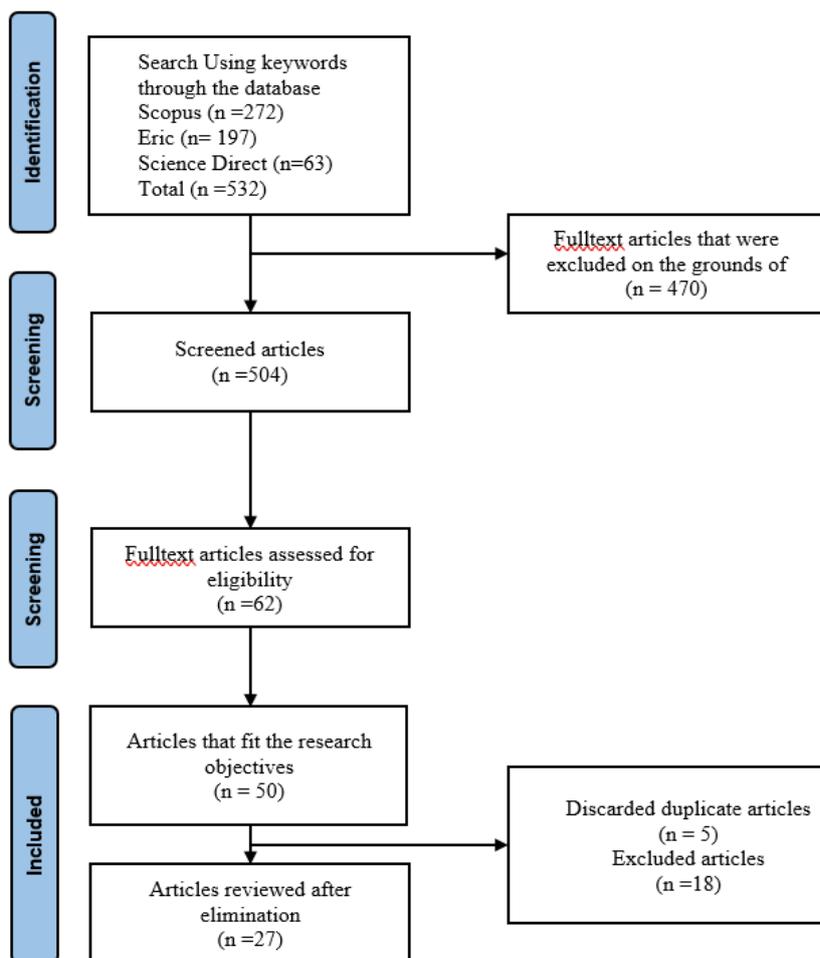


Figure 1. PRISMA method

### 3. FINDINGS AND DISCUSSION

#### 3.1 Strategies for Developing Critical Thinking Skills

Critical thinking skills are the ability to think clearly and rationally, understand logical connections between ideas, identify, construct and evaluate arguments, and solve problems systematically. It involves skills such as analysis, evaluation, inference, explanation, and self-regulation. Many strategies or ways can be used in learning to develop critical thinking skills in students. Based on the articles that have been analysed, there are effective ways or strategies used in learning to build and improve critical thinking skills. These strategies or ways can be seen in the following table.

Table 2. Strategies for Improving Critical Thinking Skills

No.	Strategies to Improve Critical Thinking	Total Articles
1.	(STEM-R) science, technology, engineering, and mathematics-religion	1
2.	Multirepresentation-Based Creative Problem-Solving	1
3.	Complexity Science-Problem Based Learning (CS-PBL)	1
4.	Platform Digital Interaktif	1
5.	E-Comic Based on SETS	1
6.	Inquiry skills teaching	1
7.	Socrates question	1
8.	Discovery-Based Multiple Representations Learning (DMRL)	1
9.	Interactive teaching	1

10.	STEAM-based blended learning	1
11.	Multirepresentation-based creative problem-solving	1
12.	Direct and experiential instructional	1
13.	Traditional musical instruments	1
14.	Researchoriented collaborative inquiry learning	1
15.	Metaverse technology applications based on science, technology, engineering and mathematics (Meta-STEM)	1
16.	Smart water monitoring with IoT in science learning with problem-based learning model	1
17.	Model induktif	1
18.	Inquiry-Creative Learning Integrated with Ethnoscience	1
19.	Multimedia Articulate Storyline 3 berbasis gamifikasi	1
20.	Integration of Inquiry-Based STEM	1
21.	Discovery-Based Multiple Representations Learning Model	1
22.	Flipped Classroom	1
23.	Problem-based learning with metacognitive	1
24.	CTL-based Physics E-module	1
25.	Comic Book as Marker of Augmented Reality	1
26.	Problem-Based Learning with Character-Emphasis and Naturalist Intelligence	1
27.	Combination of Discovery Learning and Metacognitive Knowledge	1

Based on the review of 27 articles, there are 27 different types of strategies or ways that can improve or develop critical thinking skills in students. Learning using (STEM-R) science, technology, engineering, and mathematics-religion is proven to improve critical thinking skills in students. The combination of STEM and religious elements is effectively applied in learning (Sarwi et al., 2024). Research conducted by (Fathonah et al., 2024) explained that the use of multirepresentation-Based Creative Problem-Solving can improve critical thinking skills in students. The results showed that there was an increase in critical thinking skills in students after being given treatment. Learning using Complexity Science-Problem Based Learning (CS-PBL) conducted by (Amanda et al., 2024) shows that the use of this method in learning can improve critical thinking skills so that it can be used to facilitate the improvement of these skills. The use of interactive digital platforms is necessary to optimise the development of students' thinking skills in the future (Ibrahim et al., 2024)

Learning by using electronic comics has a positive effect on students. Electronic comics will be more effective if they are SETS-based. The use of SETS-based science electronic comics can improve student character and influence students to be enthusiastic about having broad insights (Widyawati et al., 2024). Learning using incuri can also improve critical thinking skills (Khurma & El Zein, 2024). (Hu, 2023) used Socratic questions in learning. Socratic questioning is a way of teaching by asking thoughtful and probing questions. Using Socratic questions can improve critical thinking skills in students. (Chusni, 2023) applied discovery-based multiple representations learning (DMRL) in learning. Multiple representations learning involves various forms of representation such as the use of words, graphs, diagrams, tables and others. The results showed that the application of DMRL provided an increase in critical thinking skills in students.

Interactive learning has a positive impact, namely increasing critical thinking skills in students (Arviani et al., 2023). Interactive learning is learning that requires student involvement in the learning process. This learning uses technology to encourage student participation in learning. (Putri et al., 2023) using STEAM-based blended learning, the use of this strategy is proven effective to improve students' critical thinking and creative skills. The use of direct and experiential instructional conducted by (Dessie et al., 2023) showed positive results that can improve critical thinking skills in students. Traditional musical instruments are proven to improve critical thinking skills in students (Datiatur Rahmat et al., 2023). (Irwanto, 2023) used researchoriented collaborative inquiry learning to foster critical thinking skills and process skills. (Rachmadtullah et al., 2023) used Metaverse technology applications based on Science, Technology, Engineering and Mathematics (Meta-STEM) in learning.

The use of this strategy can improve students' critical thinking skills. (Irawati & Sulisworo, 2023) conducted research using Smart water monitoring with IoT in science learning with problem-based learning. After giving

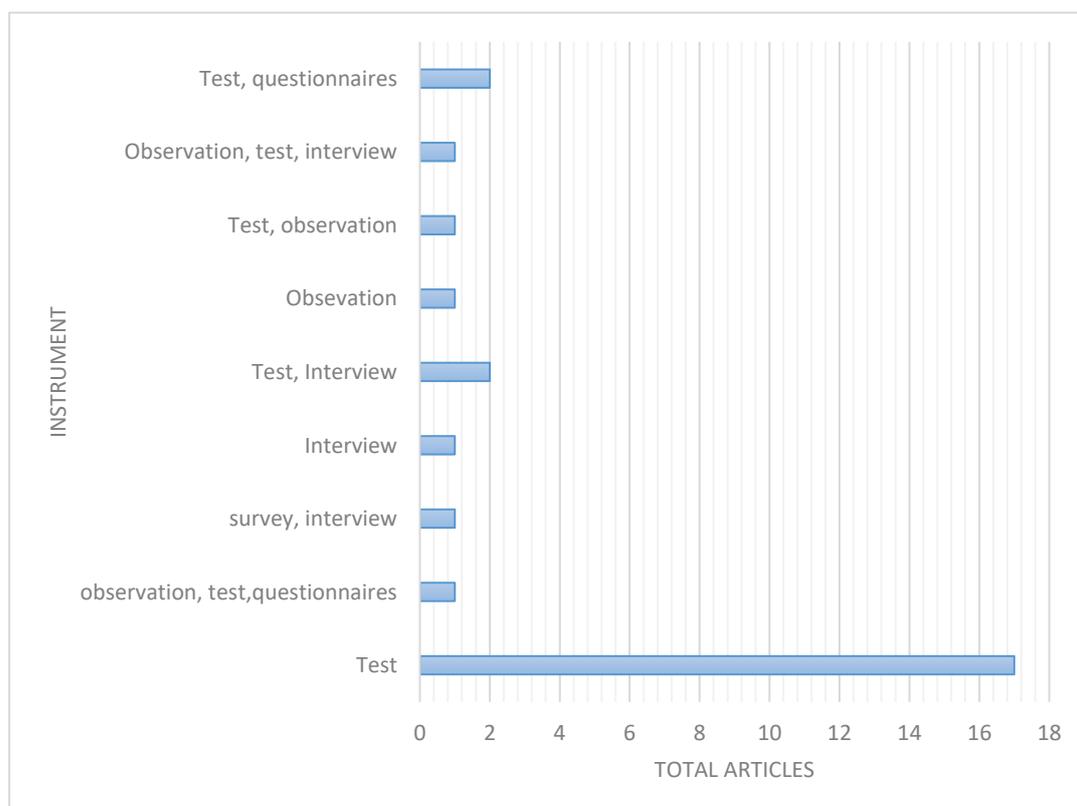
the treatment, there was an increase in critical thinking skills in students. The use of inductive learning in learning also has a positive effect on students. This is proven by research conducted by (Arjunaidi & Azid, 2022).

Creative-inquiry learning integrated with ethnoscience can also improve critical thinking skills in students, this is proven by research conducted by (Putu Verawati et al., 2022). This method is effectively used in improving critical thinking skills. The use of gamification-based storyline 2 articulation multimedia can improve critical thinking skills and independence in students (Heliawati et al., 2022). The application of STEM-based inquiry learning can have a positive effect on students, especially in improving critical thinking skills in students (Amin et al., 2022). (Chusni et al., 2022) applied discovery-based multiple representations learning model in learning. The application of this model in learning can improve critical thinking skills in students.

The flipped classroom model used in learning can improve students' critical thinking skills (Atwa et al., 2022). In flipped classroom learning, students learn the material at home through videos or teaching materials, then in class discussions, application of concepts and practice are conducted. Problem-based learning can also have a positive impact on the learning process. (Marthaliakirana et al., 2022) applied Problem-based learning with metacognitive. The results of this application improve critical thinking skills in students. (Desnita et al., 2022) using CTL learning accompanied by the use of E modules, the results can improve critical thinking skills in students. Other strategies that can be used to improve or develop critical thinking skills are the use of comic books and augmented reality by (Damopolii et al., 2022), Problem-Based Learning with Character-Emphasis and Naturalist Intelligence used by (Suhirman et al., 2021) and Combination of Discovery Learning and Metacognitive Knowledge by (Nusantari et al., 2021).

### 3.2 Instrument to Measure Critical Thinking Skills

Critical thinking skills can be measured using various types of instruments. Based on the analysis of 27 articles, there are several instruments used to measure critical thinking skills in students which can be seen in the following figure.



**Figure 2.** Instrument to Measure Critical Thinking

Based on the figure above, it can be seen that there are variations in the use of instruments to measure critical thinking skills in students. There are 2 articles that use test and questionnaire instruments (Atwa et al., 2022; Damopolii et al., 2022), 1 article that uses observation, test and interview instruments (Amin et al., 2022), 1 article that uses tests and observation (Putu Verawati et al., 2022), 1 article using observation instruments (Irawati & Sulisworo, 2023), 2 articles using tests and interviews (Arjunaidi & Azid, 2022; Irwanto, 2023), 1 article using interview instruments (Hu, 2023), 1 article using survey and interview instruments (Khurma & El Zein, 2024), 1 article using Observation instruments, tests and interviews (Amin et al., 2022) and 17 articles using test instruments (Amanda et al., 2024; Arviani et al., 2023; Chusni, 2023; Chusni et al., 2022; Desnita et al., 2022; Dessie et al., 2023; Fathonah et al., 2023, 2024; Heliawati et al., 2022; Ibrahim et al., 2024; Marthaliakirana et al., 2022; Nusantari et al., 2021; Putri et al., 2023; Rachmadtullah et al., 2023; Rahmat et al., 2023; Sarwi et al., 2024; Suhirman et al., 2021). Based on the data obtained, tests are the most widely used instrument to measure critical thinking skills in students. Tests used to measure critical thinking skills can be done at the beginning of learning or at the end of learning.

#### 4. CONCLUSION

Based on the results and discussion described above, it can be concluded that the strategies used in improving critical thinking skills vary, with the use of these various strategies proven to improve critical thinking skills. Tests are the most widely used instrument. The use of test instruments can provide a more accurate assessment of critical thinking skills.

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