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# A Review of Students' Critical Thinking Skills in Science Learning in Indonesia

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**Abstract: A Review of Students' Critical Thinking Skills in Science Learning in Indonesia. Objective:** This review study aims to analyse and describe the development of students' critical thinking skills in science learning. **Methods:** This study uses a systematic literature review by following the PRISMA form. We found 158 documents critical thinking skills in science learning in published in Scopus indexed journals from 2014 to 2024. After the screening process, 16 articles were selected for analysis using thematic analysis. **Findings:** The review findings show that the selection of learning media to enhance critical thinking skills in flexible science learning should be aligned with students' characteristics, the learning context and user-friendliness. The choice of learning models employed to improve critical thinking skills in science learning is highly variable and must be tailored to multiple criteria. Selecting the suitable model necessitates consideration of the students' attributes, the educational material, and the time constraints. Every learning model possesses distinct advantages in promoting critical thinking skills, necessitating the selection of the model that most effectively aligns with the particular requirements and educational situation. **Conclusion:** Critical thinking skills are among the most vital competencies that students should acquire. These skills are crucial in facilitating a deeper comprehension of scientific concepts among students. The literature study indicates that from 2014 to 2024, many media and learning approaches have been extensively utilized in science education. These media and educational approaches have demonstrated a beneficial effect, enhancing students' academic performance while also fostering the optimal development of their critical thinking skills.

**Keywords:** critical thinking skills, science learning, systematic literature review.

## ▪ INTRODUCTION

Education in the 21st century is undergoing substantial changes due to rapid technological progress and globalization. Education involves both the understanding and retention of essential concepts and the development of skills required for individuals to succeed in a constantly evolving environment. Critical thinking, advanced problem-solving, and digital literacy are vital prerequisites for tackling the challenges of 21st-century existence (Kardoyo et al., 2020; Khahro & Javed, 2022). Students should not just absorb material passively but must actively interact, demonstrate creativity, and employ many resources to provide distinctive solutions for new outcomes (Afandi et al., 2019).

The 2018 PISA (Programme for International Student Assessment) assessment indicated that Indonesian students' proficiency in science remains comparatively poor comparing to neighboring nations like Malaysia, Singapore, and Thailand (OECD, 2018). This arises from students' constraints in retaining scientific knowledge grounded in newly acquired elementary facts. A contributing factor to inadequate performance in science is the educational framework that emphasizes scientific content above the scientific process. Enhancing students' critical thinking skills is one method to foster their progress (Sidiq et al., 2021).

Critical thinking is an intellectual process that involves the ability to actively and adeptly comprehend, apply, analyze, synthesize, and/or assess information acquired by

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observation, experience, reflection, and reasoning (Dewaelsche, 2015; Pursitasari et al., 2020). It is imperative to develop critical thinking skills in students to facilitate their ability to effectively recognize, analyze, and address problems in their surroundings (Fitriani et al., 2019). Each learner possesses a distinct approach to critical thinking, necessitating practice for development (Fakhriyah, 2014). Critical thinking skills can be improved by presenting issues to students, thereby engaging them actively in the learning process Critical thinking skills encompass five indicators: elementary clarification, basic support, inference, advanced clarification, and strategies and tactics. These five indicators will enhance students' critical thinking skills (Ramdani et al., 2021).

Active engagement in the learning process enhances the significance of science education (Kanphukiew & Nuangchalerm, 2024). The relationship between scientific concepts and critical thinking skills is profound, as a genuine comprehension of science necessitates critical thinking skills. In contrast, critical thinking skills can develop and enhance through significant learning experiences (Tanti et al., 2020). Science education in Indonesia ought to motivate students to enhance their critical thinking skills. The deficiency in students' critical thinking skills is attributed to the lack of connection between learning and real-life challenges. Science is frequently seen in numerous facets of daily life (Arjunaidi & Azid, 2022). Enhancing comprehension of science can be achieved by integrating scientific education in schools that begins with addressing difficulties frequently encountered by children in their daily lives (Vosniadou, 2019).

A multitude of studies has been undertaken to comprehend students' critical thinking skills. This research examines the efficacy of diverse pedagogical approaches in higher education designed to cultivate critical thinking skills (Andreucci-Annunziata et al., 2023). Moreover, certain studies investigate the correlation between the Problem-Based Learning (PBL) paradigm and critical thinking skills (Thorndahl & Stentoft, 2020). Additional research investigates the use of pedagogical paradigms such Problem-Based Learning (PBL) (Anggraeni et al., 2023; Razak et al., 2022; Yu & Zin, 2023), Blended Learning (Haftador et al., 2023) and Flipped Learning (Rahmatika et al., 2024), designed to improve students' critical thinking skills.

Nonetheless, despite several studies on critical thinking skills, there remains a deficiency in research explicitly addressing the function of media in instructional models. The judicious selection and integration of media in pedagogical procedures can significantly enhance the cultivation of students' critical thinking skills. Additional research is required to investigate how media might enhance and augment the learning process in this situation.

Based on the explanation above, one of the challenges faced in science learning is the lack critical thinking skills among students. This study aims to explore more deeply through a literature review on developing students' critical thinking skills in science learning. This study is important because it can help understand more clearly the problem so that it can be the first step to finding a solution. The results of this study are expected to provide new insights and become a guide to improve students' critical thinking skills in science learning. The review questions (RQ) in this research include: RQ1) What type of learning media is used in the literature of students' critical thinking skills?; RQ2) What learning models are used in the literature of critical students' thinking skills?; RQ3) What is the impact of media and learning models on students' critical thinking skills?

## ▪ METHOD

### Research Design

This research used Systematic Literature Review (SLR) method. Systematic Literature Review (SLR) is a technique for discovering, evaluating, gathering, and rigorously analyzing data from pertinent studies about the research issue (Snyder, 2019). Systematic literature review (SLR) is a methodical approach of gathering, critically assessing, synthesizing, and presenting results from multiple studies pertinent to specific research questions or subjects (Pati & Lorusso, 2018). Systematic Literature Review (SLR) is a technique for discovering, evaluating, gathering, and rigorously analyzing data from pertinent studies about the research issue (Snyder, 2019). Systematic literature review (SLR) is a methodical approach of gathering, critically assessing, synthesizing, and presenting results from multiple studies pertinent to specific research questions or subjects (Pati & Lorusso, 2018). This review aims to delineate trends in research on students' critical thinking skills in science learning.

### Search Strategy

This study's systematic literature review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, as seen in Figure 1, encompassing the identification, screening, and inclusion stages. The article selection procedure was conducted utilizing Watase UAKE software. The investigation was performed for papers indexed in Scopus utilizing the keywords "critical thinking skill student" and "science."

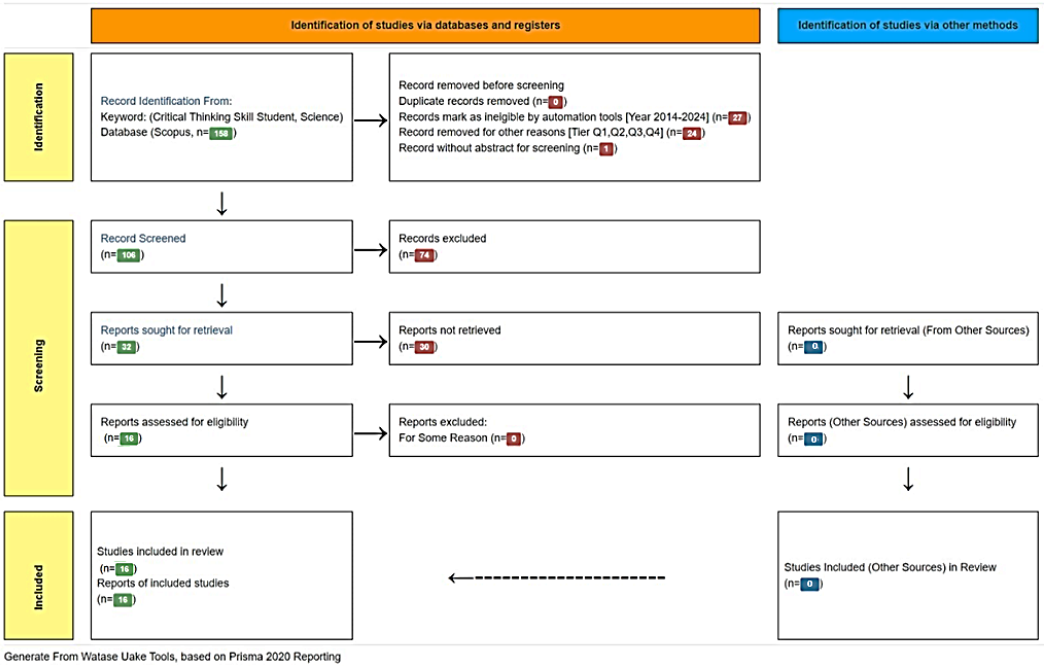


**Figure 1.** PRISMA flowchart

### Inclusion and Exclusion Criteria

Studies eligible for this evaluation were required to be peer-reviewed, published in a journal from 2014 to 2024, and composed in English. The work was required to address

at least one research question in this review. Consequently, we established many inclusion criteria for article screening. The document's abstract must include the keywords "critical thinking skill student" and "science." Secondly, the document must be an article from a publication indexed by Scopus, published between 2014 and 2024. This was conducted to ascertain the present state of knowledge in the relevant field and to guarantee that it was derived from reliable data sources. Upon the removal of extraneous and redundant papers, 106 articles remained. The document was required to be composed in English. Fourth, all chosen publications pertained to research in science learning in Indonesia. Upon evaluating and selecting publications according to these criteria, we identified 16 articles suitable for the evaluation. The article selection method also took into account the accessibility of full-text papers.

**Data Analysis**

Thematic analysis identifies, analyzes, and reports themes within the data. Braun and Clarke propose six levels of thematic analysis (Margot & Kettler, 2019). Initially, familiarize oneself with the data; subsequently, generate codes pertaining to critical thinking skills in scientific education; thirdly, develop themes; fourthly, evaluate themes in relation to the research review questions; fifthly, define and designate themes; and finally, compile the report.

## ▪ RESULT AND DISSCUSSION

The research results included in the Systematic Literature Review are articles related to students' critical thinking skills in science learning in Indonesia published in Scopus indexed journals from 2014 - 2024.

**RQ1) What type of learning media is used in the literature of students' critical thinking skills?**

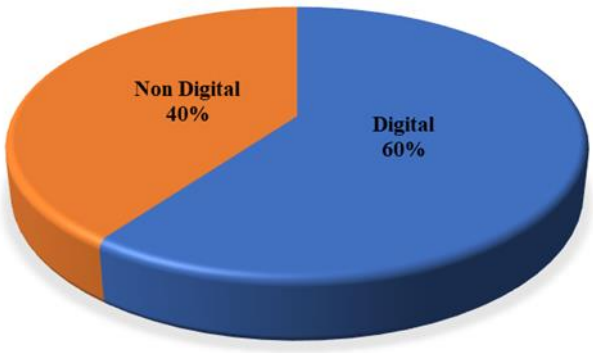


**Figure 2.** Classification of literature based on learning media

Figure 2 shows that of the 10 articles that discuss the treatment of learning media, 60% are digital media and 40% are non-digital media. Digital media have emerged as the predominant option in research owing to their numerous advantages pertinent to contemporary educational requirements. The digital media used are e-modules (Pertiwi et al., 2024; Pitorini et al., 2024), animated videos (Nevitaningrum et al., 2024), virtual simulations (Suhirman & Prayogi, 2023) and Edmodo applications (Wahyuni et al., 2019)

and i-Spring Suite 10 (Suresman et al., 2023) while non-digital in the form of modules integrated with local wisdom (Dewi et al., 2017; Ramdani et al., 2021) and inquiry (Hairida, 2016) and HOTS-based science questions (Sidiq et al., 2021). This finding shows that the selection of learning media to enhance critical thinking skills in flexible science learning should be aligned with students' characteristics, the learning context and user-friendliness.

E-modules are digital educational resources intended to facilitate autonomous comprehension among students. E-modules enable students to access educational content at any time and from any location, and can be customized to accommodate individual learning speeds and styles. The utilization of e-modules can promote critical thinking among students, as they necessitate a comprehensive understanding of the topic and the completion of exercises or problems aimed at enhancing analytical skills.

Animated videos are visual media that effectively elucidate intricate subjects in an interesting and comprehensible manner. In science education, animated movies can effectively depict scientific phenomena that are challenging to convey through verbal descriptions or static graphics. This media enhances comprehension and fosters students' creativity in critical thinking by prompting them to analyze the sequences or processes illustrated in the animation.

Virtual simulations enable students to engage with models or systems that mimic real-world scenarios within a secure and regulated setting. In science education, virtual simulations are frequently employed for experiments or activities that cannot be performed directly in the classroom. Through these simulations, students can investigate several options and analyze the outcomes of each decision or action, so enhancing their critical thinking skills.

Edmodo is a digital learning platform that facilitates online interaction between educators and students. Edmodo enhances flexible learning through features such as chats, quizzes, and information sharing. This program enables students to interact, exchange ideas, and engage in challenges that stimulate critical and analytical thinking in problem-solving.

i-Spring Suite 10 is a software application utilized for the development of interactive educational content, including quizzes, films, and simulations. This technology enhances science education by making it more engaging and difficult, thereby promoting active student participation and the development of critical thinking skills.

Despite the growing prevalence of digital media, non-digital media remains significant in education, particularly in situations where technology may be less accessible or more challenging to obtain. Modules grounded in local wisdom incorporate cultural values and indigenous knowledge into education. In the realm of science, this may entail connecting scientific material with occurrences or practices present in local communities. Integrating modules with local wisdom enhances the learning experience and fosters critical thinking among students on the interplay between science and their culture, as well as the practical applications of science in daily life.

Inquiry-based learning is a method that actively engages students in exploration and discovery. This method encourages students to inquire, design experiments, gather data, and formulate conclusions. Inquiry effectively cultivates critical thinking skills by prompting students to engage in deep reflection, analyze outcomes, and assess their conclusions.

HOTS (Higher Order Thinking Skills) questions are intended to evaluate students' competencies in critical, analytical, and creative thinking. These questions evaluate not just fundamental knowledge but also students' capacity to apply scientific principles in intricate and unpredictable scenarios. HOTS questions encourage students to not just recollect material but also to evaluate, analyze, and devise solutions to the difficulties they encounter.

The results suggest that the use of educational media to improve critical thinking skills in science education must be adaptable and customized to the students' attributes, the learning environment, and user-friendliness. This indicates that a universal method for learning media does not exist. Every learner possesses a distinct learning style. Some students prefer digital material, such as videos or applications, while others may find traditional learning approaches, like modules or inquiry-based learning, more helpful. In specific circumstances, digital media may be less accessible, particularly in regions with constrained technological resources. Consequently, non-digital media, like modules grounded in local wisdom or Higher Order Thinking Skills (HOTS) inquiries, continue to hold significance and relevance. Media that are user-friendly for both educators and students will enhance the learning process. Complex media that necessitate sophisticated technical skills may impede the learning process, whereas simpler, user-friendly media will more effectively facilitate active student interaction.

**RQ2) What learning models are used in the literature of critical students' thinking skills?**

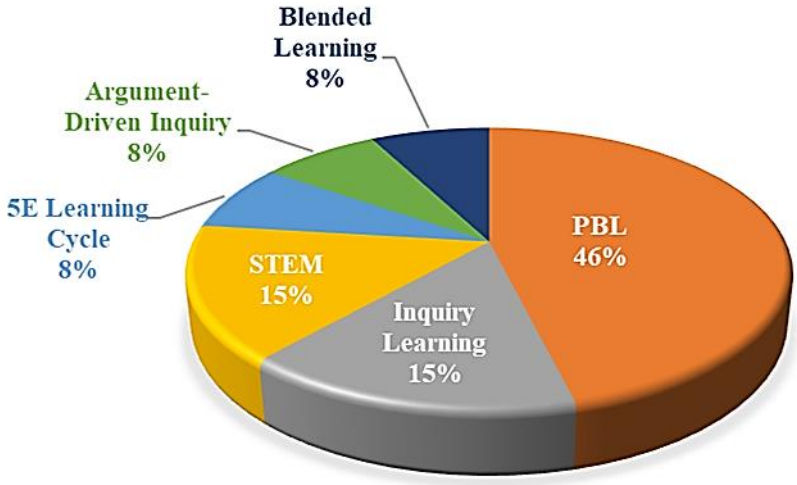


**Figure 3.** Classification of literature based on learning models

Figure 3 shows that of the 13 articles that discuss the treatment of learning models, 46% are Problem Based Learning (Arifin et al., 2020; Marthaliakirana et al., 2022; Nevitaningrum et al., 2024; Pitorini et al., 2024; Saputra et al., 2019; Suhirman & Prayogi, 2023), 15% Inquiry Learning (Hairida, 2016; Pursitasari et al., 2020) and 15% STEM (Pahrudin et al., 2021; Pertiwi et al., 2024). The remaining 8% each for 5E Learning Cycle (Ramdani et al., 2021), Argument-Driven Inquiry (Rosidin et al., 2019), and blended learning (Wahyuni et al., 2019).

Problem-Based Learning (PBL) has emerged as the preeminent educational approach in the analyzed studies. This strategy prioritizes problem-centered learning pertinent to the students' environment. In PBL, students engage in addressing intricate and unstructured challenges that necessitate study and collaborative problem-solving. Project-Based Learning cultivates critical thinking skills as students are required to identify issues, collect information, analyze data, and devise solutions. This methodology significantly improves students' analytical and evaluative skills while cultivating their critical thinking in practical situations. Another advantage is its adaptability to many learning materials and circumstances.

Inquiry Learning is a framework that emphasizes the investigative process. Students are urged to inquire, create experiments, gather data, and derive conclusions from the facts obtained. Students are educated to think critically by conducting in-depth explorations of certain topics and actively studying scientific phenomena through inquiry. This technique significantly enhances critical thinking skills as students must interrogate material, examine experimental outcomes, and draw conclusions based on the evidence they gather. Inquiry-based learning fosters profound comprehension and cultivates student autonomy in learning.

The STEM framework amalgamates the four disciplines: science, technology, engineering, and mathematics into a cohesive methodology. STEM education prioritizes problem-solving that incorporates technical and technological components, with the quantitative competencies essential for conducting experiments and analyzing data. This strategy not only fosters critical thinking in students but also equips them for real-world difficulties that increasingly depend on technical and analytical skills. STEM education promotes student involvement in demanding projects pertinent to their life, seamlessly merging theory with practice.

The 5E Learning Cycle model is an instructional framework with five primary stages: engage, explore, explain, elaborate and evaluate. This technique aids students in comprehending scientific concepts via direct experience and contemplation. During the "engage" phase, students are presented with a compelling subject or problem that incites inquiry. They subsequently "investigate" through activities that enable them to collect data and go deeper into the subject. This is succeeded by student explanations, the formulation of more intricate concepts, and the assessment of results. The 5E Learning Cycle fosters active student participation in learning and improves their critical thinking skills via reflective practices.

Argument-Driven Inquiry (ADI) is an educational framework that emphasizes the construction of arguments grounded in data and evidence. Students are required to formulate assertions, gather corroborative evidence, and develop logical arguments. This strategy cultivates critical thinking skills by necessitating that students thoroughly assess data, construct robust arguments, and contemplate diverse viewpoints. ADI significantly enhances students' analytical and evaluative skills, training them to think clearly and argue effectively.

Blended Learning is an educational strategy that integrates in-person instruction with online learning. This concept offers adaptability for students to study according to their individual requirements and interests. In-person education can be augmented by digital resources, videos, or other online assets that facilitate autonomous learning for students outside the classroom. Blended learning enables students to cultivate critical

thinking skills through the use of technology to access extensive and comprehensive knowledge.

The findings suggest that the choice of learning models employed to improve critical thinking skills in science education is highly variable and must be tailored to multiple criteria. Selecting the suitable model necessitates consideration of the students' attributes, the educational material, and the time constraints. Every learning model possesses distinct advantages in promoting critical thinking skills, necessitating the selection of the model that most effectively aligns with the particular requirements and educational situation.

**RQ3) What is the impact of media and learning models on students' critical thinking skills?**

Effective science learning relies on the use of the right strategies and models to boost students' critical thinking skills. One proven approach is incorporating questions based on Higher Order Thinking Skills (HOTS). This approach invites learners to think more deeply and creatively, so that they do not just memorise information, but can also analyse, evaluate and make better decisions in complex situations (Sidiq et al., 2021).

Integrating local wisdom into the learning process also brings significant benefits. By combining the 5E learning cycle with local wisdom, students can better understand the connection between science and their everyday experiences. This helps them to be more interested and understand science not as a subject separate from their world, but as something close and useful. (Ramdani et al., 2021). Furthermore, applying science concepts to real-life activities, like wood carving or ceramics, can greatly enhance the learning experience for students. When they relate science learning to local traditions and culture, they feel more connected to the material being taught. It also provides a sense of pride in their cultural heritage while still learning science (Dewi et al., 2017).

Moreover, engaging and interactive learning media play a crucial role in fostering critical thinking skills. For instance, i-Spring Suite 10 has been shown to positively impact learners' critical thinking skills. Through this platform, students not only grasp the material more effectively but also feel more motivated to learn, ultimately enhancing their problem-solving skills (Suresman et al., 2023).

The application of technology can also increase learners' engagement in science learning. The use of simulations such as PhET allows them to conduct experiments virtually, which presents science learning in a more engaging and interactive format. This approach makes learning more fun while providing practical experience that helps them understand scientific concepts better. (Suhirman & Prayogi, 2023). Besides simulation, animated videos in learning make students more interested and easy to understand difficult concepts. With interesting visualisations, animations encourage students to think deeper, analyse and find creative solutions. This method not only makes learning enjoyable, but also helps students build critical thinking skills that they can use in their everyday lives (Nevitaningrum et al., 2024).

The use of Socratic dialogue-based e-modules can also hone learners' critical thinking skills. The module is designed to encourage learners to think more deeply about the concepts taught through reflective questions. In this way, learners not only learn facts, but are also trained to think analytically and question their assumptions (Pitorini et al., 2024). The inquiry-STEM-based e-modules have also been proven effective in enhancing

students' critical thinking skills. Compared to conventional learning media, this e-module offers a more interactive learning experience that is relevant to the context of everyday life. (Hairida, 2016; Pahrudin et al., 2021; Pertiwi et al., 2024).

Problem Based Learning (PBL) approach is widely recognized as an effective way to enhancing critical thinking skills. By facing real problems, students are faced with the challenge of finding solutions using their science knowledge. PBL gives them the freedom to explore and develop problem-solving skills that are important in daily life. (Arifin et al., 2020; Marthaliakirana et al., 2022; Saputra et al., 2019). In addition to PBL, the Argument-Driven Inquiry and Science Context Based Inquiry Learning approaches are also effective in enhancing students' critical thinking skills. Both methods help student to think more analytically and deeply in understanding learning materials. (Pursitasari et al., 2020; Rosidin et al., 2019).

Blended learning, which integrates technology with conventional teaching methods, has been shown to effectively foster critical thinking skills. Platforms like Edmodo provide students with the opportunity to discuss and exchange ideas online, fostering better collaboration and communication. This approach encourages students to feel more engaged and inspired throughout their learning journey (Wahyuni et al., 2019).

## ▪ CONCLUSION

Critical thinking skills are among the most vital competencies that students should acquire. These skills are crucial in facilitating a deeper comprehension of scientific concepts among students. The literature study indicates that from 2014 to 2024, many media and learning approaches have been extensively utilized in science education. These media and educational approaches have demonstrated a beneficial effect, enhancing students' academic performance while also fostering the optimal development of their critical thinking skills.

This research indicates that it is essential for educators to modify learning models and media to align with the requirements and attributes of students to facilitate the complete development of their critical thinking skills. Diverse pedagogical methods such as Problem-Based Learning, Inquiry Learning, and STEM enhance the learning process, making it more engaging and pertinent to students' real-life experiences. Challenges encompass restricted access to technology in certain regions, variations in students' learning preferences, and time limitations that hinder the execution of specific educational methods. Nonetheless, this research offers significant insights, but the conclusions may not be universally relevant to all educational settings.

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