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Critical Thinking in Science Learning: Systematic Literature Review

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ABSTRACT

Critical thinking is a vital intellectual skill that enables informed judgments through the analysis of information. Its development in educational settings is essential, particularly in science learning, where analytical reasoning and problem-solving are fundamental. This study aims to analyze Scopus-indexed journal articles (Q1–Q4) that investigate critical thinking in science education. A systematic literature review process was employed to examine 57 empirical papers, encompassing three primary stages: planning, conducting, and reporting. The analysis examined research areas, subject fields, participants, data collection tools, and research methods. The results indicated that most studies employed a quantitative approach, with high school students from medium-sized schools as the primary participants. Essay tests were the most commonly used instruments for measuring critical thinking. The primary research emphasis was on creating and assessing instructional materials, particularly within the realm of physics education. These findings reveal current trends and research gaps, particularly in underexplored topics such as cross-disciplinary integration and assessment strategies. This study contributes to science education by mapping the current research landscape of critical thinking and providing insights that inform future investigations, curriculum design, and instructional innovation.

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critical thinking; literature review; science learning

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INTRODUCTION

Twenty-first-century education prioritizes the integration of knowledge, skills, attitudes, and digital literacy. Essential competencies that students must develop include critical thinking, problem-solving, creativity, cooperation, and effective communication. Critical thinking is regarded as a vital cognitive skill for addressing complex challenges in both education and life (Cahyono & Mayasari, 2018; Duncan, 2020; Fuad et al., 2017; Tiruneh et al., 2017). However, empirical data indicate that Indonesian students continue to struggle with developing this skill. Based on the 2018 PISA results, 75% of Indonesian students scored below the minimum competency level in reading, 76% in mathematics, and 66% in science (Mutia et al., 2021; OECD, 2018). In reading literacy alone, Indonesian students scored an average of 371, which is 80 points below the OECD average. These scores reflect limited ability in reasoning, argument analysis, and evidence-based decision-making—core elements of critical thinking. A preliminary study also found that science teachers in Indonesia often face challenges in embedding critical thinking explicitly in their classroom practice. These findings highlight the importance of examining how critical thinking is addressed in science education research, particularly in informing efforts aimed at enhancing instructional design and improving student learning outcomes.

The fundamentals of critical thinking can be traced back around 2,500 years to the introduction of Socrates' approach of probing questioning, which is used to support one's claims of knowledge. The Socratic questioning method, commonly referred to as "Socratic Questioning," is a well-recognized

and popular educational strategy for developing critical thinking (Edward et al., 2023; Fawaid & Nadifah, 2024; Rahardhian, 2022). Recent years have witnessed significant expansion in research concerning critical thinking and its educational applications. This has resulted in critical thinking being acknowledged as one of the four foremost competencies cited in national policy documents across 152 nations (Anderson et al., 2018; Andriati et al., 2025). Moreover, some international publications emphasize the need for critical thinking as a fundamental ability that every individual should possess (OECD, 2018). The concept of critical thinking encompasses various dimensions, incorporating specific actions and a particular attitude. The articulation of critical thinking is complex, although it can be cultivated through its use in the learning process (Facione & Facione, 2013; Paul, 1990; Rahardhian, 2022). The enhancement of critical thinking skills can be achieved through the use of instructional resources and educational frameworks (Cynthia et al., 2023; Samadun & Dwikoranto, 2022; Wenno, 2022).

Critical thinking is an essential skill vital for addressing complex and urgent issues that necessitate thorough analysis (Alafnan, 2025; Hutsalo et al., 2024; Wardani et al., 2019). When studying physics, students are required not only to accurately memorize the theories, formulas, and concepts but also to thoroughly understand them. The objective of physics education is to foster a scientific mindset characterized by a critical examination of scientific assertions grounded in empirical evidence rather than uncritical acceptance. This encompasses comprehending the principles and phenomena of physics and using them to address real-world situations. Therefore, cultivating critical thinking skills is essential for acquiring knowledge in physics and other scientific fields.

Cognitive analytical skills can be enhanced in physics through the introduction of real-world problems (Ashari, 2023; Sucipta et al., 2023; Sujanem & Putu, 2023; Živković, 2016), thereby augmenting the learning experience and improving students' conceptual comprehension (Maknun, 2020; Sin, 2014). Enhancing students' critical thinking skills can be achieved through probing inquiries and the habituation of analytical thought (Diva & Purwaningrum, 2023; Fauzan et al., 2021; Hastuti et al., 2018; Ismah & Muthmainnah, 2021; Ubaidillah et al., 2022). Students can develop answers to the presented challenges through collaborative and participatory efforts (Malik & Ubaidillah, 2021; Rubi et al., 2024). Specific research findings demonstrate a distinct correlation between physics education and students' critical thinking skills, which can be enhanced (Foote & Martino, 2018; Hadi et al., 2018; Seranica et al., 2018).

Consequently, acquiring critical thinking skills is crucial in the study of physics. The systematic literature review examined the efforts of physics researchers and educators to enhance students' critical thinking skills. The literature study focuses on learning models, educational materials, and assessment techniques within the domain of science instruction. This study offers valuable insights for academics, educators, and educational practitioners on aspects that can enhance cognitive skills in science education. The findings of this literature review provide a foundation for the strategic design and implementation of enhanced physics lessons that promote the cultivation of robust critical thinking skills. Within this framework, the objective of this study is to identify general trends in the field and to provide researchers with essential knowledge about research methodologies, participants, data collection tools, research domains, subject areas, and criteria for critical thinking, enabling them to engage in significant research.

This study aims to identify the criteria used in science learning to enhance critical thinking in literature through the analysis of bibliometric data. Specifically, it aims to examine factors such as publication year, country, and quartile of journals used. In addition, the study aims to identify various aspects, including research methods and designs, competencies in critical thinking, research domains, data collection tools, participants, and subject areas related to critical thinking in literature.

The objective of this study is to conduct a thematic analysis of students' critical thinking skills in science learning from 2019 to 2024. To achieve this objective, the research was guided by several key questions: (1) What methodologies were employed in these studies? (2) Which sample levels were most commonly represented? (3) What data collection instruments were utilized across the investigations? (4) What research domains were explored? (5) Which cognitive markers were identified in the studies? (6) What materials were used to support the research? (7) Which tools for assessing critical thinking were employed? This study aims to provide a thorough synthesis of the methodology, trends, and thematic focuses of critical thinking skills in science education by systematically addressing these research issues. The results are expected to inform future academic research and inform the development of courses that prioritize the cultivation of critical thinking skills.

METHOD

This research employs a systematic literature review methodology to examine the influence of innovation on science education. A Systematic Literature Review (SLR) is a rigorous methodology for identifying, assessing, and analyzing all pertinent information within current literature and references. The objective is to scrutinize and assess the particular criteria that require investigation (Xiao & Watson, 2017). This study utilizes data from papers sourced from various publications released in the last five years, concentrating on critical thinking in science education. This study's systematic literature review has three primary phases: planning, execution, and reporting. During the planning phase, the researcher identifies the research topic, specifically concentrating on critical thinking in science education. The criteria for article selection have now been established. The criteria are delineated in Table 1.

Table 1. Criteria for selecting articles.

Criteria	Description
Inclusion	The article discusses critical thinking in science learning. The articles used are those published between 2019 and 2024. Scopus articles (open access) Quartil (Q1, Q2, Q3, and Q4) English
Exclusion	Articles that do not discuss critical thinking in science learning. Not English Discontinu from Scopus Literature review articles are not included

The conducting stage involves collecting articles that adhere to predetermined criteria. The article was conducted with the Publish or Perish program, primarily focussing on article searches inside the Scopus database. The inquiry utilized the phrases 'critical thinking in physics education' and 'critical thinking in scientific education' for the period from 2019 to 2024. Furthermore, the author employed the application and personally accessed the websites of ERIC (EBSCO), SpringerLink, Taylor & Francis, Wiley Online Library Full Collection, ScienceDirect, Google Scholar, and Scopus (A&I) using identical criteria. Additionally, the quartile ranking of each journal was verified to determine if it fell within Q1, Q2, Q3, or Q4. Journals falling within these categories were eligible for further analysis, whereas those outside of these categories or ceased were excluded from further analysis. The publications were systematically evaluated by progressively reading the abstracts. If the abstract matches the research topic, then proceed to read the contents of the article. When evaluating the

papers that matched the established criteria, a total of 57 publications were selected as suitable for inclusion in the systematic literature review.

The final stage is writing the results of a systematic literature review. This stage plays a crucial role in communicating the outcomes of the entire review process. It involves presenting the findings in a clear, logical, and structured manner. Researchers must summarize the main themes, patterns, and relationships that emerged from the selected literature. Additionally, they should highlight any research gaps or inconsistencies identified in previous studies. The discourse must be substantiated by evidence from the examined sources to enhance the credibility of the analysis. An effectively composed results section enables readers to understand the significance of the findings within the broader context of the research subject. Therefore, careful attention must be given to this stage to ensure clarity, coherence, and academic rigor.

RESULTS AND DISCUSSION

This section presents and discusses the findings of the systematic literature review, which was conducted to explore key aspects related to the investigation of critical thinking in various studies. The analysis was guided by seven research questions focusing on (1) the methodologies employed, (2) the sample levels most commonly represented, (3) the instruments used for data collection, (4) the research domains explored, (5) the cognitive markers identified, (6) the materials utilized, and (7) the tools used to assess critical thinking skills. Each of these dimensions is discussed in detail in the following paragraphs, allowing for a comprehensive understanding of current trends, patterns, and gaps in the literature. By synthesizing the data across these categories, this review aims to highlight how critical thinking has been examined, measured, and supported within diverse educational contexts. Geographical distribution of the publications by countries. Table 2 displays the distribution of publications by countries/regions. There are publications on the subject from a total of 16 nations. The United States has the most significant density of publications, followed by Spain, Turkey, Australia, and Italy, in that order.

Table 2. Distribution of the Publications by Countries/Regions

Theme	Codes	f
Publications by Countries/Regions	Indonesia	29
	Spain	1
	USA	7
	India	3
	Mexico	2
	Turkey	4
	Australia	1
	Palestine	1
	Colombia	1
	US	1
	Taiwan	2
	Saudi Arabia	1
	Malaysia	1
	Iran	1
	China	1
	Brazil	1

Table 3 presents the distribution of publications categorized into quartiles labeled Q1, Q2, Q3, and Q4. With the highest quartile by Q1. The majority of papers applied in this study are classified as Q1 and Q2, with 19 articles in each category. This is followed by 17 articles classified as Q3 and only two articles classified as Q4.

Table 3. Distribution of the Publications by quartiles

Theme	Codes	f
Publications by quartiles	Q1	19
	Q2	19
	Q3	17
	Q4	2

An examination of the annual distribution of publications on critical thinking in primary education reveals a significant increase in the volume of publications, particularly in 2019. This discovery illustrates the evolution of scientific inquiry within the subject over time. Analysis of the publishing trend reveals that there were three publications in 2019, followed by a subsequent increase in the number of publications.

Table 4. Distribution of the Articles by Year of Publication

Theme	Codes	f
Year of Publication	2019	3
	2020	14
	2021	14
	2022	6
	2023	18
	2024	2

This section presents the frequencies of critical thinking through the codes and themes. Diverse research methodologies are employed in the study of critical thinking. The method sections of the studies were analyzed to determine the research methodologies employed in the articles and to furnish resources for researchers. The methodologies of the investigations were categorized into three groups: qualitative, quantitative, and mixed. Analysis of the research methodologies underlying the studies indicates a predominant utilization of the quantitative paradigm. Table 5 illustrates the study methodologies employed, revealing that 35 papers adopted a quantitative design, seven utilized a qualitative design, and five implemented a mixed-methods approach.

Table 5. The Distribution of the Articles by Research Approach and Design Theme in Critical Thinking

Theme	Codes			f
Research Approach and Design	Quantitative	Experimental	Pre-Experimental	2
			Quasi-experimental	33
		Non-Experimental	Correlational survey	3
	Qualitative		Case study	6
			Phenomenological analysis	1
	Mixed method		Explanatory sequential	3
			Exploratory sequential	2
	4D			1
	R&D			1
	ADDIE			1
	Design and Development			2
	Not indicate			2

Based on Table 5, 33 critical thinking studies were conducted using quasi-experimental methods for quantitative research, and six critical thinking studies employed case studies for qualitative research. Mixed methods were employed in five critical thinking studies, with details provided for two exploratory and three explanatory studies. There are several other development methods, namely 4D, R&D, ADDIE, and D&D, which are represented by one, one, one, and two critical thinking studies, respectively. Two studies did not include the research method used, so they were coded 'not indicate.' Table 6 displays the frequencies of the 'participant' motif in critical thinking.

Table 6. Frequencies of the Participant Theme in Critical Thinking

Theme	Codes	f
Participant	Undergraduate student	5
	Senior High School	14
	Junior High School	13
	Primary-school students	3
	Pre-service teachers	2
	Undergraduate engineering student	4
	Undergraduate physics education students	4
	Science teacher candidates	1
	Physics teachers	1
	Undergraduate health science students	4
	Lecturer	1
	Science teacher	1
	Not indicate	4
Participant Size	10 or below	1
	10 - 30	10
	31 - 100	22
	101-300	13
	More than 300	11

Table 6 illustrates that, out of 57 articles, the predominant participant topic in critical thinking was seen 14 times for Senior High School and 13 times for Junior High School. Analysis of participant sizes across the articles indicates that 22 studies had sample sizes ranging from 31 to 100, 13 studies had sample sizes ranging from 101 to 300, 10 studies had sample sizes between 10 and 30, 1 study had 10 or fewer participants, and 11 studies included more than 300 participants. In this context, it can be stated that researchers generally prefer medium-sized sample sizes.

This section aims to identify the data collection tools that researchers prefer to use in their studies. The findings will guide researchers who intend to carry out studies on critical thinking in science learning in the selection of data collection tools. Among the analyzed articles, some utilized multiple data collection tools to achieve data variety. The codes for data collection tools are categorized as Test and Non-Test, which are then further elaborated upon. Additionally, the instrument used to measure critical thinking is also explicitly shown. Frequencies of the data collection tool theme in critical thinking are presented in Table 7.

Table 7. Frequencies of the Data Collection Tool Theme in the Critical Thinking

Theme	Codes		f
Data Collection Tool	Test	Objective/ Multiple Choice	15
		Essay/Open-Ended	27
	Non-Test	Observations	14
		Interviews	5
		Questionnaires	25
		Expert Validations	7
To Measure Critical Thinking	Test	Objective/ Multiple Choice	14
		Essay/Open-Ended	21
	Non-Test	Observations	7
		Interviews	1
		Questionnaires	11

Table 7 indicates that 14 of the critical thinking research employed objective assessments, whereas 21 utilized essays. One study utilized interviews, whereas eleven favored questionnaires. The frequencies of the critical thinking investigations, based on observations, were seven respectively. The frequencies of the subject area theme in critical thinking are displayed in Table 8.

Table 8. Frequencies of the Subject Area Theme in the Critical Thinking

Theme	Codes	f
Subject Area	Physics	25
	Pharmacy	2
	Science	5
	Mathematics	1
	Biology	1
	Chemistry	1
	Geography	1
	Not Indicate	25

Table 8 indicates that 25 of the critical thinking studies concentrated on physics subjects, whereas five were centered on scientific themes. Additionally, two of the studies focused on pharmacy subjects, while mathematics, biology, chemistry, and geography each had one study on critical

thinking. Furthermore, 25 of them (examining the current instances and critical thinking) did not expressly specify the subject area for critical thinking. The frequencies of the research domain theme in critical thinking are displayed in Table 9.

Table 9. Frequencies of the Research Domain Theme in the Critical Thinking

Theme	Codes		f
Research Domain	Assessment		8
	Learning Material	Worksheet student	2
		Learning module	7
		Learning media	12
	Learning Model	STEM approach	4
		Inquiry-based learning	3
		Problem-based learning	5
		Project-based learning	1
		Socio-Scientific Issues (SSI)	1
		Blended learning	3
		Constructivist refexive model	1
		Thinking empowerment by questioning	1
		Perceptions of constructivist learning settings and metacognitive self-regulation strategies	1
		Computational model experiment	1
		Technology and engineering design-based learning	1
		Mathematics learning model	1
		Team-based learning	1
		Critical thinking practices	1
		Socratic method	1
		Online flipped classroom	1
		Science writing heuristic (SWH)	1
		Reciprocal Teaching Strategy	1
		Augmented reality integration (ARI) based model	1
		Active learning	1

As shown in Table 9, research areas encompass three major domains: assessment, teaching materials, and learning models. The frequency of critical thinking research categorized under the code ‘assessment’ is 8, while for the teaching materials code, it is 21. Additionally, the frequency of critical thinking research utilizing learning models is 31. Frequencies of the critical thinking criteria theme are presented in Table 10.

Table 10. Frequencies of the Critical Thinking Criteria Theme

Theme	Codes		f
Criteria CTS	Facione (1990)	Analysis, inference, evaluation, and decision-making	7
	Ennis (2011)	Explanations, skills, conclusions, strategy	4
	Kılıç & S¸ en (2014)	Engagement, cognitive maturity, and Innovativeness	1
	Wechsler et al. (2018)	Formulating problems, analyzing arguments, asking and answering questions, evaluating and defining	2
	Other Ennis works (1985-2005)	Questioning, concluding, and analyzing arguments	4
	Facione (2015)	Interpretation, analysis, evaluation, inference, and explanation and self-regulation	2
	Reynders et al. (2020)	Evaluating, analyzing, synthesizing, and forming arguments (structure and validity)	1
	Watson & Glasser (1994)	Assumption, interference, deduction, interpretation, and evaluation.	1
	No mention of source	Formulating problems, providing arguments, deductions, inductions, evaluations, decisions, and problem-solving.	2
	No mention of source		12
	Not applicable		21

Table 10 illustrates that the theme of critical thinking criteria has sixteen distinct codes. These models are named after their authors. Seven of the critical thinking studies examined Facione (1990), while four focused on Ennis (2011). Two of the critical thinking investigations concentrated on the work of Wechsler et al. (2018). The remaining critical thinking investigations only utilized the models proposed by their authors. Only one study was accessible about the critical thinking criteria established by Ennis (1985), Finken and Ennis (1993), Ernst and Monroe (2004), Kılıç & S¸ en (2014), Ennis (1996), Facione (2015), Ennis (1994), Facione et al. (2020), Watson and Glasser (1994), Ennis et al. (2005). Some criteria do not mention the source, totaling 12. Moreover, it did not include critical thinking criteria in 21 articles.

This research aims to elucidate the research methodology and design, participants, data collection instruments, research domain, subject area, and criteria for critical thinking in studies on critical thinking in science education. The analysis encompassed descriptive data, including the publication year, countries, and quarter of the studies, providing an overarching perspective of the field. The study reveals that articles on critical thinking in science education originate from 16 distinct countries. The nations with the most significant overall number of publications are Indonesia, the USA, and Turkey (refer to Table 2). This indicates that, when the criteria of this study are applied, it will be found that Indonesia has the most articles, specifically 29 articles related to critical thinking in science learning. Based on the criteria for the year of publication of the article, there are six variations of years: 2019, 2020, 2021, 2022, 2023, and 2024 (see Table 3). Where obtained in 2023 is the year with the most articles published according to the criteria related to critical thinking in science learning. Regarding the quartile level of Scopus, there are four variations: Q1, Q2, Q3, and Q4 (see Table 4). Q1 and Q2 have the same number of articles, namely 19 articles each, while the rest are in Q3 and Q4.

The findings of the text analysis indicate that critical thinking research frequently uses quantitative methodologies (refer to Table 5). This suggests that these methodologies are considered

more suitable for analyzing cognitive constructs, such as critical thinking. A strong numerical correlation between quantitative and qualitative designs may be shaped by study aims that aim to foster critical thinking through diverse interventions. The limited number of research employing mixed methodologies (quantitative and qualitative) may indicate a disregard for the potential benefits of these approaches. This may also be attributed to practical constraints such as methodological complexity, time demands, and sampling challenges. Although only a few studies employ mixed-method and developmental designs, these approaches have significant potential to produce both quantitatively reliable and qualitatively rich insights.

The findings of this review align with Behar-Horenstein and Niu (2011), who reported that most empirical studies also employed quantitative methods. However, they emphasized the importance of integrating qualitative methods to capture aspects of critical thinking that are not easily measured by standard instruments. Furthermore, Baez (2007) contends that while quantitative research is often perceived as limited in offering critical insights, it can serve as a powerful tool for social critique when used within reflective and transformative frameworks. These perspectives suggest that although quantitative approaches dominate the field, incorporating mixed-method designs may offer a more comprehensive understanding of how critical thinking skills develop in educational settings.

Most of the critical thinking studies were conducted with high school students (see Table 6). Additionally, it was also conducted among elementary school students, although the number was smaller than that of junior and senior high school students and university students. These various levels are intended to identify participants who excel in critical thinking studies, especially in science learning. It was found that research does not always require the involvement of students, but teachers and lecturers can also be involved. Regarding the size or number of participants involved, 11 out of 57 involved a considerable number, with some reaching as high as 11,000. Some studies took three years to complete. This indicates that the research purpose will always be a key factor, and studies with a large number of participants will yield broad and in-depth results.

The dominance of critical thinking research conducted at the high school level, as found in this review, is consistent with Arifin et al. (2025), who reported that most inquiry-based learning studies were carried out at the middle and high school levels. However, elementary and university-level studies were also included. Similarly, Zulyusri et al. (2023) identified the educational level and sample size as influential variables in STEM-based critical thinking research, with studies frequently targeting secondary and tertiary students. In contrast, Savran and Doğan (2020) conducted design-based STEM research focused on elementary school students, highlighting the importance of introducing critical thinking instruction at an early age. Moreover, large sample sizes were also present in their pilot studies, reaching up to 147 students, while the meta-analyses by Arifin et al. (2025) involved nearly 4,000 participants across 36 study entries. These findings reinforce the notion that the research objectives, context, and methodological design shape the variation in sample sizes. The duration of the studies also appeared to influence the impact of interventions, with Arifin et al. (2025) showing significantly larger effect sizes in studies with longer durations, especially those exceeding eight weeks. This supports the notion that more extended interventions provide deeper insights and stronger improvements in students' critical thinking skills.

As seen in Table 7, studies on critical thinking employ a diverse array of instruments, with several utilizing multiple tools during both the development and implementation phases. These instruments include both test and non-test formats, each serving different assessment purposes. Among them, essay-based assessments are the most prevalent due to their capacity to stimulate higher-order thinking. This aligns with Baig et al. (1969), who argue that essay assessments require learners to engage in advanced cognitive processes for solution generation, as opposed to merely recalling memorized facts.

The preference for essay-based instruments is further supported by Sunarti et al. (2021), whose bibliometric analysis of physics education revealed that open-ended essay questions are most frequently employed. Such formats enable students to construct and apply conceptual knowledge to real-life scenarios in a logical manner. Similarly, Bhakti (2023) found that open-ended and tiered test formats, including Two-Tier and Four-Tier instruments, are widely adopted for their capacity to assess not only conceptual understanding but also deeper reasoning skills such as evaluation and inference—core components of critical thinking.

Additionally, the use of non-test instruments, particularly questionnaires, remains prominent. These tools play a crucial role in capturing affective dimensions, such as students' attitudes, perceptions, and self-reported cognitive behaviors. As emphasized by Bhakti (2023), an effective critical thinking assessment should integrate both cognitive performance tasks and self-report measures to holistically assess students' critical thinking skills across cognitive and metacognitive domains.

Furthermore, the high frequency of subject areas related to physics, as shown in Table 8, may be attributed to the perception that physics is closely tied to daily experiences and the practical application of scientific principles. Similarly, studies focusing on biology, environmental topics, and socio-scientific issues may be driven by the inherent relevance of these fields to real-world contexts such as nature, health, and societal concerns. Notably, critical thinking has also been explored in the context of mathematics, chemistry, and geography, reflecting its interdisciplinary applicability.

These findings are consistent with previous studies. For example, Faridi et al. (2021) demonstrated that augmented reality-based physics learning significantly enhances students' critical thinking by allowing them to visualize abstract scientific phenomena. Similarly, Ramdani et al. (2021) found that incorporating local wisdom into biology and environmental science instruction promotes contextual learning, which in turn improves critical thinking. In the field of chemistry, Sutiani et al. (2021) reported that an inquiry-based learning model integrated with science literacy supports students' analytical reasoning and problem-solving abilities. These studies reinforce the interdisciplinary nature of critical thinking and underscore the effectiveness of contextual, inquiry-driven, and real-world-oriented approaches in science education.

CONCLUSION

Based on the findings of this systematic literature review, the development of critical thinking skills in science education between 2019 and 2024 has predominantly focused on teaching materials and the use of student-centered learning models, especially Problem-Based Learning (PBL). These domains have been demonstrated to play a crucial role in developing higher-order thinking skills. Furthermore, although many studies have adopted theoretical frameworks such as those of Facione and Ennis, inconsistencies remain in the theoretical alignment across studies. This review contributes to the field of science education by highlighting the importance of integrating instructional media and inquiry-based approaches to enhance students' critical thinking. It also emphasizes the need for consistent use of theoretical models to support the validity and comparability of future research. The results of this study are expected to guide educators in designing more effective learning environments and to inform curriculum developers and policymakers in promoting critical thinking as a core educational goal in science.

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