

OUTDOOR LEARNING'S INFLUENCE ON CRITICAL THINKING IN ELEMENTARY SCIENCE EDUCATION: A SYSTEMATIC REVIEW IN INDONESIA

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ABSTRACT

Critical thinking is a key competency in 21st-century elementary science education. Outdoor-based learning is considered an effective approach to foster critical thinking through authentic, real-world experiences. This study examines the effect of outdoor-based learning on students' critical thinking skills using a Systematic Literature Review (SLR) with the PRISMA protocol. Literature was collected from Google Scholar, ERIC, Scopus, ScienceDirect, and SpringerLink, covering publications from 2022 to 2026. Of 741 identified articles, eight met the inclusion criteria. The findings consistently indicate that outdoor-based learning improves students' critical thinking skills, as reflected in N-Gain scores. The most developed dimensions include interpretation, analysis, inference, and explanation. Its effectiveness is influenced by the learning model, instructional design quality, and the teacher's role as a facilitator. These results highlight the relevance of outdoor-based learning to the Merdeka Curriculum, particularly in supporting the Pancasila Student Profile through critical thinking development. The study implies the need for structured teacher professional development and the systematic integration of outdoor learning into the national science curriculum.

Keywords: Outdoor-Based learning; critical thinking; science; elementary school

PENDAHULUAN

The 21st century demands a generation that is not only academically competent but also capable of thinking critically, adaptively, and solution-oriented in facing the challenges of an ever-changing world (Sarigöz, 2023). These demands place education in a highly strategic position, particularly regarding how the education system designs meaningful learning experiences for students from an early age (Nawawi et al., 2024). Educational reforms across numerous nations, Indonesia included, are continuously being carried out to shift the learning process beyond mere knowledge acquisition toward the broader development of essential life competencies. (Voogt & Roblin, 2022). In this context, elementary school education

plays a crucial role, as this phase is the golden period for shaping mindsets, learning habits, and the foundational character traits that will serve students throughout their lives (Annur et al., 2023). As a fundamental subject in elementary school, science education holds considerable potential for cultivating higher-order thinking skills, provided it is thoughtfully designed and delivered through appropriate instructional approaches (Astutik, 2025).

Critical thinking is one of the most fundamental 21st-century skills. According to Peter A. Facione, Critical thinking encompasses a set of interconnected cognitive abilities, including interpreting information, analyzing evidence, evaluating arguments, drawing inferences, constructing explanations, and exercising

self-regulation (Li et al., 2022). In the context of science education, critical thinking skills are closely correlated with understanding scientific concepts, the ability to design investigations, and the capacity to make evidence-based decisions (Juvi et al., 2024).

For the purposes of this review, critical thinking is operationally defined according to Facione's framework, encompassing six core cognitive dimensions: interpretation, analysis, evaluation, inference, explanation, and self-regulation. Articles were included only if they employed validated instruments capable of measuring at least one of these dimensions, such as the Watson-Glaser Critical Thinking Appraisal, the Cornell Critical Thinking Test, or researcher-developed instruments explicitly aligned with Facione's taxonomy. Nevertheless, findings from the 2022 Programme for International Student Assessment (PISA) reveal that the science competency of Indonesian students still falls short of the average benchmark established by OECD member countries, suggesting the need for a comprehensive and systematic transformation of the science education approach (OECD, 2023).

Outdoor-based learning is regarded as one instructional approach with strong potential to strengthen students' critical thinking abilities. Outdoor learning utilizes the natural environment outside the classroom such as schoolyards, gardens, rivers, or nearby natural areas—as authentic sources and media for learning (O'Neill et al., 2024). This approach positions students as active agents who observe, investigate, and construct knowledge through direct experiences with nature (Andriani et al., 2025). Unlike

classroom-based learning, outdoor-based learning presents the complexity of real-world situations that challenge students to think deeply, flexibly, and reflectively (Hamna et al., 2025).

A number of recent studies have examined the effectiveness of outdoor-based learning in various educational contexts. Fan et al. (2024) demonstrated that instruction conducted beyond the classroom walls substantially boosts students' motivation, active engagement, and depth of conceptual understanding. Research by O'Neill et al. (2024) reported that classroom-external learning experiences contribute to greater student engagement, deeper comprehension of scientific concepts, and the advancement of higher-order thinking skills. In the Indonesian context, research by Laili et al. (2024) found that applying outdoor learning in elementary school science classes produced a notable improvement in students' critical thinking skills relative to those in a control group.

These findings are broadly consistent with international systematic reviews, such as O'Neill et al. (2024), which reported that education outside the classroom positively impacts student engagement and higher-order thinking across diverse national contexts. However, it remains unclear whether the magnitude and mechanism of these effects in Indonesian elementary schools mirror or diverge from international patterns, given contextual differences in curriculum design, teacher preparation, and school infrastructure a gap that the present review aims to address.

Nevertheless, comprehensive and systematic studies on the impact of outdoor-based learning on the critical thinking skills of elementary school

science students remain very limited in the Indonesian academic literature. Most existing studies are partial in nature, conducted within specific local contexts, with limited sample sizes, and employing diverse analytical frameworks, making it difficult to draw general conclusions that can be widely implemented. This shortcoming creates an urgent need for a systematic, evidence-based literature review to synthesize the findings scattered across various scientific publications.

This research gap characterized specifically by (1) heterogeneity in critical thinking measurement instruments across studies, (2) a narrow age-range focus predominantly on upper-grade elementary students, (3) the absence of longitudinal evidence on the sustained impact of outdoor learning, and (4) limited attention to moderating variables such as teacher competency and school environmental conditions serves as the primary rationale for the importance of conducting this study. Indonesia's current educational policy landscape emphasizes the reinforcement of the Pancasila Student Profile, particularly its critical thinking dimension, which further underscores the pressing relevance of this study. The Merdeka Curriculum explicitly emphasizes the importance of learning based on real-world experiences, projects, and environmental exploration as the primary modalities for developing student competencies (Ministry of Education, Culture, Research, and Technology, 2022). Within this framework, outdoor-based learning has the potential to serve as an implementation strategy aligned with the direction of national curriculum policy, while simultaneously addressing the challenge of improving the quality of science education in elementary schools.

From a theoretical perspective, outdoor-based learning in science education is grounded in several robust learning theories. Piaget's constructivist theory holds that knowledge is built through direct and active engagement between individuals and their surrounding environment. (Mandar & Sihono, 2025). Outdoor learning provides students with the opportunity to engage in direct exploration, experience cognitive disequilibrium through real-world natural phenomena, and construct new understanding through the processes of accommodation and assimilation (Fitriana, 2025). Meanwhile, Kolb's experiential learning theory emphasizes that effective learning occurs within a cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation a cycle that is naturally facilitated in outdoor learning (Andriani et al., 2025). A natural environment rich in multimodal sensory stimuli visual, auditory, tactile, and kinesthetic is capable of activating a broader and more integrated neural network compared to the relatively homogeneous classroom environment (Li & Deng, 2023). These conditions create an optimal environment for the development of critical thinking skills, which involve the integration of information from various perceptual modalities.

Building on the preceding discussion, this study seeks to systematically examine the influence of outdoor-based learning on students' critical thinking skills in elementary school science education, employing a Systematic Literature Review (SLR) approach guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. More specifically, this study aims to: (1) identify the design

characteristics and implementation models of outdoor-based learning in elementary school science education that have been reported in various empirical studies; (2) analyze the magnitude and consistency of the impact of outdoor-based learning on elementary students' critical thinking skills based on a cross-study synthesis; and (3) identify the moderating factors that influence the effectiveness of this approach in various contexts of science education in elementary schools

METHOD

This study employs a Systematic Literature Review (SLR) as its primary methodological framework. This approach enables researchers to systematically, purposefully, and reproducibly review and analyze various scientific publications related to the research topic (Carrera-Rivera et al., 2022). By conducting an SLR, researchers seek to establish a thorough understanding of a particular field by gathering, evaluating, and synthesizing findings from numerous prior studies, while simultaneously identifying gaps that remain underexplored as a foundation for advancing future research (Bancong, 2025).

One of the strengths of SLR lies in its procedures for conducting a comprehensive literature review while upholding the principles of transparency and objectivity (Page et al., 2021). This is achieved through the application of a detailed, documented search strategy, as well as the establishment of clear selection criteria to determine which articles are relevant for further analysis (Carrera-Rivera et al., 2022). To ensure a structured selection process, this study adheres to the PRISMA protocol, which divides the workflow into four main phases: source

identification, initial screening, eligibility assessment, and the final selection of articles for analysis.

This study began with the establishment of objectives and the formulation of clear research questions as the primary foundation for the literature review process. Next, the researcher established inclusion and exclusion criteria to select relevant articles. The literature search was conducted through various databases, such as Google Scholar, Scopus, Web of Science, ERIC (Education Resources Information Center), Springer Link, ScienceDirect, and SINTA (Science and Technology Index), using keywords aligned with the research focus. The retrieved articles then undergo a screening process based on titles, abstracts, and full texts, with the entire selection process documented in a PRISMA flowchart illustrating the number of articles at each stage.

Subsequently, articles meeting the criteria are analyzed and synthesized to identify key findings, which are then classified into specific categories based on particular dimensions, such as learning approaches or educational levels. The final stage of this study is the formulation of recommendations for future research based on the gaps and limitations identified in the reviewed studies. Defining clear research objectives and specific questions to guide the entire literature review process is a fundamental step in the Systematic Literature Review methodology (Rethlefsen et al., 2021).

a. Identification Stage

A systematic literature search was conducted using electronic databases, including Google Scholar, ERIC, Scopus, ScienceDirect, and Springer Nature Link. The search utilized relevant keywords such

as “outdoor-based learning,” “critical thinking,” “science learning,” “elementary school,” and combinations of these using Boolean operators (AND, OR). The final database search was conducted in March 2026. The search was limited to articles published within the last 5 years, specifically from 2022 to 2026. From this identification process, a total of 741 articles were identified

b. Screening Stage

After removing 87 duplicate articles, a total of 654 articles remained and proceeded to the screening stage. The screening was conducted based on the title and abstract by two independent reviewers. Articles were excluded if they did not discuss outdoor-based learning, were not related to critical thinking skills, did not discuss science education, or originated from non-journal sources such as blogs, general websites, or publications without a peer-review process. Following this process, 491 articles were excluded, leaving 163 articles to advance to the next stage.

c. Eligibility Stage

166 articles underwent full-text review to evaluate their eligibility according to the predefined inclusion and exclusion criteria. The inclusion criteria used included: (1) the article discusses outdoor-based learning, (2) the article discusses critical thinking skills, (3) the article discusses science learning, (4) the research was conducted at the elementary school level or equivalent, (5) the article was published between 2022 and 2026, (6) the article is from an indexed scientific journal, and (7) the article is available in full text and accessible. From this process, 158 articles were excluded for the following reasons: they did not discuss outdoor-based learning, did not discuss critical thinking skills, did not discuss science education, were conducted at levels other than elementary school, and the articles were not available in full text or were inaccessible. A complete overview of these two criteria can be seen in Table 1.

Table 1: Inclusion and Exclusion Criteria

No	Inclusion Criteria	Exclusion Criteria
1	Research articles on outdoor-based learning	The article does not discuss outdoor-based learning
2	Articles on critical thinking skills	The article does not discuss critical thinking skills
3	Research articles on science education	The research article does not discuss science
4	Research conducted at the elementary school level or equivalent	Research conducted outside the elementary school level
5	Articles published over the past five years (2022–2026)	Research not conducted between 2022 and 2026
6	Articles must be from indexed scientific journals (Google Scholar, Scopus, ERIC, ScienceDirect, and Springer Nature Link)	Articles from non-journal sources, such as blogs, general websites, or publications without a peer-review process
7	Articles must be available in full text and accessible	Articles that are not available in full text or cannot be accessed
8	Articles must be scientific publications	Documents with non-scientific journal publication types, such as books, conference proceedings, essays, opinion pieces, and scientific reports

d. Included Stage

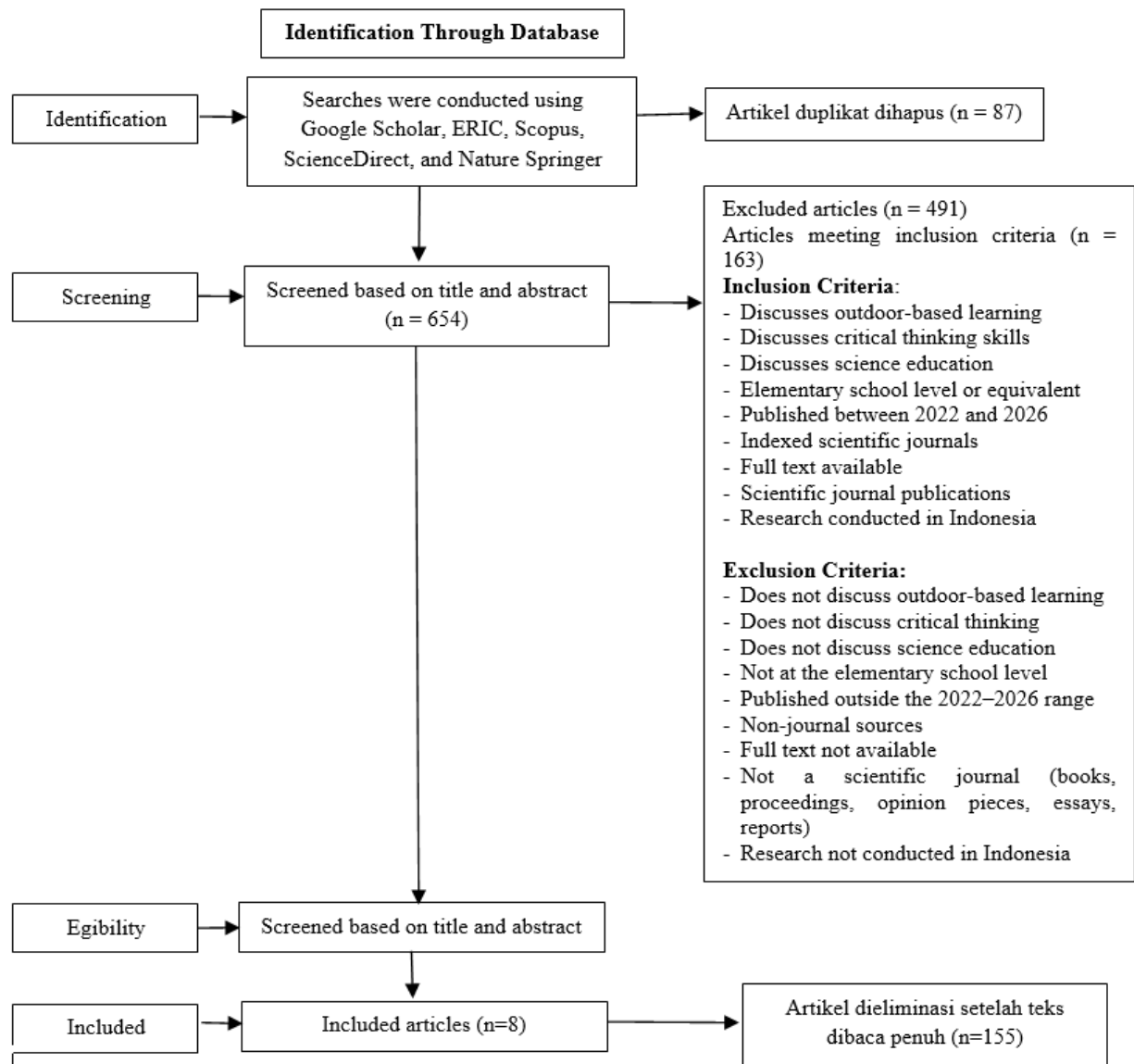
The final step involved selecting articles suitable for analysis. A total of 8 articles were chosen and analyzed further regarding the impact of outdoor-based learning on students' critical thinking skills in science education at the elementary school level. The articles were then analyzed based on the research questions. The data analysis was guided by the following research questions:

1. How do various studies describe the implementation of outdoor-based learning in science education at the elementary school level?
2. To what extent does outdoor-based learning affect the development of

critical thinking skills among elementary school students, as evidenced by prior research?

3. Which specific components of critical thinking skills are fostered through outdoor-based learning in elementary school science education?

The PRISMA protocol flowchart used is shown in Figure 1



RESULT

A literature search using the databases cited revealed that eight articles met the criteria established for this study. The articles meeting these standards were published within the last five years,

between 2022 and 2026, and met the other previously established inclusion criteria. These articles underwent a rigorous selection process before being included in the research analysis. The findings from these articles are presented in Table 2.

Table 2 Summary of Research Findings

No	Title	Author	Research Method	Findings
1	Development of an Outdoor Learning-Based MERDEKA Curriculum Module to Enhance Critical Thinking Skills in 5th-Grade	Wihati et al, (2024)	Research and Development	The findings revealed that implementing the MERDEKA curriculum module based on outdoor learning significantly improved critical thinking skills among fifth-grade science students at SD Negeri Sekolah Binaan I, Jatibarang Subdistrict, Brebes Regency, as demonstrated by an average

	Elementary School Science Education			N-Gain score of 0.806498609, which is classified under the "highly effective" category.
2	The Role of Outdoor Learning in Enhancing Students' Critical Thinking Skills in Science Education	Hamna et al, (2025)	Mix Methode	The findings affirm that outdoor learning significantly contributes to strengthening critical thinking skills by providing authentic and contextual learning experiences, implying that teachers should incorporate outdoor activities as part of science instructional strategies aimed at cultivating higher-order thinking skills.
3	The Effect of an Outdoor Study-Based Project-Based Learning Model on Improving Students' Critical Thinking Skills in Elementary School Science Education	Pratiwi et al, (2024)	Quantitative	The findings indicate that (1) the Project-Based Learning model integrated with Outdoor Study demonstrated a moderate effect on critical thinking skills among fifth-grade science students at SDN 85 Singkawang, (2) a moderate enhancement in students' critical thinking skills was observed following the application of the Project-Based Learning model integrated with Outdoor Study in fifth-grade science classes at SDN 85 Singkawang, and (3) the implementation of the Project-Based Learning model integrated with Outdoor Study was carried out effectively in fifth-grade science classes at SDN 85 Singkawang.
4	The Effect of a Problem-Based Learning Model Combined with Outdoor Learning on the Problem-Solving Skills of Fifth-Grade Elementary School Students	Juniasih & Riastini (2024)	Quantitative	The findings suggest that combining the PBL model with outdoor learning effectively enhances problem-solving skills among fifth-grade elementary school students. This implies that teachers are encouraged to employ diverse teaching and assessment strategies, while positioning themselves as facilitators and mentors who guide students throughout the problem-solving learning process.
5	The Effect of Outdoor Learning Methods on Students' Critical Thinking Skills in Science Classes for Fifth Graders at SD Negeri 23 Gelumbang	Aprilia et al, (2024)	Quantitative	The findings demonstrate that the outdoor learning method significantly influences the development of critical thinking skills among fifth-grade elementary school students in science class.
6	Outdoor Problem-Based Learning; Enhancing Critical Thinking with Real World Experiential in	Martasari et al, (2025)	Quantitative	The findings reveal that conventional learning proved to be less effective in fostering critical thinking skills compared to the problem-based learning model implemented in an outdoor classroom

	Science Learning			setting.
7	The Effect of Outdoor Learning Methods on Students' Critical Thinking Skills in the IPAS Subject for Fourth-Grade Elementary School Students	Ramadhani et al, (2025)	Quantitative	The findings indicate that the outdoor learning method had a significant effect on students' critical thinking skills in fourth-grade IPAS instruction at SDN 1 Gantiwarno, East Lampung, during the 2024/2025 academic year, as supported by the independent samples t-test results yielding a significance value of $0.000 < 0.05$.
8	The Effect of Using the Outdoor Study Method on Fourth-Grade Elementary School Students' Critical Thinking Skills in Science Class	Laili et al, (2024)	Quantitative	The findings reveal that the experimental group demonstrated a more substantial improvement in critical thinking skills compared to the control group, concluding that the outdoor study method exerted a significant positive effect on enhancing critical thinking skills among fourth-grade elementary school students in the IPAS subject, thereby indicating its potential as an effective learning strategy for cultivating higher-order thinking skills at the elementary school level.

DISCUSSION

The Effectiveness of Outdoor-Based Learning in Improving Students' Critical Thinking Skills

A synthesis of eight articles reveals that all studies consistently demonstrate that outdoor-based learning yields a significant impact on enhancing students' critical thinking skills compared to conventional learning approaches. Laili et al. (2024) reported a significance value of 0.003 ($p < 0.05$) in the application of the outdoor study method in fourth-grade IPAS (Natural Sciences) classes, with the average critical thinking ability score of the experimental group increasing from 75.2 to 83.5, while the control group only rose from 74.8 to 76.1. Ramadhani et al. (2025) obtained a stronger significance value of 0.000 ($p < 0.05$) in a quasi-experimental study involving 47 fourth-grade students at SD Negeri 1 Gantiwarno, with a calculated F-value for linear

regression of $12.200 >$ the critical F-value of 4.30. Aprilia et al. (2024) also confirmed similar findings with a significance value of 0.006 ($p < 0.05$) in fifth-grade science instruction, where the mastery rate in the experimental class surged from 40% to 88%, far surpassing the control class, which reached only 63%. The consistency of the hypothesis test results from these three quantitative studies which differ in context and grade level provides robust empirical evidence that outdoor-based learning is not merely a variation in teaching methods, but also a pedagogical intervention that tangibly drives the development of higher-order thinking skills among elementary school students.

The magnitude of improvement in critical thinking skills was further corroborated through a cross-study analysis of N-Gain scores. Wiharti et al. (2024) recorded the highest N-Gain score

of 0.806 classified as “highly effective” through the integration of outdoor learning into the MERDEKA curriculum module covering ecosystem components in fifth grade. Juniasih & Riastini (2024) found an N-Gain of 0.72, categorized as high, in the PBL model with outdoor learning variations, compared to the conventional group, which scored only 0.55. Pratiwi et al. (2024) obtained an N-Gain of 0.50, classified as moderate, in the Project-Based Learning model based on Outdoor Study, while Aprilia et al. (2024) reported an average N-Gain of 56.7% (sufficiently effective category) for the experimental class compared to 32% (ineffective) for the control class. These differences in N-Gain values suggest that the effectiveness of outdoor-based learning is not uniform but is significantly influenced by the pedagogical models and structures integrated into the program. The more structured and systematic the outdoor learning design, the greater the improvement in critical thinking skills that students can achieve. This aligns with Vygotsky’s scaffolding principle (Mandar, 2025), which states that optimal cognitive development occurs when students receive structured support within their zone of proximal development.

Variations in Instructional Models Combined with Outdoor Learning

One of the key findings of this systematic literature review is the diversity of instructional models integrated with outdoor learning approaches across various studies. Martasari et al. (2025) combined Problem-Based Learning (PBL) with outdoor learning and found that the experimental group achieved an average critical thinking score of 86.76 compared to 68.56 in the control group, with an N-

Gain of 0.63, categorized as moderate. Juniasih & Riastini (2024) demonstrated that the PBL model with outdoor learning variations enhances fifth-grade students’ problem-solving skills, achieving an N-Gain of 0.72 (high), with the experimental group’s average posttest score of 85.71 substantially surpassing the control group’s score of 77.00. Similarly, Pratiwi et al. (2024) applied Project-Based Learning based on Outdoor Study and obtained a calculated t-value of 15.8075, which exceeded the critical t-value of 2.0017. The diversity of these models demonstrates that outdoor-based learning is compatible and adaptable to various pedagogical frameworks, provided that the element of direct experience with the real environment remains a core component of the learning process.

The integration of outdoor learning with the PBL model, in particular, has strong theoretical support from the constructivist perspective. The outdoor environment provides authentic problems that serve as the subject of investigation within the PBL cycle, so that students are not solving hypothetical problems, but rather real-world problems that they encounter, observe, and experience firsthand. Martasari et al. (2025) explain that when students observe the swinging of a swing in a city park or monitor the bounce of a ball from various heights, they naturally construct an understanding of potential and kinetic energy through concrete experiences. This process reflects Kolb’s experiential learning cycle (Mandar, 2025), which begins with concrete experience, proceeds to observational reflection, abstract conceptualization, and culminates in active experimentation. Wiharti et al. (2024) reinforce this argument by demonstrating

that the integration of outdoor learning into the MERDEKA framework which includes the Concept Exploration and Contextual Demonstration stages creates a differentiated learning environment that optimizes students' independent construction of scientific knowledge, in accordance with the principles of student-centered learning in the Merdeka Curriculum.

The Mechanisms of Outdoor Learning in Developing Dimensions of Critical Thinking

The analyzed articles not only statistically demonstrate the effectiveness of outdoor-based learning but also reveal the specific mechanisms through which learning outside the classroom develops various dimensions of critical thinking skills. Hamna et al. (2025), who employed a mixed-methods approach with a sequential explanatory design, qualitatively described that students participating in outdoor learning demonstrated significant development in the aspects of interpretation, analysis, and explanation. Field observation data show that when students directly observe plants in the school environment, they naturally interpret morphological characteristics, analyze similarities and differences among specimens, and evaluate the functions of plant parts within the ecosystem. This process directly hones inference and evaluation skills, which are core components of critical thinking according to Facione. Interview results in the study by Hamna et al. (2025) also confirm that students find it easier to understand and explain science concepts after interacting directly with real objects in the field, compared to simply reading from textbooks.

Ramadhani et al. (2025) added more specific quantitative findings, namely that after being exposed to outdoor learning, the experimental group showed improvement across all indicators of critical thinking, including: providing simple explanations, building basic skills, drawing conclusions, offering further explanations, and devising strategies and tactics. This condition differs significantly from the initial condition, where students tended to be passive and unaccustomed to expressing their opinions due to the dominance of the teacher-centered model. Martasari et al. (2025) reinforce these findings by explaining that the outdoor environment provides multisensory stimuli including sight, sound, texture, and temperature that encourage students to actively ask questions, observe, and test hypotheses directly. This rich sensory stimulation not only enhances learning motivation but also strengthens long-term memory and conceptual understanding. These findings support the theory of embodied cognition, which states that human cognition does not occur solely in the brain but is influenced by the body's physical and sensory experiences as it interacts with its environment (Mandar, 2025). Thus, outdoor-based learning in science education inherently creates optimal conditions for the comprehensive development of critical thinking skills.

The Role of Teachers as Facilitators in Outdoor Learning

A cross-article analysis reveals that the success of implementing outdoor-based learning is largely determined by teachers' capacity as facilitators who are able to design, guide, and reflect on learning experiences outside the classroom. Laili et al. (2024) emphasize that teachers need to

design outdoor activities aligned with IPAS learning objectives, ensure student safety, and integrate field experiences with classroom discussions and structured reflection. This requires a shift in the teacher's role from an information provider to a thinking facilitator who guides students in constructing knowledge through direct experience. Aprilia et al. (2024) add that the fifth-grade teacher at SDN 23 Gelumbang actively designs observation worksheets that encourage students to identify natural phenomena, ask questions, and draw conclusions based on empirical evidence, rather than merely memorizing scientific definitions from textbooks.

In the context of integrating the PBL model with outdoor learning, the teacher's role as a facilitator becomes increasingly complex and crucial. Martasari et al. (2025) note that teachers must be able to design contextual problems relevant to phenomena in the surrounding environment, organize students into investigative groups, and guide the analysis process without providing direct answers. Juniasih & Riastini (2024) emphasize that in the outdoor PBL model, teachers act as guides who accompany students through the process of formulating problems, collecting data, analyzing findings, and presenting solutions. This role aligns with Vygotsky's sociocultural theory, which states that effective learning occurs through meaningful social interaction between teachers and students within the zone of proximal development (Mandar, 2025). Teachers who are competent in guiding outdoor learning not only enhance students' critical thinking skills but also build self-confidence, independence, and

collaboration skills essential 21st-century competencies.

Relevance to the Merdeka Curriculum and 21st-Century Skills

The findings of this SLR are highly aligned with the spirit of the Merdeka Curriculum, which emphasizes meaningful, contextual, project-based learning focused on the development of students' holistic competencies. Wiharti et al. (2024) explicitly demonstrate this synergy through the development of instructional modules that incorporate outdoor learning within the MERDEKA framework (Starting from the self, Concept exploration, Collaborative space, Contextual demonstration, Elaboration of understanding, Connections between materials, and Real-world action). This module not only received expert validation with a feasibility rating above 90% for content, language, and instructional design aspects but also yielded an N-Gain of 0.806, categorized as highly effective. Laili et al. (2024) also emphasize that the outdoor study method aligns with the implementation of the Merdeka Curriculum because it naturally promotes project-based learning and reinforces the Pancasila Student Profile, particularly the dimensions of independence, cooperation, critical thinking, and creativity. Thus, outdoor-based learning is not merely an alternative pedagogical strategy but an approach that is structurally aligned with the direction of Indonesia's national curriculum.

Beyond the academic dimension, several studies have also identified the broader impact of outdoor-based learning on the development of 21st-century skills. Hamna et al. (2025) noted substantial improvements in communication,

collaboration, and problem-solving skills among students who engaged in outdoor learning activities. Students not only develop cognitive abilities but also demonstrate increased self-confidence, the ability to work together in groups, and the courage to ask critical questions. Juniasih & Riastini (2024) emphasize that when students collaborate on projects in the great outdoors, they indirectly develop important interpersonal skills such as exchanging ideas, sharing responsibilities, and making joint decisions. This multidimensional development aligns with UNESCO's Education for Sustainable Development (ESD), which integrates the cognitive, affective, and psychomotor domains into a cohesive learning experience (Mandar, 2025). In other words, outdoor-based learning in elementary school science does not merely improve test scores on critical thinking skills, but shapes students into well-rounded individuals who are both critical thinkers and adaptive collaborators in the 21st century.

Implementation Challenges and Opportunities for Development

Although all studies demonstrate consistent positive effects, an in-depth analysis of the eight articles reveals a number of implementation challenges that warrant serious attention. First, most studies were conducted with relatively small sample sizes, ranging from 14 to 76 students from one or two schools, so generalizing the findings to a broader population must be done with caution. Laili et al. (2024) explicitly acknowledge that the sample of 40 students from SDN Kebondalem-Mojosari limits the generalizability of the findings. Second, nearly all studies employed quasi-

experimental designs without full randomization, meaning confounding variables such as socioeconomic background, individual learning styles, and teacher characteristics could not be fully controlled. Third, Martasari et al. (2025) note managerial challenges in managing classes in open spaces, including environmental distractions, difficulties in maintaining student focus, and more complex group coordination compared to classroom-based learning. These constraints indicate that the effectiveness of outdoor-based learning is not automatic but rather highly dependent on teacher readiness, school support, and the quality of the implemented instructional design.

Nevertheless, the potential for developing outdoor-based learning in elementary school science is wide open, particularly in the context of the Merdeka Curriculum policy and the push to strengthen the Pancasila Student Profile. Hamna et al. (2025) recommend that teachers design outdoor activities more systematically by preparing structured observation tools, probing questions that encourage analysis and inference, and clear post-activity reflection steps. Wiharti et al. (2024) provide concrete evidence that the development of scientifically validated outdoor learning-based instructional modules can serve as a solution to the limitations in teachers' competencies when designing effective outdoor learning. Theoretically, this development reinforces Mezirow's concept of transformative learning, which states that changes in understanding and awareness occur through experiences that challenge old assumptions and open new perspectives (Mandar, 2025). In the context of elementary education, outdoor-based learning serves as a bridge between

abstract science learning in the classroom and the complex real world outside the classroom, shaping students who are not

CONCLUSION

Based on the results of a systematic literature review of eight empirical articles published between 2022 and 2026, outdoor-based learning has been shown to consistently and significantly improve students' critical thinking skills in science education at the elementary school level, as evidenced by significant p-values across all quantitative studies and N-Gain scores, with diverse implementation approaches including Project-Based Learning, Problem-Based Learning, and the MERDEKA curriculum modules that position the natural environment as an authentic learning context to develop critical thinking dimensions including interpretation, analysis, inference, explanation, and self-regulation. Nevertheless, its effectiveness is highly dependent on the quality of instructional design and the teacher's capacity as a facilitator. There is a need for larger-scale studies using randomized controlled trials to strengthen the generalizability of findings, given that nearly all studies employ small samples with quasi-experimental designs; the need for longitudinal research to examine the long-term sustainability of the impact of outdoor-based learning; the scarcity of studies on lower-grade students who also require an experience-based approach; the lack of in-depth examination of moderator variables such as socioeconomic background, school environment

only conceptually science-literate but also critical, adaptive, and ready to face the challenges of the 21st century.

characteristics, and teacher competencies, as well as the limitations of standardized critical thinking assessment instruments specifically designed for the context of elementary school science outdoor learning. It should be noted that the findings of this review are bounded by their context: all eight included studies were conducted in Indonesian elementary schools, and caution should be exercised when generalizing conclusions beyond this setting, particularly to school systems with different infrastructural, cultural, or curricular conditions. From a policy and practice standpoint, these findings call for: (1) structured teacher professional development programs focused on the systematic design of outdoor learning activities that specifically target inference, analysis, and reflective thinking; (2) integration of outdoor learning sequences into official science subject syllabi at the elementary school level, with clear alignment to the Pancasila Student Profile competencies; and (3) the development of standardized, context-sensitive assessment instruments for measuring critical thinking in outdoor science learning environments, to enable more rigorous cross-study comparisons in future research. Thus, outdoor-based learning remains a relevant pedagogical approach that aligns with the Merdeka Curriculum in fostering critical thinkers who are independent and adaptable in the 21st century.

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